AN EMPIRICAL APPROACH FOR THE RELATIONSHIP BETWEEN LOGISTICAL PERFORMANCE AND LOGISTICAL PROCESS MATURITY

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ABSTRACT

Quantifying logistical operations' maturity and performance levels is a quite clear opportunity for a company to align its performance measurements and process improvement actions with its broader policies of strategic planning. The paper investigates the relationship between logistical processes maturity and logistics performance, with specific references both to the Business Process Orientation Maturity Model and to SCOR metrics. An extensive quantitative research carried out by means of a survey with 478 Brazilian Companies; the statistical analysis mixed up the use of descriptive statistics and the structural equation modeling (SEM). Building upon a bibliographic research effort on the subject, this article approaches the evolution of performance measurement systems, embarking from a traditional vision and changing into a more innovatory perspective by reporting on the origins of maturity models and presenting its main empirical contributions. The empirical results indicated a strong and positive relationship between process maturity and logistics performance.

KEYWORDS: Process Maturity, Performance, SCOR.

INTRODUCTION

In recent years, a growing amount of research, much of which is still preliminary, has been dedicated to investigating maturity model development and performance measurements for the strategic management of logistical processes in companies and supply chains (Chan and Qi, 2003; Gunasekaran *et al.*, 2001; Coyle *et al.*, 2003).

The concept of process maturity, including logistics processes, derives from the understanding that processes have life cycles or developmental stages that can be clearly defined, managed, measured and controlled throughout time. A higher level of maturity, in any business process, can be achieved if three conditions are respected: (1) better control of the results; (2) improved forecasting of goals, costs and performance; (3) greater effectiveness in reaching defined goals and (4) improving managements' ability to propose new and higher targets for performance (Lockamy and McCormack, 2004; Poirier and Quinn, 2004).

In order to meet the performance levels demanded by today's customers in terms of quantitative and qualitative flexibility of service in demand fulfillment, delivery consistency and reduction of lead times related to fulfilling orders, firms have developed repertoires of abilities and knowledge that are used in their organizational process (Day, 1994 *apud* Lockamy and McCormack, 2004). In the past two decades, logistics management processes has evolved, also because of these new demands, from a departmental perspective, extremely functional and vertical, to an organic arrangement of integrated horizontal processes, definitely oriented to providing value to intermediate and final customers (Mentzer *et al.*, 2001). This new pattern of logistical process management has focused on the development and application of different maturity models and performance metrics useful as support tools to help define a strategy and face trade-offs, as well as to identify items that are considered critical to improvement of logistical services rendered to a client.

The purpose of this article is to present the results obtained from quantitative research in Brazil that investigated both the maturity level of several Brazilian companies on its logistical processes and the relationship between process maturity and logistical performance.

This article is divided into four sections including this brief introduction. In section two, the origin of the Performance Measurement System concept is discussed. In addition, a leading maturity models is discussed; the Business Process Orientation Maturity Model. In section three, methodology and results are shown and analyzed. In section four, conclusions are presented, exploring the common characteristics and the main differences between the models, synthesizing the contributions of this article and suggesting hypothesis that should be investigated in future research about the theme in the field of corporate logistics.

THEORETICAL FRAMEWORK

Performance Measurement Systems – PMS – An introductory overview

According to Neely *et al.* (1995), one of the problems about performance measurement literature concerns its diversity. This means that each author has a tendency to focus on different aspects of the performance measurement system design. In spite of such diversity, in the field of operations management, a significant part of the literature tends to corroborate the hypothesis that the metrics of performance should come from the firm's production strategies and used to reinforce the importance of strategic variables and management of trade-offs in manufacturing.

Beamon (1999) highlights the characteristics found in an effective PMS, which can be used as a reference in evaluating measurements systems. These are: i) Inclusiveness – the possibility of measuring all relevant aspects; ii) Universality – the possibility of allowing comparison under many different operational conditions; iii) Measurability – the possibility of measuring required data; and iv) Consistency – the possibility of consistency between measures and organization goals.

Performance measurement systems are evolving from a system based on measurement and cost control – traditional PMS – to a system based on the measurement and creation of value by means of non-cost performance measures – innovative PMS – (De Toni and Tonchia, 2001); those whose nature is not economic or explicitly financial.

Within the recent developments of performance measurement systems, mainly related to the logistical process in supply chains, SCOR (Supply Chain Operation Reference Model) has gained great visibility in business and academic communities over the last few years. Due to the contribution made by SCOR to the evolution of different maturity models developed for supply chains, detailed information about some of its characteristics and functionality are presented in the next section of this article.

The SCOR model

The Supply Chain Operation Reference model (SCOR), created by SCC (Supply Chain Council) with the mission of facilitating supply chains across industries and benchmarking, contains planning, sourcing, manufacturing, delivery and returns processes and defines the process elements, metrics, best practices and technology used within each area (Bolstrorff and Rosenbaum, 2003; SCC, 2004).

The SCOR model also provides a “scorecard” framework for development of performance measures and goals. Figure 1 provides a simplified example of a scorecard that is constructed from SCOR performance metrics. The scorecard is used to define an enterprise business strategy, align the activities of the partners and to identify the business value that is obtained through the improvement in operations efficiency.

Scorecard				
Overview Metrics	SCOR Level 1 Metrics	Actual	Goal	Value from Improvement
Delivery Performance/ Quality	Delivery Performance to Commit Date	50%	85%	$20M
	Fill Rates	63%	94%	$10M

FIGURE 1: SCOR Card – Metrics Approach
Source: Supply Chain Council – www.supply-chain.org

The SCOR model emphasizes process orientation (a horizontal focus) and deemphasizes organizational or functional orientation (vertical focus). This means that the model focuses on the activities involved in the process and not on the professional group or organizational element that may execute such activity.

SCOR was designed and maintained to assist supply chains of diverse complexity from several industries. The purpose was not to determine how a group should manage its business or adjust its systems and information flows. Considering this, every organization that implements improvements using the SCOR model will need to adapt it to their specific process, practices and systems.

Maturity models and *logistical processes management*

A maturity model represents a methodology with components related to definition, measurement, management and business processes control. These have been shown to be very similar management approaches/concepts to BPR (Business Process Reengineering), thus attracting a growing interest not only by companies but also by researchers involved in this area (Chan and Qi, 2003; Gunasekaran *et al*, 2001). Although its origins are not directly linked to logistics, there has been a growing number of researches in recent years that represent the use of maturity models based on KPI – Key Performance Indicators – to analyze the activities from logistical supply chains to manufacturing and distribution itself. Those exploratory studies are expected to push forward a research agenda specially addressing supply chain management concepts and practices related to operational performance control systems (Chan and Qi, 2003; Gunasekaran *et al.*, 2001).

In the following section, a leading maturity model currently used by companies to analyze the performance of their logistical processes is presented. Specifically, the Business Process Orientation Maturity Model, developed by DRK Research (a group associated with North Carolina State University) will be examined.

The Business Process Orientation Maturity Model - BPOMM

The concept of Business Process Orientation suggests that the companies may increase their overall performance by adopting a strategic view of their processes. According to Lockamy and McCormack (2004), companies that strategically focus on their business processes reach greater levels of performance and have a better work environment based on high levels of cooperation and less conflict.

A very important aspect of this model is the use of SCOR to organize and classify the processes within a supply chain (Lockamy and McCormack, 2004; SCC, 2003). The SCOR model was utilized because of their process orientation and growing use among professionals and academics who are directly involved with supply chains and logistics.

The five stages of the maturity model depict groups of practices that are employed at different levels of process maturity producing increasing levels of supply chain performance. With each level of maturity comes increasing levels of predictability, capability, control, effectiveness and efficiency.

Ad Hoc, the model's first level, is characterized by poorly defined and non-structured practices. Performance is unpredictable and costs are high. At the second level, **defined**, SCM's basic processes are defined and documented. At the third level, **linked**, broad application of SCM principles occurs. The organizational structures become more horizontally oriented. Cooperation among intra-organizational functions, suppliers and clients, are represented by teams that share measures and common objectives within the supply chain. At the fourth level, **integrated**, the company, suppliers, and clients strategically cooperate on the processes' levels. Performance measurements for the supply chain are broadly deployed and collaboration is used to describe many activities. The process improvement objectives are assigned to teams and costs are drastically reduced. Client satisfaction, as well as team spirit, becomes a competitive advantage. Finally, at the final level, **extended**, competition is based in multi-organizational supply chains. Trust and auto-dependence build the support base of the extended supply chain. Process performance and trust in the extended system are measured. The supply chain is dominated by a client-focused horizontal culture. Investments in system improvements are shared, as well as the investment returns.

In summary, the model identifies the supply chain management activities that can improve a company's competitive performance. The maturity measurement questions are grouped into maturity variables which have precedence as indicated in the model of Lockamy and McCormack (2004). This provides a method for determining the maturity of an organization's supply chain processes and suggests appropriate next steps to progress to the next maturity level.

This section has presented the fundamental concepts of BPO maturity. The next section will outline the methodological roadmap used this empirical study. Instrument development procedures, pre-testing, data collection procedures and the statistical techniques (correlation and structural equation modeling) will all be discussed.

METHODOLOGY AND RESEARCH RESULTS

The approach to this research uses a survey based descriptive study of a quantitative nature using a sample of logistical professionals operating in a cross industry sample of Brazilian companies. An electronic survey was conducted between January and February 2006 using a very diversified sample composed of companies from many different economic sectors. This included manufacturing, construction, retail, graphics, mining, communication, information technology, utilities (gas, water and electricity) and distribution industries.

Instrument development

A specialized literature review on the subject of "performance management systems and maturity models" was first completed. Next, the model proposed by Lockamy and McCormack (2004) was used as reference for the development of 85 questions using a Likert scale of 1 to 5 (similar to earlier research using the model). The questions were translated into Portuguese by the researchers and the translations were tested using various test subjects. Adjustments were made as needed until the translations were deemed valid. Finally, the data collection instrument was constructed using PHP language and MySQL database and applied using the Internet.

Pre-Test, sample composition and data collection

Since this was the first use of the model in Brazil, the first phase of data collection was a pre-test used to validate the translated instrument and to calculate the recommended sample size for final data collection. The questionnaire was given to a group of 30 respondents representing companies from diverse segments. Translated questions were adjusted as needed based upon feedback from this group.

Using the data from this pilot sample, an estimate of the population variance was calculated using the maturity levels of each respondent. The calculation of the final sample used a reliability level of 95% and an error "E = 9,4". The pre-test standard deviation was 77,40. The recommended size for the final sample was then determined by using the formula below (Anderson *et al.*, 2002, p. 300):

$$n = \frac{(z_{\alpha/2})^2 \sigma^2}{E^2} = \frac{(1{,}96)^2 \, 77{,}4^2}{9{,}4^2} = 261 \text{ respondents} \quad [1]$$

With the recommend sample size of 261 respondents and the questionnaire and the instrument validated, phase 2 was begun. Two Brazilian associations - IMAM Institute and ABIGRAF, provided a list of respondents that participated in this research sample.

Data preparation

The first step in data preparation was analysis and treatment of the missing data within the returned surveys. Due to the length of the questionnaire, there was a real risk of unanswered questions resulting from respondent fatigue or skipping questions. In order to help reduce the possibility of missing data, electronic, automatic pre-processing of the questionnaires was built into the instrument. Additionally, as Hair *et al.* (2005) suggested, a simple solution for the missing data is to eliminate the problematic cases and/or variables for which the frequency of missing data was extreme. For the first level of purification, all the questionnaires that had more than 15% missing data were excluded from the sample. This resulted in 479 remaining surveys of the initial 534. Of the 479 remaining cases, only 17 still had missing data. More than 50% of these had up to 3 variables missing out of the 112 variables used on the analysis.

In accordance with Hair *et al.* (2005), when the missing data occurs under a random standard, steps can be applied to minimize its effect. In order to identify the random standard of the missing data, a t test was executed. This test evaluates the difference of the means between two groups in order to determine if the missing data patterns are random. The conclusion was that the occurrences were completely random making it possible to use substitution methods for the missing data (Hair *et al.*, 2005). Hair *et al.* (2005), one of more the widely used methods, uses mean substitution of the series to treat missing data. This approach was used to treat the remaining 17 incomplete surveys. The substitution by mean method substitutes the missing values for the mean value of that variable on the basis of all the valid answers. After the identification and treatment of outliers, one case was deemed problematic and removed. The final sample size was 478 valid surveys.

Using the 478 valid cases, variables for the constructs were generated. The maturity construct variable (McCormack *et al.*, 2003), M_Maturity, was generated using the sum of the 85 questions for each case. It is important to note that some questions appear in more than one category of the model. The M_Maturity variable was then used to evaluate the level of maturity for the sampled companies and test the relationships to performance.

Data analysis

Using descriptive statistics (frequency distribution) profiles of the respondents were examined. The first variable analyzed was the position of the respondents in the organization. 62,6% of the respondents in the sample held, at the time of this research, managerial or executive positions in their respective companies. For the function of the respondent, 20,7% were in Distribution followed by Planning and Schedule, Sales, Manufacturing and others. 49.2% of the respondents were from transformation industries, followed by transport, storage and communications, each with approximately 16%. For the location of the company, 50,4% were in in São Paulo. The rest were from the states of Minas Gerais, Rio Grande do Sul, Paraná, Rio de Janeiro and Santa Catarina.

After analyzing the demographics of the sample, the maturity of the companies, M_Maturity, was then examined. The sample had a mean of 323, with a standard-deviation of 72 points, which is very close to the standard-deviation in the pretest data. The distribution of maturity scores by maturity level, using the McCormack *et al.* (2003) model, suggests that the participants were mainly maturity levels 3 (44,4%) and 4 (40,8%), followed by level 2 (7,5%), level 5 (6,1%) and level 1 (1,3%).

Additionally, the performance scores for the main areas of the SCOR (Plan, Source, Make and Deliver) were examined next. This variable used a Likert scale of 5 points. All scores were deemed higher than 3,45 when compared to competitors. Although all performance means in the main areas of the SCOR were located between 3 and 4, when comparing the statistical difference between means by using t test (using a reference value of 3,59), the only mean that had a statistical difference was the Plan area. This result could indicate less of a focus of the companies on the planning function, compared to Source, Make and Deliver. When comparing their performance with their main competitors, 84.7% of the companies had rated their performance equal or superior in Plan; 89.1% equal or superior in Source; 87% equal or superior in Make; e 85.1% equal or superior in Deliver.

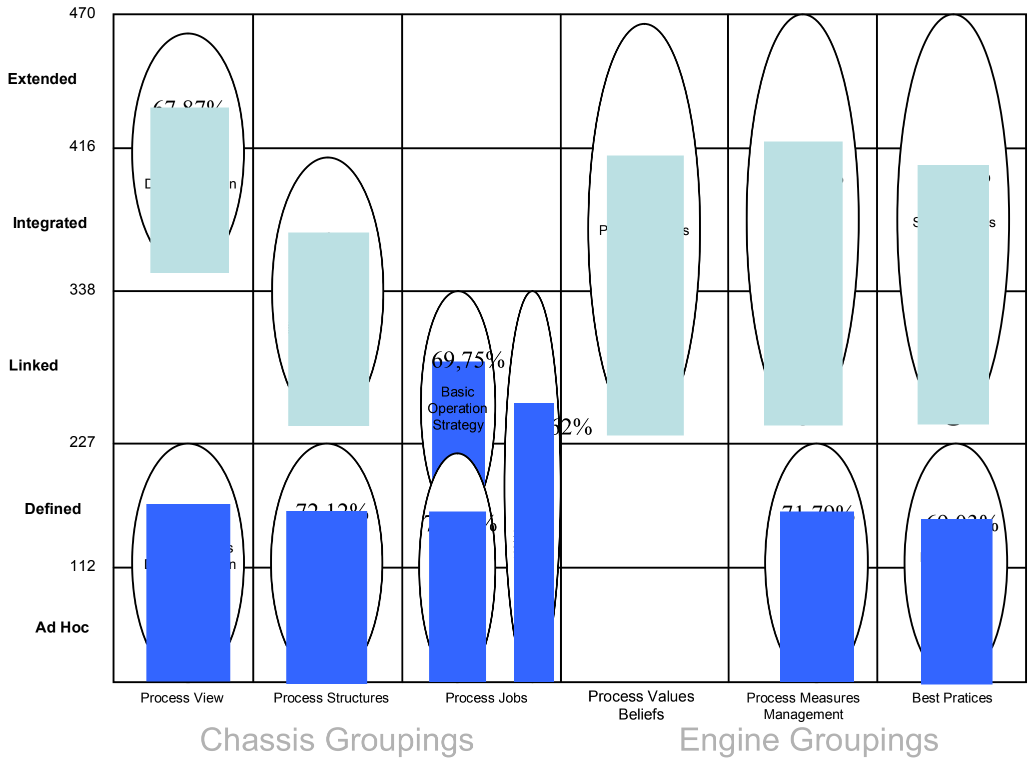

FIGURE 2 – Mean Percentage of Total Component Scores
Source: Research data.

Each of the twelve groupings of maturity model structural components (McCormack *et al.*, 2003) had an average score that ranged between 58,67% for Advanced SCM Practices and 74,76% for Basic SCM Practices. Considering the positioning of each grouping of components within each maturity level of the model, it is possible to conclude that, normally, the groupings of components located at the lower levels of maturity should have lightly higher averages than those located in higher levels of maturity. This illustrates a precedence or tendency for the companies to focus on its basic practices before the advance practices (Figure 2).

Correlation analysis between the performance and maturity constructs

In order to answer the research question developed in this paper, “What is the relationship between logistical (supply chain) planning process maturity and performance?”, test were run using the Spearman correlation coefficient, a non-parametric version of the Pearson correlation coefficient.

The test, based on the Spearman coefficient, is appropriate for ordinal data and or data intervals that do not satisfy normality constraints.

The results of examining the relationship between performance of the main areas of the SCOR with M_Maturity indicated a positive, strong and highly significant correlation in all cases. All correlations p-values were less than 0,001. The coefficients were: Plan 0,733; Source 0,639; Make 0,718; and Deliver 0,595. As review of the correlations between constructs indicates, the null hypothesis that considers an absence of a statistically significant association between the levels of maturity and performance can be rejected. The logistical (supply chain) planning maturity of the companies in the study and the logistical performance have a strong and positive relationship thus confirming the hypothetical model purposed in this study.

Interrelationship analysis with Structural Equation Modeling

In order to better understand the relationship between performance and maturity, the PLS algorithm was used. Partial Least Squares (PLS) regression is a multivariate data analysis technique which can be used to relate several response (Y) variables to several explanatory (X) variables. The method aims to identify the underlying factors, or linear combination of the X variables, which best model the Y dependent variables. PLS can deal efficiently with data sets where there are very many variables that are highly correlated and involving substantial random noise. PLS is primarily intended for causal-predictive analysis in situations of high complexity but low theoretical information (Jöreskog and Wold, 1982)

The test was applied according to SCOR areas using maturity as a formative construct composed of indicators of maturity for Plan, Source, Make and Delivery impacting the performance construct as a reflexive one created by overall performance indicators of Plan, Source, Make and Delivery areas. After running the PLS algorithm, the following the model converged at the eighth interaction cycle resulting in the weights and loadings shown in Figure 3.

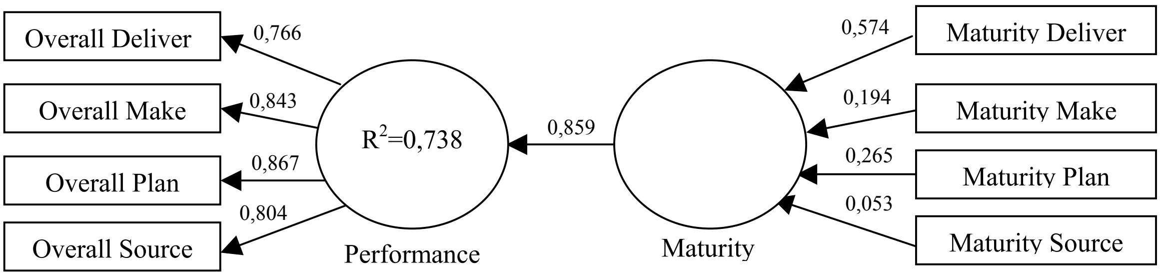

FIGURE 3: Maturity and Performance Results
Source: Research data

As presented in Figure 3, the result of analyzing the path coefficient – the correlation between the latent variables from the maturity and performance constructs – was an expressive value of 0,8592. This value corroborates previous research results showing a strong relationship between maturity and performance of the logistical processes (Lockamy and McCormack, 2004).

When the formative construct of maturity was examined, the Deliver area had a significantly higher coefficient than the others areas. These results suggest that maturity indicators for Deliver have a greater impact on logistical performance than the other SCOR areas. This might be explained by the major importance normally given by practitioners and academics to transportation compared with other activities belonging to the logistics supply chain function. The strong influence of Deliver activities can also be seen in the resulting equation for performance using the indicators for the maturity model construction:

$$\text{Performance} = \text{Deliver}(0{,}5741) + \text{Make}(0{,}1936) + \text{Plan}(0{,}2653) + \text{Source}(0{,}0535) + \xi \quad [2]$$

It is important to mention that, in spite the fact that this equation explains about 73,83% of the logistic performance results, it is proposed only to illustrate the weights of each SCOR area over the performance results.

Analyzing the quality indicators of the model (Table 1), it is possible to affirm that all results showed a very good adequacy of the scales used on the variables to represent the performance latent variables.

TABLE 1: Scale quality indicators for the performance construct

AVE	0,6741	Cronbachs Alpha	0,8381
Composite Reliability	0,8920	Redundancy	0,4971

Source: Research data

In summary, using these results, it is possible to state that there is a strong and positive correlation between maturity and performance of the logistic processes. Additionally, 73,83% (R Square) of the performance results can be explained by using maturity indicators. It means that if companies use maturity indicators in order to direct and measure improvement in its processes, it will generate a positive impact on logistic performance. This result also contributes to the use of maturity models in research on logistics processes by confirming the practical performance results acquired from its implementation and use.

CONCLUSIONS

Logistical processes, as well as other kinds of processes, demand management models geared towards actions resulting in improvement and measurement of results or impacts of these actions. It is very difficult for a company to develop efficient Logistical (supply chain) management processes without having logistical performance measured and controlled. Quantifying its logistical operations' maturity and performance levels using a maturity model represents an opportunity for a company to solidify and align its performance measurements and process improvement actions with its competitive strategies. This alignment gives the organization an opportunity to evaluate not only the degree of successful application of the strategies for logistical processes but also alignment with its broader policies of strategic planning.

From the point of view of corporate leadership, maturity models have broad application, in that they emphasize performance measurement and continuous process improvement in whatever process or activities involved. The maturity models are support tools for corporate leadership, specifically the leadership of the logistical processes, in terms of determining the actual stage of maturity, setting the goals for the next level of performance and identifying the items considered more critical to implement so that the companies can focus their resources.

One such emphasis could be put upon delivery process, as this variable has demonstrated on this research to have a much greater impact on the logistical performance than any other SCOR area. This result could be indicating that one explicit set of tasks related to this specific process may be in condition to generate important results on the overall logistical performance of firms. In other words: physical distribution continues to impact decisively logistics performance, but this accomplishment has to be rooted, in its planning procedures, in a broader sense, by recognizing the importance of managing properly the different trade-offs between activities and processes related to supply, production and distribution logistics cycles.

Future research

As a result of and as follow up to this research study, below are questions that may be explored in future research.

- What are the main barriers that must be overcome by companies when they decide to apply any maturity model oriented to the control and improvement of logistical process?
- Is there a precedence of improvement activities in a maturity model beyond the basic and advance categories indicated in this research?
- How can a maturity model be used as a standard to analyze different companies from the same branch or from the same supply chain?
- What are the costs involved in the planning and implementing of maturity models in the supply chain?

Answers to such questions can contribute significantly to the practical use of maturity models. Would maturity models be useful if there is no evidence that the concept of SCM itself is being effectively applied by a representative number of supply chains in any market? At the present time, there isn't a model able to properly synthesize all the complexities typically encountered in the management of logistical processes in the wider context of supply chains (extended supply chains or supply chain networks), although efforts are being aimed at improving and extending the individual performance evaluation systems of the companies into suppliers, distributors and customers.

Therefore, research is continuing on developing new and improved maturity models that can contribute to the principle of continuous improvement in a supply chain that is truly integrated across company boundaries. In the future, it is predicted that certifying a company's level of maturity, according to the level of their logistics process maturity, will gain relevance, similar to total quality and certifying professional and services of IT. In addition, as discussed by McComarck (2002), evaluating and certifying a supply chain network's maturity level will be a new frontier in the use of cross company maturity models. In this sense, it is gaining momentum the massive use of benchmarking and other different measurement systems geared towards the continuous improvement of planning, supply, manufacture and distribution processes, translated in more robust and imposing levels of process maturity for firms and supply chains.

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