

LIST OF LEAN MANUFACTURING PRACTICES IN THE ADOPTION OF CLEANER PRODUCTION: A STUDY USING STRUCTURAL EQUATIONS

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Abstract

The objective of this article is to verify whether lean manufacturing (LM) practices are positively related to the adoption of cleaner production practices (P+L) in industries in the metal-mechanic sector, in order to test the hypothesis - widely argued in literature - that when identified as lean production, the industry also tends to be green production. The research was carried out with industries of the branch in the states of Rio Grande do Sul and Santa Catarina, Brazil, through a survey, used in order to measure their opinion, identifying what are the main affinities, the P+L and ME practices and how much they relate to each other in an indirect and practical way. The analysis of this study had a quantitative and descriptive character. In the end, the objective was achieved; revealing that lean manufacturing influences cleaner production by 89%.

Keywords: lean manufacturing, cleaner production, structural equations.

Introduction

Companies They are looking innovate your capabilities to excel in your their respective markets. In this way, the insertion of practices facilitators in a process productive is considered a means effective for leveraging results positive , in addition to keeping them at the top of the ranking. Thus , the use of mechanisms like manufacturing lean (ME) and adoption of production techniques cleaner (P+L) validate this purpose , because according Marodin et al. (2018) ME produces more , with quality and at a cost reduced , avoiding waste , which also It increases value for the customer .

Regarding P+L, De Oliveira Santos (2020) highlights that the The 20th - century production model was based on resource idea natural unlimited , an idea that crumbled over time, as evidenced by ... impacts of the benefits economic and their repercussions regarding to the quite

environment, which has generated concern among companies. In employing P+L, Giannetti et al., (2020) complement the importance of technologies and initiatives aiming for sustainability, with the involvement of everyone (MA et al. 2022).

This given, the objective of this article aims to verify if manufacturing practices lean (ME) relate positively with the adoption of production practices cleaner (P+L), with the purpose of testing the hypothesis - broadly argued in literature - that when it is identified like lean production, the industry tends also to be green production.

The investigation was applied in a survey conducted with industries in the metal-mechanical sector, in the states of Rio Grande do Sul and Santa Catarina. Conducting the research, it was made from the approach Quantitative, as well as descriptive. The type of sampling is descriptive sampling. no probabilistic put convenience. The collection was by email, implemented via *Google Forms*, whose referral was made put three Waves of remittances, between the months of August 2025 and February 2026. The Excel program was used to tabulate the data and results. you same; the SPSS 24 *software for analysis* The statistical *software* and AMOS 24 were used to develop the final model.

In the analysis and discussion of results it will be detailed profile of the sample – which presents your classification main productive, illustrated in Figure 4; following in individual validation of the constructs, which is shown in Table 2 presents the factor loadings and variance explained and Cronbach's Alpha, well As Table 3 shows, AVE, reliability composite and variance extracted. The analysis multivariate presentation in Table 4 checking the model fit measures theoretical, in addition to Figure 5, which presents the equation model. structural differences exist between ME and P+L practices. Finally, in considerations finals will Taking into account the limitations of the study, and the research future.

Literature

Manufacturing lean

The term Manufacturing Lean (LE), Lean Manufacturing or Lean Production, as It is also known, it was introduced in Japan by Toyota in 1950s (LIKER, 2005). It emerged as one response to the difficulties faced by companies Japanese in to reach scale in quantity of products, offering the possibility of earnings. put middle of a philosophy based in production management lean, which proposes the delivery of products and services with high quality and low costs (MOORI; PESCARMONA; KIMURA, 2013). Supported for the Based on the principle of the Toyota Production System, ME has based on waste elimination in the flow productive, representing one strategy alternative to the production model in mass (HINES *et al.*, 2004; CHAVEZ-ESCOBEDO, *et al.*, 2026).

ME can be understood as a method that allows you to "do More with less – less time, less space, less effort human, less machinery, less material" (DENNIS, 2008, p, 31). It consists in one production management strategy that has put The objective is to seek improved quality. put through the elimination of waste from activities that do not generate value (WOMACK and JONES, 2004; TAYAL and KALSI, 2021). It comprises a set of recommendations, principles, and techniques that organizations they can follow when the goal is to make the enterprise more lean and agile (WOMACK and JONES; ROOS, 1992; VASILESKA, *et al.*, 2024).

ME is perceived as a way to generate value for process productive and add value advantage competitive to the business . Its focus this in reduction of the time that a The piece takes time to go through the process. productive , even your finalization (BADHOTIYA, *et al.*, 2024) . In this sense , what the system the search is waste elimination put through maximizing the productivity and effectiveness of processes . For Irakumar et al. (2012) , by By eliminating waste , it is possible to reach the effectiveness and, consequently , increased profitability . Based on this Understanding is possible. understanding ME as one a multidimensional approach that encompasses management practices such as just-in-time, quality systems , work teams , manufacturing in cells , stakeholder management , among others , in an integrated way (PAPANDREA et al. 2020; SHAH and WARD, 2003). In this process the efficiency and the pursuit of improvement continuously become success factors , given that ME strongly depends on the interaction of the chain (ESKANDARI *et al.* 2022) .

Coelho et al. (2008) argue that the ME system encompasses one approach systemic that will beyond the limits departmental , indicating that also can be represented for the concept of medium environment . For the authors , aligned to the management objectives Environmentally , ME contributes to minimizing impacts . environmental caused by operations industrial , ensuring the achievement of better performance indicators in in terms of cost , quality and productivity , as well as the achieving gains in indicator performance environmental - by use Resource efficiency , through the reduction of waste and consumption of materials , energy and water (PALANGE and DHATRAK , 2021; MATINDANA and SHOSHIWA, 2025) .

THE that Regarding Porter and Linde (1995, p. 122), they agree that “ the efforts to reduce pollution and efforts to maximize you profits they share the same principles basics , including the use efficient use of inputs, material substitution , and minimization of activities . unnecessary ”, are considered important Differentiation strategies through impact reduction environmental . In this sense , they believe that the association between the best production practices and techniques lean and management environmental he can to contribute to better results (ARABI, *et al.*, 2026) . When based in production practices lean management environmental adds value by promoting protection to the quite environment and by actions for interacting with the system productive (SCHMITT et al. 2021).

Clean Production (CP)

In the repertoire organizational debate about the environment environment and its consequences for the world he has been agenda each time more frequent . The need to address such issues is a response to the current scenario , which comes requiring companies to take a new look at processes productive and a posture more effective in Choosing paths that lead to results . more effective and ecologically correct . Ometto et al. (2015) indicate that this logic requires think in addition to product improvements – which aim to to reduce costs and increase quality , and move forward . in The direction of process optimization to reduce impact . environmental about the activities generated (LATINOVIĆ; MARKOVIĆ; TOMAŠEVIĆ, 2026) . In this reality the The implementation of P+L is presented as one strategy important for achieving objectives and generating value (DO COUTO PEREIRA *et al.*, 2022) .

Proposed by the *United Nations Industrial Development Organization* (UNIDO) and the *United Nations Environment Programme* (UNEP), P+L emerged as a concept applied to a strategy environmental Preventive and integrated into processes , products , and services . According to UNEP, P+L refers to the application systematized planning with a focus

environmental turned to the Increased overall efficiency and reduced risks . to the beings humans and the environment environment . Includes in this way application continuous of a strategy economic , environmental and technological , integrated into processes and products (ZHANG and BAO, 2026) .

For Philippi et al. (2016), this idea this each time present within the scope organizational for the The fact that, starting from the implementation of P+L, it is possible to reach benefits economic trailers to the use more resource efficient scarce as energy , water and raw materials . It is , therefore , a strategy that acts directly in production and operations management , which can provide gains environmental and economic to the organizations . (BARBIERI, 2011; UNEP, 2012; DA SILVA, 2019; MA et al. 2022). Figure 1 shows the P+L application in issue of processes , products and services .

Figure 1 – Representation of the P+L Concept



Source: Adapted from the concepts proposed by Barbieri (2011).

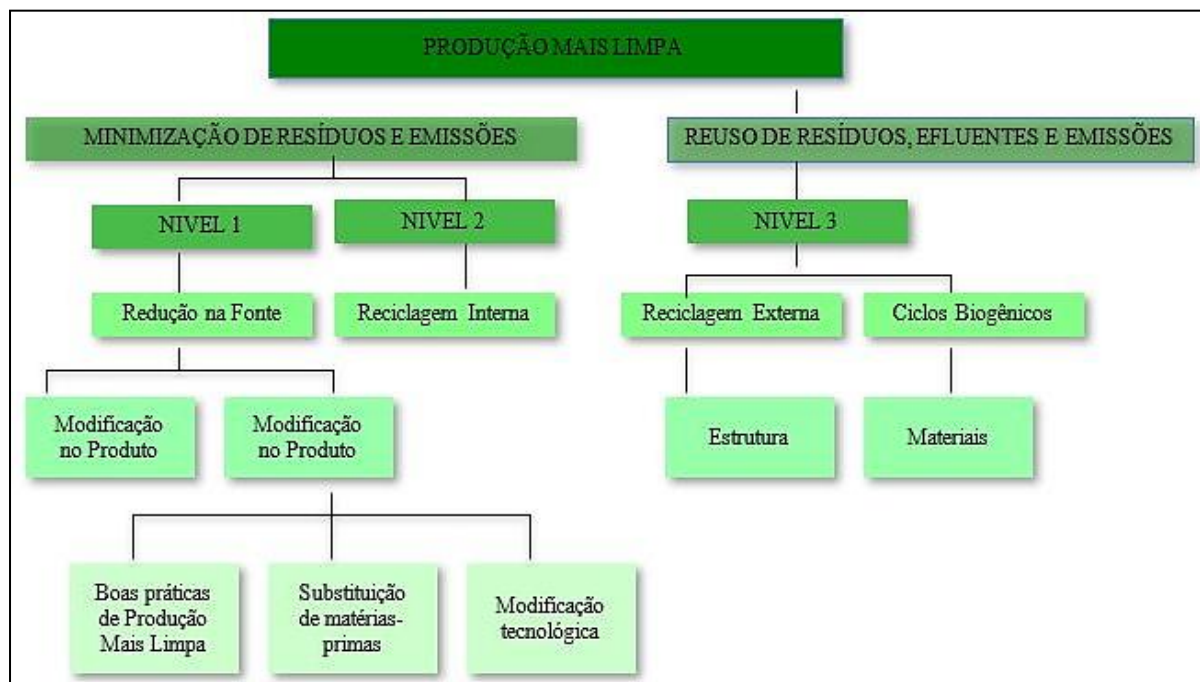
As a management tool , P+ L aims to promote improvements environmental factors in the process and development of products , and contribute to the development sustainable (GLAVIC; LUKMAN, 2006). For this , it considers the variable environmental in all you levels of the organization , stimulating actions to be implemented within the company , making the process more efficient in the use of their inputs to the to generate more products and less waste (DOMINGOS et al. 2012; OMETTO et al. 2015; DA SILVA, 2019). In a more Specifically , it can be said that PM+L seeks to analyze how operations organizational they are performed , and to identify which stages of the process they are being wasted , allowing identify Optimization and improvement spaces to avoid waste (DO COUTO PEREIRA et al. 2022; ESPINOZA-MARTINEZ, *et al.*, 2025) .

Such a definition It expresses the change in attitude that organizations need demonstrate to the aim the adoption of conduct productive more sustainable (WANG and SHEN, 2026) . Because it is a strategy turned to the development of improvements in the practices In organizational contexts , P+L requires one Change in practices and behaviors . For UNEP (1995), the basis for the Implementing P+L implies basically in three Factors : Improvement technological , acquisition of *know-how* and change of attitudes . This movement requires the Identifying a new approach to the relationship between industry and the environment involves understanding the practice of management . environmental responsible . Therefore, it is understood that the

decision to implement P+L is associated with characteristics entrepreneurs , given their importance in generating opportunities to obtain competitive advantage (XUE *et al.*, 2024) .

The National Center for Technologies Clean (CNTL) presents you different levels of intervention in a P+L application system . Figure 2 represents these levels .

Figure 2 – P+L Hierarchy



Source: CNTL (2003)

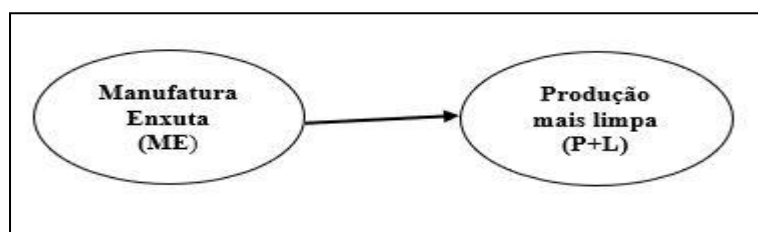
According to Figure 2, level 1 indicates the measurements. priorities to be achieved , both in terms of product (changes in composition of the elements , durability , quality standards , etc.), how much to the process productive (modifications that contribute to waste reduction and process simplification) . Such measures aim to promote the minimization of waste production . put means of improvements us procedures administrative and technical . Level 2 covers internal retraining by through the reintegration of waste , whether by recovering product components . or through the reuse of raw materials , among other processes . Finally , level 3 , which encompasses external recycling , obtained through external reuse .

Among you benefits Provided by the implementation of P+L, UNIDO (UNITED, 2002) highlights : the increase in productivity , ensured for the use more efficient use of raw materials ; promoting better performance environmental , achieved by eliminating waste and reducing impact . environmental , oriented put one low strategy cost effective (SANTHOSH; SUBHANI; BAHURUDEEN , 2021) . As to the UNIDO/UNEP (1995) indicates obstacles that interfere with the implementation process of P+L . some Factors such as : resistance to change ; conception erroneous (lack of information) about the technique and the importance given to quite environment); no existence of policies national organizations that provide support to the clean production activities ; barriers economic (allocation) incorrect accounting of environmental costs and investments) and barriers techniques (new technologies) .

According to Capra (1982), one aspect related to the obstacles it says Regarding the loss of flexibility , considering the need for structures and standards . more rigid . The CNTL (2005) indicates that a large The challenge for companies is to include P+L (Product and Loss) in planning. strategic , given the difficulty of incorporating it into levels operational and management . According to Sultama et al. (2023), to achieve a work environment decent in the companies and avoid environmental pollution . environment , are necessary approaches innovative . That he can include the adoption of technologies eco- efficient products ecologically correct put part of the business owners , well how to implement a resource management more efficient (ESPINOZA-MARTINEZ, *et al.*, 2025) . Campaigns rigorous management environmental can be carried out to create activities inclusive and ecological in areas urban (XUE *et al.*, 2024) .

P+L can be implemented in any sector of activity , however , in order to be effective requires one analysis technical , economic and environmental detailed description of the operations , aiming to the identifying opportunities that enable improve efficiency organizational , without increased costs for the company (SILVA and MEDEIROS, 2006; CENTRIC AUSTRIA, 2005; SCHMITT *et al.* 2021; DO COUTO PEREIRA *et al.* 2022) . Therefore, P+L includes both a condition to achieve improvements environmental factors in the product development process . as one contribution to a bigger sustainability of the world (GLAVIC and LUKMAN, 2006). To make the research feasible the models theorists of Oliveira (2017), Parente *et al.*, (2017) and Jabour *et al.* (2013) represented in Figure 3.

Figure 3 – Model proposed



Source: Adapted from Oliveira (2017), Parente *et al.*, (2017) and Jabour *et al.*, (2013)

Method

The research he was carried out with industries in the metal- mechanical sector in the states of Rio Grande do Sul and Santa Catarina. The execution of the same he was made from the approach quantitative (HAIR JR *et al.* 2017; MALHOTRA; BIRKS; WILLS, 2012). As to the design , was applied one type search *survey* . The *survey* was used for the purpose of measuring the opinion of the industries , identifying which are the main ones. affinities between P+L and ME practices , and how greatly They are related in an indirect and practical way . The study is of a... descriptive , as it refers to a content this nature , to describe the variables latent in studies by Hoyle (1995) and Hair *et al.* (1998), with regard to the use of equation modeling technique structural methods for estimating the relationship between variables .

According to Hair *et al.* (1998) , the use of equation modeling technique structural is more indicated in studies involving : (1) the likelihood of dealing with multiple relationships between variables , simultaneously and efficiently statistics ; and (2) a agility in estimating in an accessible way these relationships and provide the passage of a analysis exploratory to confirmatory . Following the reasoning of Hair *et al.* (2009), one should initially to analyze

critically the data “ analyze the averages, deviations patterns , asymmetries , and kurtosis for the variables , even they being composed of scales " Intervals ". In the tabulation of data and results Excel was used to organize you same ; SPSS 24 *software for analysis* The statistical *software* and AMOS 24 were used to develop the final model .

He was applied the sampling no probabilistic put convenience . According to Hair Jr et al. (2017), the elements or individuals in sampling studies put convenience they are selected based on your similarity presumed with the population and in your availability immediate . Generally , these elements they are customers of establishments commercials , allowing the researcher do contact with a large number of people in short time periods and below cost . Although sampling put convenience it is fast and cheap due to the easy Sample selection and data collection is difficult . to assess the representativeness of this sample. in in relation to the population .

Data collection and research instrument

The research It occurred between August and November 2020, having as characteristic of cross-sectional research - data collection took place in one specific time stage (CAUCHICK; MIGUEL; HO 2010). Sending the questions he was put email method for a population A sample of 260 industries . The data collection instrument was... adapted from Oliveira (2017) , in which the relationship between P+L, ME and performance environmental , economic and operational aspects , in a multi- factor study cases . Therefore , the scale tasked with consolidating the Likert scale from 1 to 7 ("1. Disagree") Completely "a" to "7. I agree." Totally .”) According to Hair et al. (2009) response scales allow bigger sensitivity in gathering information and in the scope of the phenomenon , as they prove levels more subtle and perceptible aspects of the respondent 's intention in in relation to each variable .

The collection via email was operationalized via *Google Forms* , whose message body electronics He explained what the research was and what it was. The intention of the same , including the identification of the researcher who sent it . The forwarding took place put three waves of remittances , between the months of August the October 2020, as per Table 1 .

Table 1 – Control of sending emails regarding participation in the survey .

Sending waves	Date of shipments	Amount	% based on number of shipments
1st wave	18/08/2025	70	27%
2nd wave	19/11/2025	120	46%
3rd wave	02/02/2026	70	27%
Total sample		260	100%

Source: Prepared by the authors (2022)

Of the 260 questionnaires sent , 107 returned put present addresses incorrect or put The problem is with the email provider , which represents 29% of the total population . Of the total population were 153 questionnaires were received , corresponding to a return rate of approximately 37% ,

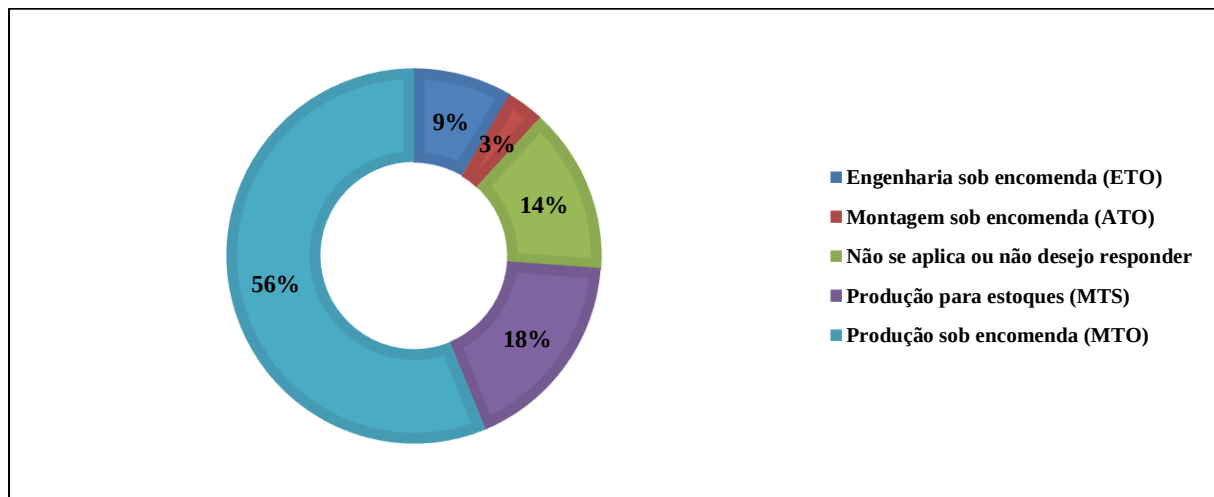
which were received until February 6, 2026; no there was presentation of *outliers*, as they are needed to answer the survey questions. All answers they were mandatory, totaling the Final sample of 153 cases. The questionnaire return pattern. he was markedly influenced by the number of contacts cultivated, according expected in literature by Schaefer and Dillman (1998), in this type of *survey*, response rate tends to be significantly elevated if the researcher Consider that: i) the rate of return is spontaneously adjusted to the number of contacts related to the respondent; ii) personalization of the invitation; iii) combination of data collection procedures. (SCHAEFER; DILLMAN, 1998; HAIR JR et al. 2017).

Discussion

As to the sample profile, composed by industries, it is explain that 93 (61%) use some manufacturing practices lean, 35 (23%) employ them fully and 25 (16%) do not use them. In the regard about the function of each respondent 42 (27%) are technicians, 30 (20%) are employees, 23 (15%) supervisors, 16 (10%) owners, 15 (10%) foremen, 15 (10%) managers, 8 (5%) wished If you do not respond, 4 (3%) are directors.

Regarding Regarding time with the company, 89 (58%) have up to 5 years old, 25 (16%) are 6 to 10 years old, 18 (12%) are 11 to 15 years old, 10 (6%) are over 21 years old, 7 (5%) are 16 to 20 years old, and 4 (3%) do not apply. or no I wanted to answer. The time that the The company operates in the metal- mechanical sector: 48 (31%) aged 10 to 25 years, 43 (28%) over 50 years, 36 (24%) aged 26 to 50 years, 24 (16%) less than 10 years, 2 (1%) not applicable. The classification productive industries also he was evaluated and it is represented in Figure 4.

Figure 4 - Typification main productive



Source: Prepared by the authors (2022)

Out of a total of 86 industries 27 operate with make -to-order (MTO) production, 27 produce for stock (MTS) production, 22 not applicable or no I wanted to answer, 13 custom engineering (ETO) and 5 custom assembly (ATO) .

Individual validation of the constructs

For the analysis of unidimensionality he was Analysis performed Factorial Exploratory , by component method main through rotation orthogonal Varimax for each of the constructs , by through maximizing the square of the variances of the factor loadings (MALHOTRA; BIRKS; WILLS, 2012). They were factor loadings found relevant in practically all variables , or that is , above 0.5 - which are considered acceptable (HAIR Jr. *et al.*, 2017).

In addition , there were made effective Bartlett's sphericity test and the Kaiser-Meyer-Olkin (KMO) test . The first of these indicated that the correlations they were significant to the One level was 0.000 and the other obtained a value of 0.910 . results join to the recommendations (HAIR Jr. *et al.* 2017; MALHOTRA; BIRKS; WILLS, 2012). Reliability he was determined through Cronbach's Alpha, indicating that all you values they are above the indicated levels by Hair Jr. (1998) of < 0.7, and of the variances explained , which remained above 0.5, which is the minimum value. As recommended by HAIR Jr. *et al.* (2017) , Table 2 provides a summary. of these results.

Table 2 – Sample reliability and variance indices explained for each construct .

Constructions	Variables	Factorial loadings	Variance explained	Cronbach 's alpha
Production cleaner P+L	Projprod1	0.857	77.05%	0.850
	Projprod2	0.916		
	Projprod3	0.859		
	Procprod1	0.749	63.21%	0.946
	Procprod2	0.837		
	Procprod3	0.771		
	Procprod4	0.855		
	Procprod5	0.819		
	Procprod6	0.707		
	Procprod7	0.675		
	Procprod8	0.824		
	Procprod9	0.810		
	Procprod10	0.849		
	Procprod11	0.805		
	Procprod12	0.817		
	Reut1	0.803	72.16%	0.807
	Reut2	0.879		

	Reut3	0.865		
	Recint1	0.837		
	Recint2	0.898	76.87%	0.849
	Recint3	0.894		
	Recext1	0.849	64.75%	0.720
	Recext2	0.767		
	Recext3	0.796		
Manufacturing Lean ME	Feedforn1	0.788	66.65%	0.872
	Feedforn2	0.837		
	Feedforn3	0.759		
	Feedforn4	0.854		
	Feedforn5	0.840		
	JITforn1	0.868	73.28%	0.809
	JITforn2	0.903		
	JITforn3	0.794		
	Desform1	0.816	58.66%	0.857
	Desforn2	0.744		
	Desforn3	0.756		
	Desform4	0.852		
	Desform5	0.719		
	Desform6	0.697		
	Envclie1	0.842	62.20%	0.870
	Envclie2	0.741		
	Envclie3	0.790		
	Envclie4	0.807		
	Envclie5	0.845		
	Envclie6	0.695		
	Prodpux1	0.799	62.70%	0.788
	Prodpux2	0.871		
	Prodpux3	0.838		

	Prodpux4	0.639		
	Fluxcont1	0.864	68.85%	0.883
	Fluxcont2	0.881		
	Fluxcont3	0.883		
	Fluxcont4	0.789		
	Fluxcont5	0.719		
	Setup1	0.883	81.84%	0.889
	Setup2	0.944		
	Setup3	0.886		
	Postal Code 1	0.802	68.39%	0.883
	CEP2	0.887		
	CEP3	0.840		
	CEP4	0.796		
	ZIP code	0.806		
	Envfunc1	0.854	78.60%	0.909
	Envfunc2	0.910		
	Envfunc3	0.886		
	Envfunc4	0.896		
	TPM1	0.872	82.37%	0.928
	TPM2	0.925		
	TPM3	0.911		
	TPM4	0.921		

Source: Prepared by the authors (2022)

In terms of validity convergent , were reliability assessed composite and variance extracted from each of the constructs . As presented in Table 3, the reliability values composite and variance extracted for everyone you constructs they are admissible . All you values they are superiors to the advised (HAIR Jr. et al. 1998; 2017).

Table 3 – AVE, reliability composite and variance extracted

Constructions	BIRD	Reliability composed	Variance extracted
P+L	0.551	0.949	92%
ME	0.580	0.972	51%

Source: Prepared by the authors (2022)

The P+L and ME construct presented AVE values above 5.00. However, these values they were accepted as demonstrated in Table 4. A stage descriptive study impacted in analyze the interactions between the variables put mid - cycles interactive, based on criteria constituted in Literature (HAIR Jr et al. 1998; 2017; RINGLE; DA SILVA; DE SOUZA BIDO, 2014; MALHOTRA; BIRKS; WILLS, 2012).

Analysis multivariate

Model Validation theoretical

The validation of the Theoretical Model was initially carried out by analyzing the quality of the model fit measures, the results of which are shown in Table 4.

Table 4 – Model Fit Measures Theoretical

Adjustment measures	Recommended	Values
RMSEA	> 0.05 and < 0.08	0.54
CFI	> 0.90	0.979
TLI	> 0.90	0.972
NFI	> 0.90	0.979
RFI	> 0.90	0.914
NFI	> 0.90	0.935

Source: prepared by the authors (2022)

Your results presented they were satisfactory. However, the model values they can vary very in as a function of sample size and simulations, too. They indicate that they obtained results acceptable for the model tested. The Indicators of good quality for the model proposed they were obtained in terms via AVE, reliability composite and *Cronbach's alpha*, both for the ME construct and for P + L.

Model structural

The model organized It was the reflective one, and for the phase confirmatory analyses were adopted interactive analyses of the estimations statistics such as AVE, Cronbach's Alpha and Reliability Composed, confronting them with the analysis phase. initial.

Examining the P+L construct, the variables observables projprod and procprod they presented higher loads. The variable procprod presented a charge of 0.88, and it is connected directly to manufacturing processes; while the variable projprod, which stands for product design, had a

load of 0.77. The return variable represents the reuse of some underlying material from the processes internal affairs, and had a load of 0.54; observing internal recycling (*reuinterna*) and external reuse (*reutexterna*) - the first being concerning the reuse of waste and residues us own manufacturing processes, while the second refers to the reuse of waste and residues in other manufacturing processes of the company itself company - both are significant, because internal reuse he had a charge of 0.63 and *reutexterna* a charge of 0.68.

In the ME construct, all loads were significant, the control process statistician (*contest process*) had a charge of 0.88 – which demonstrates control Rigid and systematic in the manufacturing process of industries. Employee involvement (*envfunc*) obtained a charge of 0.81; with regard to the Supplier development (*devform*) the value presented It was 0.82; the *Just In Time* supplier (*JIT supplier*) – which determines that everything must be produced, transported or purchased at the exact time - presented a charge of 0.81 - well such as TPM (*Total Productive Maintenance*), or maintenance total productive, which obtained a charge of 0.81 in which the approach is sought general on Equipment maintenance aimed at achieving production. perfect : i) without breaks ; ii) without small stops or bottlenecks ; iii) without defects ; ivi) without accidents .

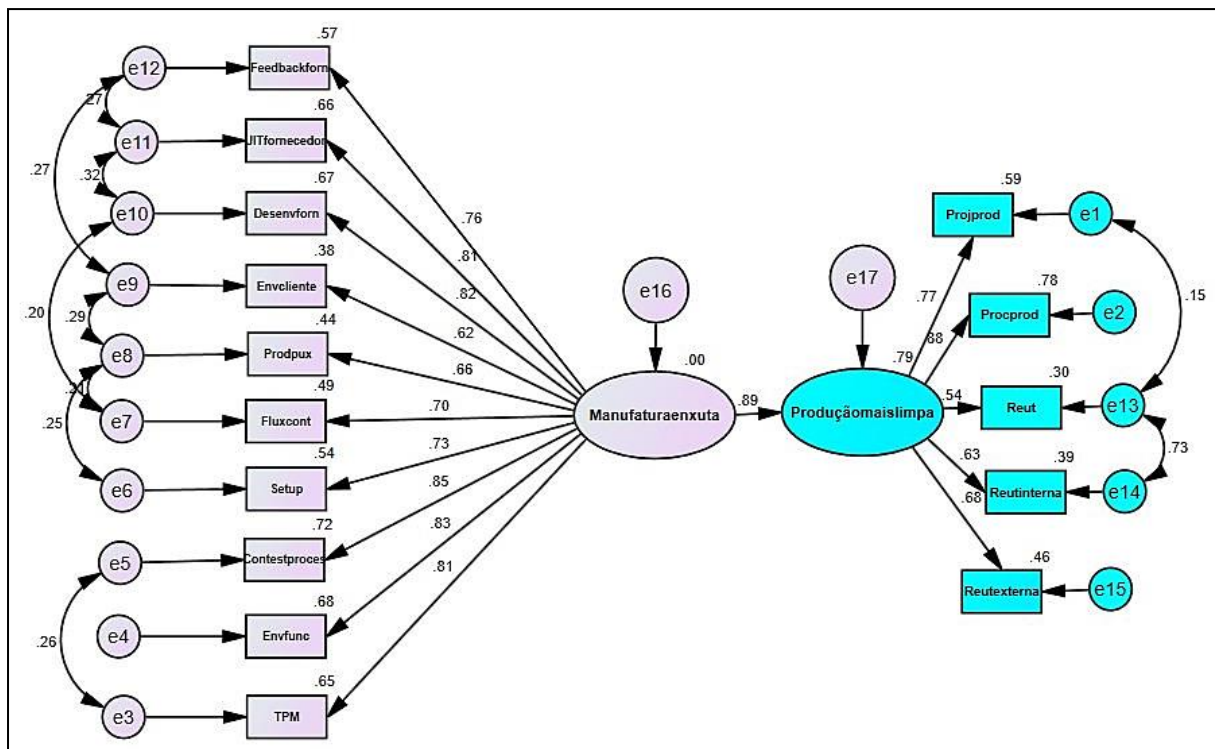
Feedback for suppliers (*feedbackform*) highlighted a load of 0.76, and leans towards performance, as the tendency is for the sense of competition. increase in the market, making it possible for prices to rise. be answered more slightly and there should be an effort to reduce delivery times for orders. The setup presented a load of 0.73, which assesses the time issues that the collaborator delay in make the tool change, if these they are below expectations, and if the equipment present Short setup time. The flow Continuous production (*fluxcont*) highlighted a value of 0.70, which addresses the classification. in groups according to processing needs similar, classification in Groups according to similar programming (sequencing) needs, equipment they are grouped together to produce in flow continuous one product family, product families They determine the factory layout and production rate. this Scheduled according to customer demand rate.

The production pull (*prodpux*) presented a load of 0.66 and evaluated the following Questions : Production is " driven " by the shipment of products. finished, production in the Workstations are " driven " by demand. current next Station, the production system is fully or exclusively pull and the use of Kanbans, boards or Cardboard containers for production control.

Customer engagement (*envcliente*) obtained a charge of 0.62 and verified the contact constant with the customers considering : the customers often visit our company ; the customers give return about our performance in quality and delivery ; the customers they are actively / directly involved in product offer current and future ; the customers share demand information current and future with some Department of Industry and Customer Satisfaction Research.

The ME variables presented values statistically significant within the model analyzed. An explanation for this. high significance level The statistical analysis of ME variables is due to the fact that these variables they were tested in research published in other studies for model validation theoretical, according presented in Figure 4.

Figure 5 - Equation Model Structural differences between ME and P+L practices



Source: prepared by the authors (2022)

Structural model between ME and P+L practices, illustrated in Figure 4, presents the second-order latent variables, or that is, it presents the practices of ME and P+L. Remembering that these variables are composed of the variables manifest or observables. From this model it is possible to extract the following main notes: there are strong relationships between ME and P+L practices, a charge of 0.89; which is what Hair recommends. *et al.* (2017) and Malhotra; Birks; Wills (2012) state that the values that are equal or greater than 0.500 are statistically significant.

Considerations finals

The objective of this work is to answer whether manufacturing practices lean are dating positively with the adoption of production practices cleaner, in industries in the sector metalworking he was achieved; revealing that the manufacturing lean influence production is at 89% cleaner. P+L is strongly influenced by ME practices with regard to the shocks environmental relevant to the resource consumption (resources) natural resources, energy, water, inputs, materials cousins, etc.) and in waste generation (viewed as waste). Therefore, Manufacturing Lean, which is geared towards investigation of effectiveness on the factory floor, also this engaged in question environmental. Our search showed that, despite the manufacturing objective being the factory floor, this has anxieties more extensive, allusive also to the industry and the entire value chain.

Regarding ME, the principles lean they were extremely significant. Considering the control the process statistician with the highest loading of 0.85, this shows that the issue of quality this very present in industry and is evaluated through graphs specific to the "CEP", according to the

position of the samples, in affinity to the lines limits. The research corroborates with studies involving the themes of ME and P+L.

Finally, ME practices do not they are obstacles of order technical and operational for the P+L learnings in industries. It is possible harmonize and systematize them, smoothly, while point that the possible compensation be equalized with the change organizational structure of the industry, by training method in training sessions with management and the collaborators. An improvement program continuous, with certifications in quality area and in area environmental, which would support ME and P+L practices.

Limitations of the study and research future

As to the limitations methodologically, it is imperative to emphasize that the number of 153 respondents he was one limitation where there were 45 questions in Hair Jr *et al* . (2017) recommends a *survey* of 5 to 10 respondents put question.

Because this is a simple cross-sectional study, the sample size is restricted. It lies in the fact that it refers just to the sector metalworking, with a focus in the industries. The scope geographical research he was limited the industries in Rio Grande do Sul and Santa Catarina, this he can to have caused some Bias. The implementation of research with samples. probabilistic more extensive would be a way to mitigate these two limitations, which may originate results different. For research future the application of case studies, after model preparation structural quantitative obtained, could to supply results more in-depth and specific. It is also recommended studies comparisons between regions demographics, countries, service sectors, etc ...

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