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PEU method: An analysis of its applicability and implementation limitations in Brazilian companies

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Abstract *— This study analyzes the intellectual production on the PEU Method in the last 20 years and seeks to identify the main characteristics related to the applicability and limitations of the PEU method in various national economic sectors. Consists of a revisionist study on the evolution and use of the PEU method in Brazilian companies, developed through the analysis of empirical studies published on the subject. analyzes are performed using descriptive statistics. The research results confirmed that the implementation of the PEU Method was possible in all economic activities (Bibliographic Portfolio) analyzed, whenever used in environments related to production, and that its implementation provided important information for management control. The relevance of the study is based mainly on the new economic contexts and the evolution of production processes, where the costing methods traditionally used have been shown to be inefficient in generating useful information for decision making.*

I. INTRODUCTION

In the process of management, control and measurement of results, accounting has always sought to adapt to market dynamics and new needs and informational speed, changes that resulted from the development of innovative and relevant practices for management and cost accounting.

Thus, cost accounting, which initially emerged for the evaluation of inventories and calculation of the result, was improving and started to be used also in the management field, helping control and decision making (Abbas et al., 2016).

With the emergence of a new production system composed of multiprocessor companies in an increasingly complex environment, with shared costs, the costing systems, which were originally concerned with distributing direct and indirect costs to the products and services originated, began to prove inefficient in the process of measuring and comparing production costs.

In this context, new methodologies emerged with relevant approaches that foresaw the use of equivalence methods to measure production in multi-producer companies (Bornia, 2010; De La Villarmois & Levant, 2007; Levant, 2001). Among such methods, the Time-Driven Activity-Based Costing - TDABC, the Unité de Valuer Ajouteé - UVA and the Method de Georges Perrin - GP can be found in the literature, the latter being a precursor in Brazil of the Production Effort Units method. – PEU, which aim to enable a single comparison of production, regardless of the items produced in terms of variety and quantity (Ferrari & Borgert, 2015). Later, in view of the limitations of some costing methods, the

literature began to show evidence of the need to use hybrid models that contain more than one costing methodology.

The emergence of new costing methods, understood as something inherent to the evolution of organizational reality, has still encountered some barriers in their use, such as their applicability, limitations, doubts about compliance with tax legislation and especially, the habitual use of traditional methodologies.

Some studies have tried to mitigate these factors, some comparing the applicability of costing systems (Wernke et al., 2019; Abbas et al., 2016; Wernke et al., 2015; Machado et al., 2006), evaluating its applicability in conjunction with other methods (Kremer et al., 2012; Silva et al., 2009; Sabadin et al., 2007) and verifying the adequacy of costing methodologies to tax legislation (Schultz et al., 2012).

However, it is noted that the amount of research on the use of the PEU methodology is still very limited when compared to other costing methods, such as ABC costing (Zanievicz et al., 2013), making it a very promising field in terms of research opportunities(Ferrari & Borgert, 2015), mainly regarding its applicability and implementation possibilities in different economic sectors.

Thus, in order to contribute to the literature on equivalence methods, this study aims to investigate the main similarities related to the applicability and limitations in the process of implementation or execution of the PEU method in Brazilian companies. The analyzes were developed from research with a qualitative approach carried out through the review of a Bibliographic Portfolio (BP) composed of 39 articles published in the main national cost accounting journals and congresses.

The relevance of the study is based mainly on the new economic contexts and the evolution of production processes, where the costing methods traditionally used have been shown to be inefficient in generating useful information for decision making.

At another point, the work is justified by the low representation of publications on the PEU in journals in the Accounting and Production Engineering areas (Wernke & Rufatto, 2019), where searches carried out with the descriptors “PEU”, “unit of production effort”, “units of production effort”, “equivalence models” and “equivalence methods” on the CAPES journal portal resulted in only 19 results (within a horizon of 20 years), pointing to a vast field of research opportunities, mainly due to the need for a better conceptualization of the method (Ferrari & Borgert, 2015).

Finally, this study hopes to contribute to a greater diffusion of the PEU method beyond the southern region of the country.

II. THEORICAL REFERENCE

Costing methods are sets of techniques – or models – used to determine the costs of products and services (Schultz et al., 2012) and, consequently, measurement of business results. There are several approaches for determining the costs incurred, where the literature has classified them as traditional or contemporary.

Among the traditional methods, Johnson & Kaplan (1987), Brimson (1996), Kaplan & Cooper (1998) and Megliorini (2012) mention Absorption Costing, Homogeneous Section Methods – RKW and Variable Costing; and as contemporary methods, the Costing per Production Unit - PEU, the Activity-Based Costing - ABC and more recently (in 2001), the Time-Driven Activity-Based Costing – TDABC (Abbas et al., 2016).

Accounting practice has shown greater preference for the use of Absorption Costing, ABC Costing and Direct Costing (Silva et al., 2009), with emphasis on the first. Although the literature points to criticisms regarding its use, mainly due to the low quality of the information provided when compared to other costing methodologies (Kaplan & Cooper, 1998) and its inefficiency for decision making , the Absorption costing has some advantages.

Among them are: being a method that meets fiscal requirements, its low implementation complexity when compared to other methods, having its applicability increased as the proportion of indirect costs decreases, having increased applicability as the The number of products decreases, which tends to explain why the method is still the most used by medium and large companies in Brazil (Abbas et al., 2015; Frezatti, 2005).

Several factors may have contributed to the preference for using Absorption Costing in financial accounting, among which the literature points out (i) the divergent understanding of concepts and terminologies, (ii) the tradition of its use and (iii) the scarcity of studies on other methods for tax purposes (Schultz et al., 2012).

As for the first factor, the cost area has two distinct approaches: the managerial one, which provides information for planning and controlling costs; and the fiscal, which provides information for valuing inventories and determining the result.

It happens that this last approach, as it establishes that both direct and indirect costs must be allocated to the products and services produced or performed (Schultz et al., 2012), tends to appropriate some expenses that are not

directly related to its elaboration (or realization). This creates conflict with a series of concepts and terminologies that shape cost accounting, which is why it is common for there to be discrepancies between the results reported by management and fiscal reports.

As for tradition, until the 1970s, Brazilian accounting still had a discussion about the adoption of two costing methods, Absorption Costing, which allocates both direct and indirect costs to products and services; and Variable Costing, which allocates only variable or direct costs to products and services, treating indirect costs, even if linked to production, as expenses for the period (Schultz et al., 2012).

With the enactment of Law No. 6,404/76 and Decree-Law nº. 1,598/77, Brazilian accounting was faced with new accounting and tax guidelines, especially with regard to the concepts of product costs (which, according to the rule, include both direct and indirect production) and control and evaluation of stocks. Due to the fact that it does not foresee the appropriation of indirect costs to products, Variable Costing became incompatible with the tax rules in force, Brazilian accounting chose to use the "only" method that met the legislation: Absorption Costing (Schultz et al., 2012).

It is important to note that tax legislation provides for the incorporation of indirect costs into products, but does not require the use of a specific method, that is, it does not require the use of Absorption Costing.

However, even after other costing methods were disseminated in Brazil (Contemporary Methods), the tradition and preference for the use of Absorption Costing remained (Abbas et al., 2015; Silva et al., 2009; Frezatti, 2005).

Finally, there is the lack of studies on the use of other methods. The increase in competitiveness among global companies verified from the 1980s and during the 1990s, the growing demand for more accurate information in response to the problems generated by the continuous expansion of the proportion of fixed costs resulting from the modernization of industrial parks (Schultz et al., 2012) made other costing methods (PEU, ABC and TDABC) appear and started to be disseminated and used by management accounting. Although these methods bring managerial advantages and innovations, and make it possible to absorb costs (which makes them susceptible to use by financial accounting for the purpose of valuing product inventories and, consequently, the result for the year), as they were introduced in parallel with the Absorption costing (as it satisfactorily meets the needs of financial accounting), little has been invested in studies on the use of contemporary costing methodologies for tax purposes.

Following this line, the Brazilian literature in the area of costs, when it comes to analyzing and comparing costing methods, has prioritized comparisons involving the most known methodologies (Absorption costing, Variable/Direct and ABC), with little attention to other contemporary methodologies (TDABC and PEU methods) in terms of comparative studies (Wernke et al., 2019), although there has been an increasing use of these new models in companies. In this context, there is a need for more studies that explore the use, applicability and limitations of contemporary costing methodologies in business environments.

Finally, considering the fact that the ABC method is much better known and disseminated in the literature and in organizations than other contemporary methods, and because TDABC represents only a new approach to ABC, this work chose to investigate the only equivalence model proposed by the methodology. of the PEU, analyzing in a revisionist way its applicability and limitations in several sectors of the Brazilian economy.

2.1. Origin and Development of the Production Effort Unit – PEU.

Predecessor of the GP and UP methods, the PEU method had its emergence linked to the theoretical concept of unifying the measurement of industrial production through a single unit of measurement, the production effort (Sakamoto et al., 2001; Allora & Allora, 1995). It seeks, in short, to create a unit of measure common to all the company's products and processes (Wernke et al., 2013), able to quantify products of different natures as if they were the same (Silva et al., 2009), allowing to compare the degree of efforts needed to complete them (Wernke & Rufatto, 2019).

Its theoretical conception is based on the notion of production effort, that is, effort performed by a working machine, human effort, capital effort, applied energy effort and others directly and indirectly applied (Sakamoto et al., 2001).

In this way, the PEU is basically concerned with the transformation costs (Wernke et al., 2019; Bornia, 2010), based on 03 (three) principles: (i) Consistency of Relationships, (ii) Stratifications and (iii) Added Value (Allora & Oliveira, 2010), as shown in figure 01.

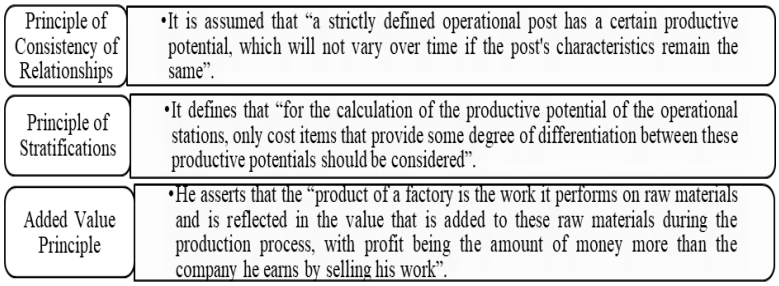

Fig.1. Characterization of the principles of the PEU method.
Source: Allora & Oliveira (2010).

Finally, regarding the PEU implementation process, the literature states that it occurs in six stages, as shown in Figure 02, which include the calculation of the factory's total production in the period in terms of PEUs.

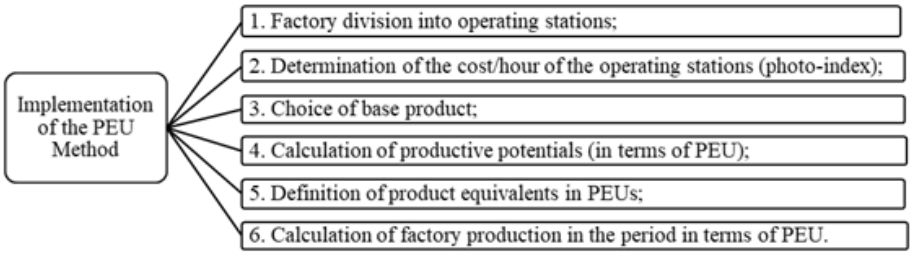

Fig.2. Implementation Steps of the PEU method.
Source: Bornia (2010). Adapted by the authors.

2.2. Characteristics of the PEU Method to be analyzed.

At this stage, some questions were formulated in order to make it possible to investigate, in a revisionist way, the applicability and limitations/difficulties of the PEU method in national companies.

First, it should be noted that the Production Units system deals with the introduction of a Production Effort Unit in the company, through which it measures the efforts of all productive activities in the factory (Allora & Allora, 1995). In this way, the PEU only works with the transformation costs (Bornia, 2010), tending to be applicable only to the industrial environment (Pereira, 2015). Thus, regarding the applicability of the PEU, it is expected to verify, in a revisionist way, whether it is also applicable to other economic segments, evaluating the following point:

Q1: Based on the BP, did the PEU prove to be applicable to other economic segments?

The implementation of the PEU method, according toWernke et al. (2019),Wernke et al. (2018), Guimarães Filho et al. (2016), Pereira (2015) and Souza & Diehl (2009) takes place in six phases: (1) division of the factory into operational stations; (2) determination of the cost/hour per operating station; (3) choice of base product; (4) calculation of the value of the PEU/hour of each operating station; (5) definition of product equivalents in PEUs and (6) calculation of total factory production in the period in terms of PEUs.

In this implementation process, the literature has alerted for greater attention to the first three stages, since the process demands the team's ability to analyze, due to the particularities of each company (Oenning et al., 2010) and the need to determine the base product, where the subjectivity of the method is (Malaquias et al., 2007). In this context, in order to evaluate the level of detail of the application of the method in the analyzed companies (BP), the following research question arises:

Q2: Based on the BP, did the studies consistently show the stages of implementation of the PEU method, with strong attention to the first three stages of implementation?

Evaluating the characteristics of the PEU methodology, its contribution to production management is noted. The method is useful for analyzing and managing production processes and evaluating performance (Martins & Rocha, 2015) and provides information on the use of productive capacity in terms of efficiency and effectiveness and productivity (Bornia, 2010; Biasio & Monego, 2005), making it possible to maximize production, manage physical constraints and analyze product profitability (Werne, 2012).

The definition of operational stations and the measurement of production in PEU's allow the generation

of indicators of installed capacity and idleness (Confessor et al., 2015), offering subsidies for carrying out simulations of scenarios (Nascimento, 2012), comparing its historical evolution. In this way, other questions for investigation arise:

Q3: Based on BP, did the PEU method provide relevant information for management control with regard to performance analysis (Efficiency, Effectiveness and Productivity)?

Q4: Based on BP, did the PEU method make it possible to perform scenario simulations, making the decision-making process more effective?

On the other hand, the PEU method is more applied as a costing tool that supports production management, providing better control and planning of manufacturing processes, cost reduction and, consequently, a more competitive sales price (Biasio & Monego, 2005). It is useful for evaluating performance, costing products and even setting sales prices(Martins & Rocha, 2015) and analyze and profitability of products (Werne, 2012). In view of the above, the following propositions arise to be tested on the applicability of the PEU in national companies:

Q5: Based on the BP, did the PEU method provide relevant information for management control with regard to the pricing issue?

Q6: Based on the BP, did the PEU method provide relevant information for management control with regard to the costing item?

Another point to be highlighted is that the PEU encounters problems with regard to the total cost of products, since it does not apply to the measurement of operations that are not directly related to the production process (Beuren & Oliveira, 1996). Thus, by working only with the transformation costs, it may present problems in defining the total cost of the products, which could be mitigated by the implementation in conjunction with other costing methodologies.

In this optics,Silva et al. (2009) and Beuren & Oliveira (1996) comment that for a Costing System to meet the needs of generating information in organizations, it is necessary to use a Costing Method or the combination of more than one of them. Thus, with a view to evaluating the possibility of integrating the PEU together with another costing methodology, the following question arises:

Q7: Based on the BP, have the studies proven the joint applicability of PEU with other costing methods (Absorption, ABC, TDABC, etc)? Which one(s)?

Analyzing the limitations/difficulties of use/application of the PEU method, the literature cites that, as it focuses only on the determination of the transformation cost, it is difficult to apply in companies that have a significant portion of administrative expenses (Werne, 2012). In this context, we have the following research question:

Q8: Based on the BP, did the PEU method encounter difficulties in use / application due to the relevance of administrative expenses compared to total expenses?

Other limitations of the PEU method include its high complexity and cost ofImplementation (Pereira, 2015), requiring a specific system to support the processing and data, in addition to not identifying the portion of costs associated with process losses. Therefore, we have the following questions to check:

Q9: Based on BP, did the PEU method present high implementation complexity?

Q10: Based on BP, did the PEU method present a high implementation cost, either due to the need to formulate usual procedures or due to the need for a specific system to support data processing and information analysis?

Q11: Based on the BP, did the PEU method present difficulties in the treatment of waste?

One of the foundations of the PEU methodology is the “principle of constant relationships”, which states that an operational post has a certain productive potential that does not change over time, as long as its characteristics remain constant (Kliemann Neto, 1994). Thus, the PEU presents difficulties of application in companies where the products vary regularly and needs constant revision of the calculations and the production structure (Pereira, 2015). In this way, industrial companies with production to order, whose products are NOT repetitive, where it is not possible to establish a common unit of measurement of production, are unable to use the PEU (Bornia, 2010).

Other limitations of the method reside in the difficulty of finding (determining) the relationships between the work required by the various products of the company and of measuring the production efforts, as it is an abstract concept (Bornia, 2010), and by the subjectivity present in the determination of the base product (Malaquias et al., 2007), although recent works indicate that, regardless of the base product chosen, there is no change in the final value allocated to each product in terms of unit cost of transformation(Moterle et al., 2020). In this context, the last questions to be analyzed are formulated:

Q12: Based on the BP, did the PEU method present difficulties arising from the preservation of the 'principle of constant relations' and the need for constant revision of the calculations arising from changes in the production structure?

Q13: Based on BP, did the PEU method encounter difficulties in using / applying the method due to product variability?

Q14: Based on BP, did the PEU method find it difficult to measure production efforts?

Finally, Appendix 01 presents a summary of the issues evaluated regarding the applicability and limitations of the PEU methodology in various sectors of the Brazilian economy.

III. METHOD

The methodology adopted in this work consists of a revisionist research on the use of the PEU method in Brazilian companies, developed through the analysis of empirical studies published with the theme "Production Effort Unit" between 2001 and 2020, available on the CAPES journal portal and in cost congresses.

As for the approach, it is a qualitative research with a descriptive approach, and seeks to identify the main characteristics and similarities related to the applicability and limitations of the use of the PEU method in various national economic sectors.

In the data collection stage, articles published in journals and in national congresses were selected. To this end, a systematic review was carried out in the Capes journal databases, especially the "Web of Science" and "Scopus", using the following search words: "unit of production effort", "PEU", " equivalence models", "equivalence methods" and "hybrid costing", being necessary that, in the process of searching in the journals, these words were found either in the title, or in the abstract or in the keywords of the studies related to the topic.

As a cut-off criterion, only national case studies that dealt with the PEU theme published in the last 20 years (from 2001 to 2020) with an empirical approach were selected. The choice of empirical national studies was due to the fact that its purpose was to be able to review and evaluate the evolution of the use of the PEU method in Brazil and other characteristics such as applicability and limitations in the national market.

The preliminary survey provided an initial base with 65 works, including 46 case studies, which were filtered in order to parameterize the Bibliographic Portfolio (BP) to be analyzed, resulting in 39 distinct economic activities composed of 19 works published in several national magazines, 14 works published in the Brazilian Congress of Costs, 02 works published in the International Congress of Costs and other 05 works presented in events.

Once the BP was defined, it was sought through the theory of measurement to attribute objective properties to the characteristics found in the analyzed journals. Thus, it was decided to map and measure the descriptive elements present in the text, using the measurement theory, transforming the observations reported in the texts into Nominal Scales.

In order to parameterize the criteria for measuring the applicability and limitations of the PEU method in various economic sectors, a research guide was developed to collect information, in an electronic form, where the authors, responsible for the interpretations, at the end of reading the journal they had to enter their perceptions in the collection form, following a Likert scale of options.

For the elaboration of the research guide (form) for collecting the information, a preliminary literature review on the topic was carried out (PEU method), generating an initial instrument with 39 investigation items. Then, the instrument was submitted to the analysis of 2 experts with solid knowledge in the PEU methodology for content validation, generating a final instrument with 14 investigation items, in addition to other items necessary to identify other characteristics relevant to BP, such as identification of the sector or economic activity analyzed, for example.

As it deals with the researcher's perceptions and interpretations regarding the content present in the text of the articles, one of the limitations present in this research was the evaluator's subjectivity regarding the interpretation of the item and its measurement. However, in order to reduce this limiting factor, the information collection script had a three-level response scale, detailed in Appendix 03, in addition to the option "not applicable", when there were no reports about a certain item studied. in the article.

Finally, once the information was collected, a descriptive analysis of the results was carried out, where it was possible to review the evolution of the applicability of the PEU method in recent years in Brazil, presented in the next section.

IV. RESULTS AND DISCUSSIONS

4.1 Results of the Analysis of the Applicability of the PEU method in national companies

The first stage of analysis focused on evaluating similarities regarding the applicability / use of the PEU method in the economic activities (BP) analyzed.

A preliminary analysis showed that, although the literature points out that the method shows a strong tendency to be applicable only to the industrial environment, the research results revealed the existence of its applicability in other economic sectors (especially in the service sector), as can be seen visualized in Figure 03,

especially when Transformation Costs represent the largest proportion of Total Expenses, as shown in Figure 04.

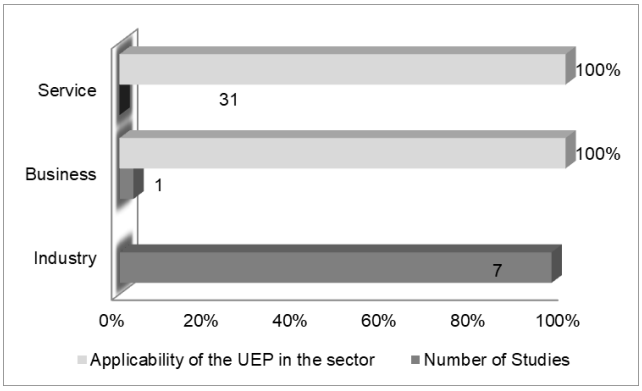

Fig. 3. Assessment of the Applicability of the PEU Method in other economic segments.
Source: Prepared by the authors.

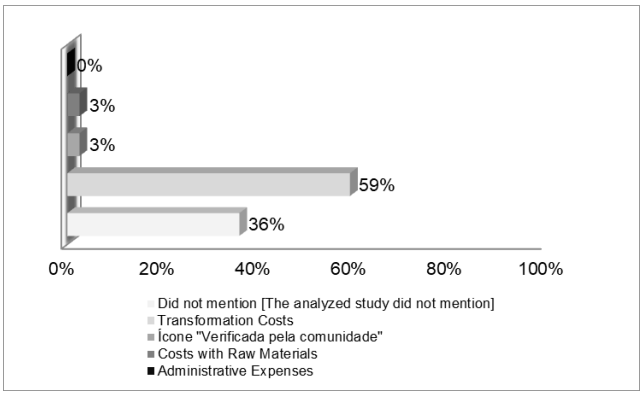

Fig.4. Breakdown of Total Expenses
Source: Prepared by the authors

As can be seen in Figure 03, there is a predominance of studies on the use of PEU in the industrial sector (31 articles or 79% of the BP), followed by the services sector (7 articles or 18% of the BP) and an insignificant number of studies that assess its applicability in commerce (1 article or 3% of the BP). However, all studies indicated its applicability (100%) in the analyzed economic sector.

In the analyzes referring to the service providers, the operational stations were replaced by "activity effort measures (MEA)" of each sector, enabling the implementation and application of the PEU method.

Another characteristic found in the research was that the enterprise analyzed in the "commerce" segment tested the applicability of the PEU in only one department of the company, the pizza preparation sector, as it has the desirable characteristics for the application of the method (transformation process).

Figure 04 complements the analysis by providing the relative percentage of the composition of expenditures on its total structure. It is noted that, of the economic activities analyzed, 59% have greater representation of transformation costs in their expenditure structure; 35.9% of the studies did not mention this composition; 2.6% have the three types of expenses in similar proportions and 2.6% have a greater representation of raw material costs.

None of the studies indicated the applicability of the PEU method in economic activities with greater representation of administrative expenses over the others, corroborating the theory. It is also worth mentioning the expressive proportion of studies that did not mention this composition explicitly or implicitly (35.9%), which makes a deeper analysis difficult.

Evaluating the consistency of the methodology implementation process in the analyzed enterprises and the applicability of the method in conjunction with other costing methods, this research found the following results (figures 05 and 06).

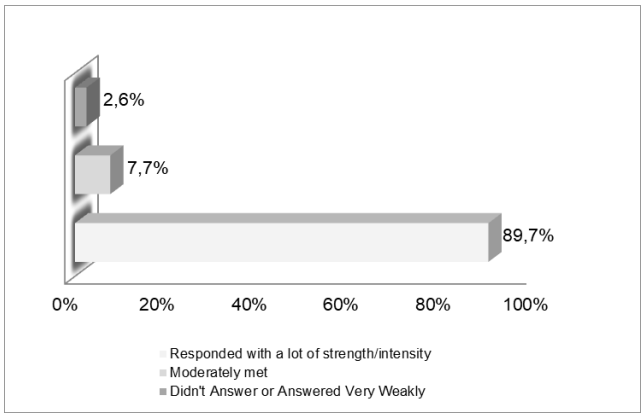

Fig.5. Evaluation of the consistency of the implementation steps of the PEU method.
Source: Prepared by the authors.

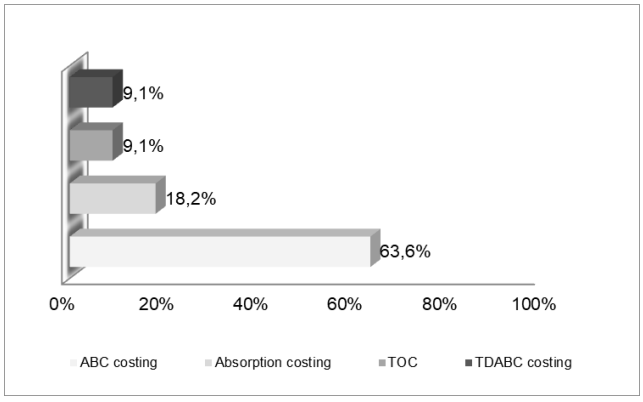

Fig.6. Assessment of applicability in conjunction with other costing methods.
Source: Prepared by the authors.

As can be seen in Figure 05, most studies (89.7%) consistently showed the stages of implementation of the PEU method, with strong attention to the first three stages of implementation; 7.7% presented them in a moderate way (without much emphasis or in a summarized way) and

only 2.6% did not give much importance to reporting or describing the implementation stages in the enterprise object of study.

The results obtained regarding the consistency of the stages of implementation of the PEU demonstrate the feasibility of future research in the segments included in this work (BP), with the possibility of replication in other segments, enriching the literature on the PEU Method.

Regarding the aspect of its applicability in conjunction with other costing methods, the results showed that 71.8% of the studies did not attempt to carry out this evaluation and 29.2% had this objective. Of this contingent, the results presented in Figure 06 show that 63.6% of the studies evaluated its applicability in conjunction with the ABC method; 18.2% evaluated its applicability in conjunction with Absorption Costing and 9.1% evaluated its applicability in conjunction with the TOC method or TDABC Costing.

In this way, it is noted that there is a greater concentration in studies that evaluate the use of the PEU in conjunction with the ABC Costing, and if we consider its new approach (TDABC), this percentage reaches 72.7%, all these contemporary methodologies of cost.

Evaluating the quality of the information generated by the PEU for the evaluation of business performance and simulation of scenarios, the following results were found (figures 07 and 08).

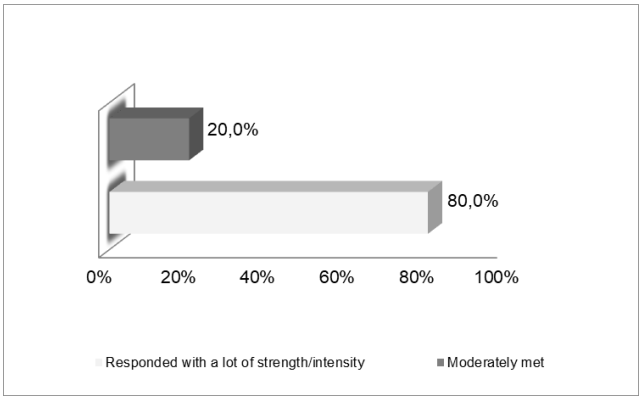

Fig.7. Assessing the applicability of PEU information for performance analysis.
Source: Prepared by the authors.

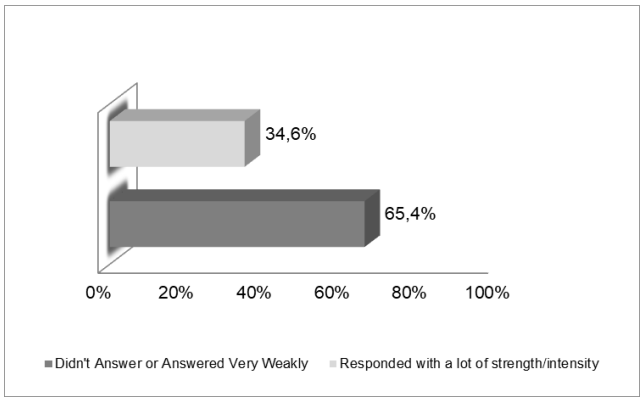

Figure 08. Evaluation of the possibility of performing scenario simulations.
Source: Prepared by the authors.

Regarding the aspect of information generated by the PEU for performance analysis, 23.1% of the studies did not attempt to carry out this evaluation. Of the works that were proposed (76.9%), presented in Figure 07, the results indicate that in 80% of the studies, the quality of the information generated by the PEU had strong applicability for the analysis of performance; another 20% pointed out that the information generated partially met.

The possibility of carrying out this analysis with the wealth of data from the calculations at the operating stations is one of the strengths of the PEU method and shows, in a substantial way, its importance for the management of the company.

As for the possibility of simulating scenarios, 33.3% of the studies did not attempt to carry out this evaluation and 66.7% had this objective. Of this contingent, figure 08 shows that in 34.6% of the cases, the studies reported that the implementation of the PEU made it possible to significantly simulate scenarios; another 65.4% pointed out that the information generated did not meet or met very poorly.

What was verified in the vast majority of articles was the analysis of data from a company with the authors' option of not simulating scenarios. That is, the focus was always directed to the data obtained in a given production process.

The results obtained regarding the analysis of the quality of information for the management of the sales price or costing of products/services are presented in figures 09 and 10.

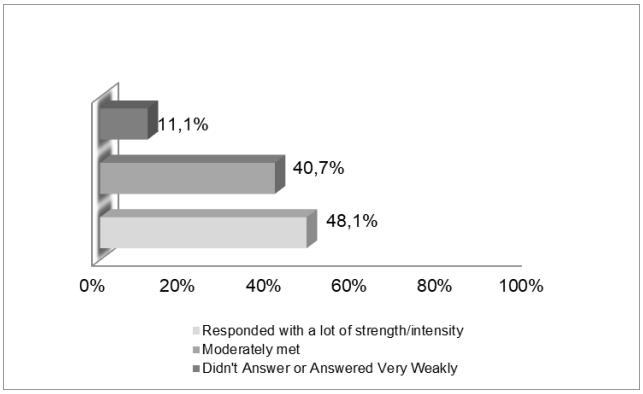

Fig.9. Assessment of the ability to generate information relevant to Pricing.
Source: Prepared by the authors.

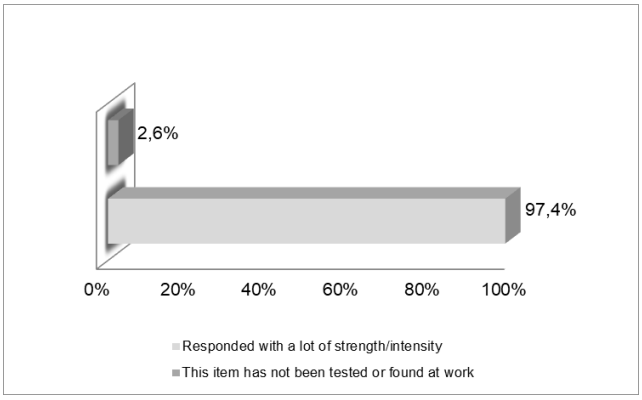

Fig.10. Assessment of the ability to generate information relevant to Costing.
Source: Prepared by the authors

The results obtained found that in 69.2% of the studies, the information generated by the implementation of the PEU was used for pricing (the other 30.8% did not analyze this item). Of this contingent (69.2%), figure 09 shows that 48.1% strongly complied with this requirement; 40.7% responded moderately and 11.1% did not respond or responded very poorly.

Analyzing the method's ability to generate information relevant to costing, the results presented in Figure 10 demonstrate that in 97.4% of the studies, the PEU method met this requirement very intensively and in only 1 case (2.6% of the sample) this item did not generate such information, since the implementation work could not be completed, as they were waiting for the availability of a database for management reports.

Finally, the results found related to these two items, Costing and Pricing, clearly demonstrate the wealth of information generated by the implementation of the PEU and its strong contribution to the decision-making process.

4.2 Results of the Analysis of Limitations / Difficulties of the PEU method.

The second stage of analysis focused on evaluating the main difficulties in implementing the PEU method in various national economic sectors. The results regarding the analysis of the level of complexity and cost of implementation can be seen in figures 11 and 12.

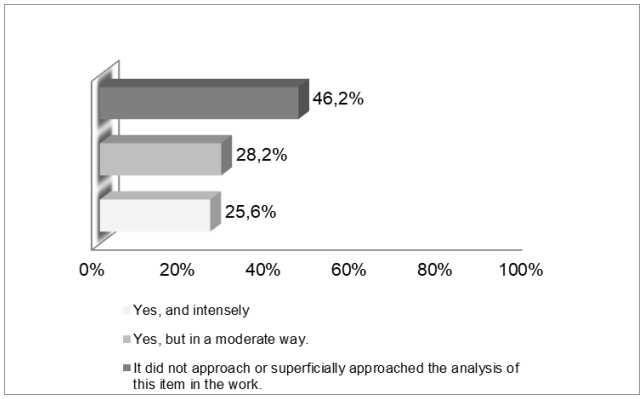

Fig.11. Assessment in the level of Complexity of implementation of the PEU in the analyzed companies.
Source: Prepared by the authors

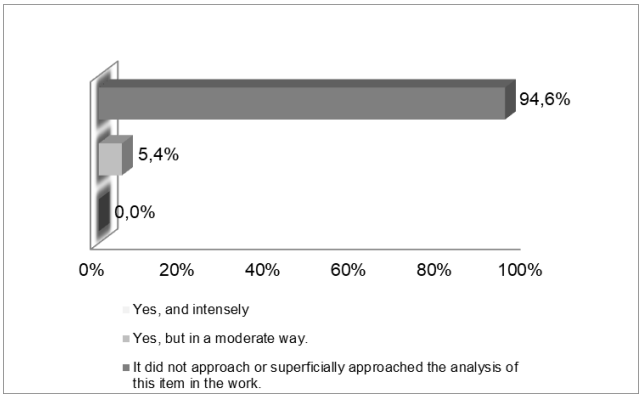

Fig.12. Evaluation of the cost of implementing the PEU in the analyzed companies.
Source: Prepared by the authors

Analyzing the results presented in figure 11, nNote that 46.2% of the studies did not or only superficially approached the analysis of this item in its scope. Of the studies that had this concern (54.8%), almost half of the studies (25.6%) indicated that the method had high implementation complexity in the studied enterprise and the rest (28.2%) indicated moderate complexity.

With regard to the cost of implementing the PEU (figure 12), most of the studies analyzed (94.6%) did not or only superficially approached the analysis of this item and the rest evaluated these costs as moderate.

It is worth noting that the disparity between the two results obtained: while the complexity in the implementation proved to be high or moderate in all the cases that addressed it, proving to be one of the main

difficulties for the implementation of the PEU method, mainly due to the need for measurement of the operative stations, on the other hand, the cost of this implementation was moderate, but with an unrepresentative sample (5.4%).

Despite this result found, this cost should not be discarded, as it is believed that implementation costs are proportional to the level of complexity, mainly because it requires greater qualification and experience of the professionals involved in these consultancies.

The results regarding the analysis of the need to formulate usual procedures or the need for software and its contribution to the treatment of waste are presented in figures 13 and 14.

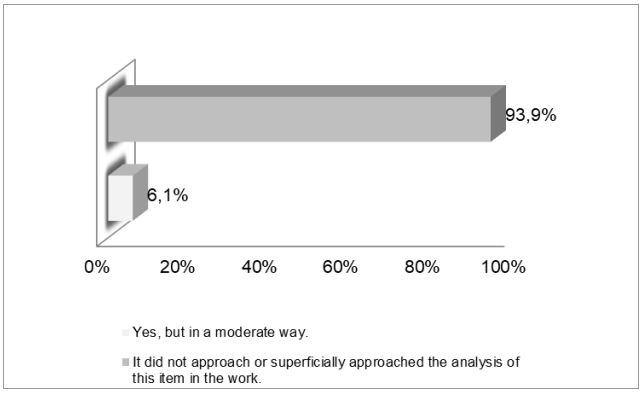

Fig.13. There was a need to formulate usual procedures or a need for software.
Source: Prepared by the authors.

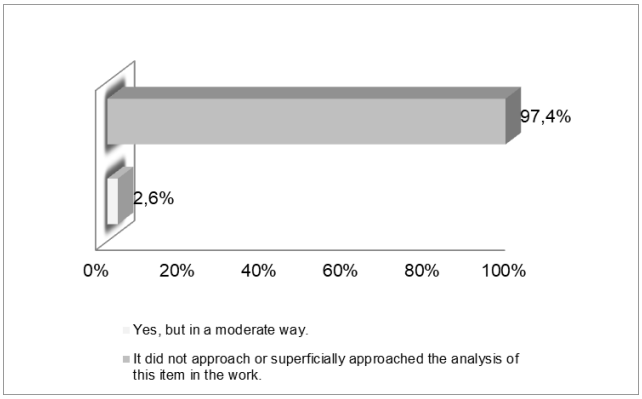

Fig.14. Assessment of difficulties in the treatment of waste.
Source: Prepared by the authors

Analyzing the results shown in figure 13, nit is noted that 93.9% of the studies did not address or superficially addressed the need to formulate usual procedures or the need for software for the implementation of the PEU method. Therefore, the spreadsheets used by the companies were sufficient for the implementation, not requiring a specific program.

Of the studies that addressed this topic, none reported a strong need for these items. Analyzing the need for waste treatment (figure 14), 97.4% of the studies did not address or superficially addressed this item in their scope.

Below we present the results of the evaluation of the difficulties arising from the preservation of the 'principle of constant relationships' and the use of the method due to the variability of the product (Figures 15 and 16).

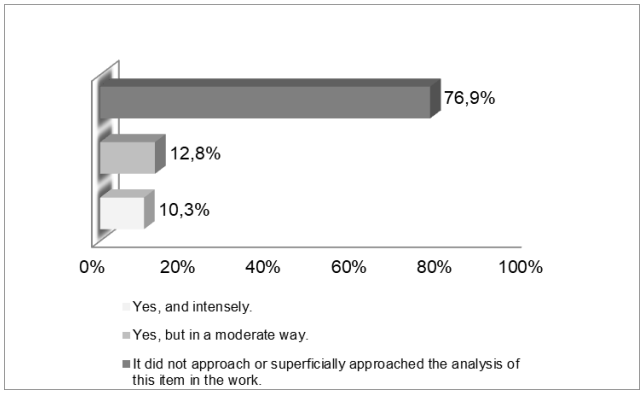

Fig.15. Assessment of the difficulty arising from the preservation of the 'principle of constant relationships'.
Source: Prepared by the authors

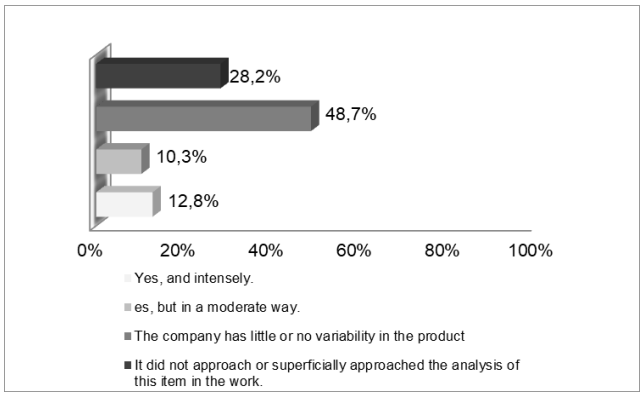

Fig.16. Assessment of the difficulty of using the method due to product variability.
Source: Prepared by the authors

Regarding the aspect of difficulties arising from the preservation of the 'principle of constant relationships' (figure 15), the results showed that 76.9% of the studies did not attempt to carry out this evaluation. Of those who evaluated this item, 12.8% found moderate difficulties and another 10.3% reported strong difficulties in the analyzed company.

Regarding the difficulties in using the PEU method in the analyzed companies due to product variability (figure 16), 28.2% did not address this item or approached it superficially and almost half of the studies (48.7%) indicated little or no product variability in the analyzed company. Of the studies that reported this difficulty, 12.8% showed moderate difficulties and another 10.3% indicated strong difficulties.

The fact that most of the companies studied had a restricted line of products caused the lack of difficulty pointed out regarding the preservation of the 'principle of constant relationships' and variability. However, it should be noted that these companies could have several products in their production line, but the authors chose to study only one specifically.

Finally, the study showed that, in general, the analysis of the limitations/difficulties of implementing or using the PEU method proved to be a vast field for further research, since most of the works analyzed did not or only superficially approached these items.

V. CONCLUSION

This article investigated, through revisionist research, the main similarities related to applicability and difficulties / limitations arising from the use of the PEU Method in national companies and institutions, based on the results of 39 articles (BP) published on the CAPES journal portal and other scientific platforms.

The main result of this article confirmed that the implementation of the PEU Method was possible in all the economic activities analyzed, whenever used in environments related to production, and that its implementation provided important information for management control. It also demonstrated the two ends of the implementation: the benefits and the difficulties, with the benefits being more evident due to the occurrence of several citations of several articles.

In the case of difficulties, a more thorough assessment was not possible, since most of the studies did not or approached the analysis of this item in its scope superficially.

In the analysis of the similarities in the application of the method in the analyzed works, the results showed a strong preference for using it to measure efficiency, pricing and costing, with this last item being the one with the highest intensity (practically all studies), reinforcing the wealth of information it can generate, especially when compared to that provided by traditional costing systems.

The main limitation of this research lies in the subjectivity of the authors' analysis, since the classification of “strong”, “moderate” and “weak” depended on the intensity of the presence of phrases and words throughout the text of the article. Even so, some conclusions presented indicate a high degree of precision because of the high recurrence of positive statements in the vast majority of articles, such as the confirmation that the PEU method is applicable in the production process of industries, services and commerce.

Likewise, the lack of citations of certain variables creates a great opportunity for future research, mainly related to the limitations and difficulties present in the method.

Finally, in view of the large concentration of studies related to the PEU method having been carried out by educational institutions located in the southern region of the country, it is believed that a wide dissemination of the method in other HEIs can contribute to increasing the number of companies studied. , meet specific demands from other regions or economic sectors and expand and enrich the literature, disseminating knowledge on the subject.

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APPENDIX 01

Summary of questions to be evaluated about the applicability and limitations of the PEU methodology.

Q1: Based on the BP, did the PEU prove to be applicable to other economic segments?	Q8: Based on the BP, did the PEU method encounter difficulties in use / application due to the relevance of administrative expenses compared to total expenses?
Q2: Based on the BP, did the studies consistently show the stages of implementation of the PEU method, with strong attention to the first three stages of implementation?	Q9: Based on BP, did the PEU method present high implementation complexity?
Q3: Based on BP, did the PEU method provide relevant information for management control with regard to performance analysis (Efficiency, Effectiveness and Productivity)?	Q10: Based on BP, did the PEU method present a high implementation cost, either due to the need to formulate usual procedures or due to the need for a specific system to support data processing and information analysis?
Q4: Based on BP, did the PEU method make it possible to perform scenario simulations, making the decision-making process more effective?	Q11: Based on the BP, did the PEU method present difficulties in the treatment of waste?
Q5: Based on the BP, did the PEU method provide relevant information for management control with regard to the pricing issue?	Q12: Based on the BP, did the PEU method present difficulties arising from the preservation of the 'principle of constant relations' and the need for constant revision of the calculations arising from changes in the production structure?
Q6: Based on the BP, did the PEU method provide relevant information for management control with regard to the costing item?	Q13: Based on BP, did the PEU method encounter difficulties in using / applying the method due to product variability?
Q7: Based on the BP, have the studies proven the joint applicability of PEU with other costing methods (Absorption, ABC, TDABC, etc)? Which one(s)?	Q14: Based on BP, did the PEU method find it difficult to measure production efforts?

Source: Prepared by the authors

APPENDIX 02

Works published in journals analyzed in this research.

Year	Author	Title	Field of Activity	periodical
2001	Lembeck; Wernke	Application of the PEU method in the enamel industry	enameled	Brazilian Congress on Costs
2001	Sakamoto; Allora; Oliveira	Improvement in management tools: the implementation of the UP' - production unit - at Seara Alimentos S/A	SEARA – Poultry, swine and industrialize products	National Meeting of Production Engineering
2005	Borgert; Silva	Hybrid costing method for cost management in a service provider company	Services provision	International Cost Congress
2005	Sabadin; Grunow; Fernandes	Integration of ABC costing with the UP method: a case study	Food sector	Accounting Universe Magazine
2005	Farias; Lembeck	Application of the PEU costing method in a small industrial company	uniforms	International Cost Congress
2006	Machado Borgert; Lunks;	ABC and PEU - an essay in a software company	Software Company	Brazilian Congress on Costs
2006	Oenning; Neis; Mazzioni	Calculation and management of costs by the production effort units method - PEU	Mattresses and foams	Brazilian Congress on Costs
2006	Zanin; Oenning; Cortina	Cost management through the Production Effort Unit (PEU) - Case applied to a	furniture	Excellence in Management and Technology

		furniture industry		Symposium
2006	Morozini; Gass; Carpenedo; Zuffo	Application of the PEU approach in a company in the manufacturing sector: a case study	wooden handles	S & G. Systems & Managem.
2009	Silva; Borgert; Schultz	Systematization of a hybrid costing method for the costing of medical procedures: a joint application of the ABC and PEU methodologies	Universitary hospital	Journal of Management Sciences
2009	Montini; Loyal; Mareth	Comparison between costing methods: productive effort unit (PEU) and traditional simple apportionment	Milk Processing Plant	Context (UFRGS)
2010	Novaski; Assunção	An application of value analysis in a manufacturing company through PEU.	Manufactur.	GEPROS
2010	Wernke; Mendes	PEU method applied in a small frame factory	frame factory	RC&C
2011	Kremer; Richartz	Development of a hybrid costing model for companies providing services on demand	accounting service provider	Brazilian Congress on Costs
2011	Luiz; Gassparetto; Schnorrenberger	Calculation of costs based on the Production Effort Unit Method (PEU): study in a cosmetics company	cosmetics	Brazilian Congress on Costs
2011	Kunh; Francisco; Kovaleski	Application and use of the unit of production effort (PEU) method for management analysis and as a tool to increase competitiveness	Fridge	Online Production Magazine
2012	Milanese; Salazar; Cittadin; Ritta	PEU costing method: a proposal for a poultry agroindustry	Poultry Agroindustry	Santa Catarina Journal of Accounting Science
2012	Souza; Figueiredo Junior	Determinants of the diffusion of the 'unit of production effort' (PEU) costing method in the textile industry of Ceará	Textile industry	Industrial Management Magazine
2012	Zonatto; Silva; Toledo Filho; Drebes	Use of the unit of production effort (PEU) method to determine the transformation costs of a bent glass industry for commercial refrigerators	Glass Industry	Industrial Management Magazine
2012	Belli; Andruchechen; Richartz	Structuring a hybrid costing system in a company providing forest harvesting services	Company providing forest harvesting services.	Brazilian Congress on Costs
2012	Wernke; Junges; Claudio	Non-financial indicators of the PEU method applicable to small industry management	electrical resistors	Iberoam. Journal Of Industrial Engineering
2012	Wernke; Mateus	Cost worksheet by the PEU method applied in a small animal food industry	pet food	Brazilian Congress on Costs
2012	Rocha; Pereira; Ritta; cittadin	PEU Costing Method: A Case Study in a Rice Processing Company	Rice processing	UFSC Congress of Controllership and Finance
2012	Nascimento	Measurement of production costs: Use of the PEU method in a case study	Metallurgical (parts for construction equipment)	UFSC Congress of Controllership and Finance
2013	Souza; Ferrari; Reis	Application of statistics in the distribution of weights for activities in the provision of telecommunications services	Provision of telecommunication service	Brazilian Congress on Costs
2013	Giasson; Pacheco; Camargo; Motta; Zanandrea	An application of the PEU method: case study in an automotive parts company	Automotive parts	GEINTEC Magazine
2013	Wernke; Lembeck; Junges; Ritta	PEU Method: Case Study on the Applicability in a Small Women's Clothing Factory	Women's Clothing	Iberoamer. Journal Of Industrial Engineering
2015	Fontoura; Cardoso	Costing method changes and the impact on the management information system: a qualitative study	food	CEPE studies
2015	Wernke; Junges; Lembeck	Comparison between PEU and TDABC methods: case study	Sewing (Outsourced Industrial Sewing)	Accounting Environment Magazine
2015	Confessor; Walter; Freires; Oliveira;	Application of the PEUS method for production management: a	bags and shoes	Tekhne and Logos

	Amorim	case study		
2016	Batista; Walter	Application of the PEUS method for the cost of a pizzeria	Pizzeria	Brazilian Congress on Costs
2017	Battini; Marian; Boff; Pletsch	PEU costing method: application in a continuous production system.	Mechanical metal	Brazilian Congress on Costs
2017	Vichinhesky; Bendlin; Ferreira; Ferreira	Costing Method PEU - Production Effort Unit: Case Study in a Ceramic Industry in the North Plateau of Santa Catarina	ceramics	Brazilian Congress on Costs
2017	Lacerda; Schultz; Walter	The applicability of the production effort units method in a bakery: evidence from a case study	Bakery	Systems & Management
2017	Carraro; Souza; Ribeiro; Freitag; Saints; Pinheiro	Combined use of PEU and TOC in a fitness industry	fitness equipment industry	Brazilian Congress on Costs
2018	Silva	Implementation of the PEU Method in a Small Palm Heart Processing and Packaging Industry in Northern Santa Catarina.	Palm heart processing and packaging	Brazilian Congress on Costs
2019	Wernke; Junges; Zanin	Measurement of factory idleness by the ABC, TDABC and PEU methods	Laundry	Contemp. Accounting Magazine
2019	Wernke; Rufatto	Adoption of a Single or Segmented Cost Spreadsheet by Factory Sectors: Interventionist Study on the PEU Method	clothing factory	Brazilian Congress on Costs
2020	Moterle; Wernke; Zanin	Influence of the choice of base product of the units of production effort (PEU) method on the unit cost of transformation	Refrigerator (Sausage)	Exact (Online)

APPENDIX 03

Response levels present in the survey script.

Tightly: Strong - clear indication of the proposition in the text, leaving no doubt of its importance for the article studied.

Partially: Partial - even if the proposition is not clearly informed in the text, through the result found, the authors of this article assume its importance for the article studied.

Weak / Null: Weak/Null - Did not address or superficially addressed this item at work.

Not applicable: This item has not been tested or found at work

Source: Prepared by the authors.