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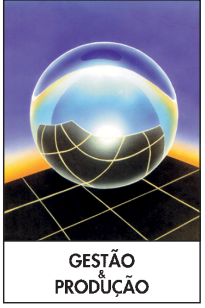

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Measuring Green Productivity: a proposal measure

Mensurando a Produtividade Verde: uma proposta de métrica

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Abstract: Green Productivity aims to ensure environmental protection by doing profitable business through a multidisciplinary, systematic and holistic approach, recognizing that the environment and development are two sides of the same coin. In this sense, the present study aims to propose a model for the measurement of the level of Organizational Green Productivity through the environmental problems generated by productive activities and the concern of organizations to align their productivity to environmental protection. This is an exploratory and bibliographical research. The proposed model allows, through calculation of productivity and environmental impact, to verify the situation of the organizations and their level in this type of productivity, being able to be classified as: high, medium and low, supporting the identification of measures that come to contribute to the improvement of this level.

Keywords: Productivity; Environmental responsibility; Measuring performance.

Resumo: *A Produtividade Verde visa a garantir a proteção ambiental ao fazer negócios rentáveis por meio de uma abordagem multidisciplinar, sistemática e holística, reconhecendo que o meio ambiente e o desenvolvimento são dois lados da mesma moeda. Neste sentido, mediante os problemas ambientais gerados pelas atividades produtivas e a preocupação das organizações em alinhar a sua produtividade à proteção ambiental, o presente estudo tem o objetivo de propor um modelo para a mensuração do nível de Produtividade Verde Organizacional. Trata-se de uma pesquisa exploratória e bibliográfica. O modelo proposto permite, por meio do cálculo da produtividade e do impacto ambiental, verificar a situação das organizações e o seu nível nesse tipo de produtividade, podendo ser classificado como: alto, médio e baixo, dando, assim, suporte para a identificação de medidas que venham contribuir para a melhoria desse nível.*

Palavras-chave: *Produtividade; Responsabilidade ambiental; Medição do desempenho.*

1 Introduction

In the last decades, the search for the different needs of individuals has been increasing, resulting in increased complexity in relations between organizations and society, directly reflecting the intensification of production volume and changes in production processes, especially in the need to improve levels Productivity.

In this context, productivity at the organizational level seeks to provide subsidies for organizations to face up to the competition in the competitive market and to make better use of their resources to be employed in the generation of goods and services. In this way, productivity is related to the efficiency of the organization in obtaining maximum results with the minimum effort or resources used. Therefore, it is a metric or indicator that can guide industrial managers how to better manage resource use (Moura, 2007). However, it should be emphasized that industrial managers should be concerned with improving business productivity from a more comprehensive perspective, in which they consider, in addition to maximizing and optimizing their resources, environmental prevention,

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since productive activities consume resources and Generate wastes / lifting that, if not properly managed and destined, are sources that generate significant impacts on the environment.

Therefore, in order to encourage this perspective and promote the preventive approach regarding the relationship between business productivity and the environment, the concept of Green Productivity arises, which extends the aspects considered by traditional productivity when considering environmental impacts and the consumption of resources within their approach. Green Productivity was established by the Asian Productivity Organization (APO), which initiated its Green Productivity Program in 1994, with the aim of increasing it through the minimum use of resources and the reduction of environmental impacts. Green Productivity has been disseminated in the Asian continent, where its methodology has been applied in the most different types of industry: cooking oil production; Car parts (Gandhi et al., 2006); Pepper production (Sittichinnawing & Peerapattana, 2012) among others.

Its applicability comes to ratify the need to use metrics so that it can be measured in the industrial context. In the pertinent literature to the measurement of this type of productivity, there are few studies with this focus, highlighting those performed by Kim & Hur (2003) and Gandhi et al. (2006) because they present metrics for measuring Green Productivity Focused on process and product, respectively. However, with regard to the measurement in the organizational scope, it was verified in these works the limitation of a measurement with focus only on the comparison and analysis of processes or products, without amplifying this perspective for the other aspects of the organization. Thus, the need for a metric that seeks to evaluate the organization as a whole is reasserted.

In order to do so, among the measurements of Green Productivity mentioned above the Kim & Hur (2003) works are highlighted. These authors demonstrate, through the Green Productivity Index (IGP), the inversely proportional relationship between productivity and environmental impact. According to Kim & Hur (2003), the higher the productivity of a process and the lower the environmental impact generated by it, its Green Productivity will be better. Taking an analogy to this assertion, one can consider that the Green Productivity of an organization can be measured by the inversely proportional relation between its productivity and the impact generated by its activities. Therefore, the higher its organizational productivity and the lower the environmental impact generated, its level of Green Productivity will be better. Considering this, the present study aims to propose a model for measuring the level of Organizational Green Productivity.

This study is justified itself by searching to fill the existing gap in the literature regarding the measurement of Organizational Green Productivity, as well as being a source of research in which the most diverse productive sectors can be contemplated, considering that measure of productivity is being a little disseminated in the national literature.

2. Theoretical foundation

2.1 Green Productivity

The term Green Productivity was created and used by the Asian Productivity Organization (APO). According to the APO, this is a strategy to improve productivity and environmental performance for global socioeconomic development. It is the application of appropriate management systems, technologies and techniques to produce responsible environmentally products and services. To do so, this concept started from the presupposition of integration improvement from productivity to development and environmental protection, in which productivity provides the framework for continuous improvement, while environmental protection provides the foundation for sustainable development.

Face of the concept of Green Productivity proposed by the APO, several authors sought to complement or synthesize it. In this sense, we highlight (Henson & Culaba, 2004), who consider it as a new paradigm in sustainable manufacturing, in which conservation of resources and minimization of waste are simultaneously the strategy of better environmental performance and organizational productivity. Meanwhile, Tuttle & Heap (2007) clarify that the definition of Green Productivity reflects the Asian view of productivity, which has always had a dual focus: business and its macro environment, which are contemplated by this type of productivity, since it involves a concern with focus on the customers (quality) to achieve the right balance between profitability and environmental performance.

Such authors brings as contribution the emphasis in the strong link between economic (productivity and quality) and environmental, showing that both aspects can not be focused in isolation, but seen in an interdependent way; beyond linking Green Productivity to the concept of sustainability through its contribution to economic, environmental and social dimensions. In the economic dimension, productivity reflects the reduction of costs and maximization of rentability. The environmental one considers the reduction of the environmental impacts and the consumption of resources of the system. The social reflects the concern in the generation of products and processes aimed at improving the quality of customers' life, in the community and society. In this sense, Green

Productivity has its essence focused on three focuses, as it is shown in Figure 1.

Figure 1 highlights that Green Productivity seeks to guarantee and extend environmental protection by making profitable business through a multidisciplinary, systematic and holistic approach, emphasizing teamwork and the application of appropriate technologies and techniques. So there is the recognition that environment and development are two sides of the same coin and that the concept of Green Productivity is based on environment, quality and profitability, which forms its triple focus.

However, with regard to the triple focus of Green Productivity, (Saxena et al., 2003) state that it distinguishes itself in three characteristics: Productivity improvement, environmental compliance and integrated approach. According to these authors, the improvement productivity is one of the side of the coin of the Green Productivity. In this perspective, Kaizen's approach in respect to continuous improvement is the basis on which this kind of improvement - achieved through the adoption of principles of the PDCA cycle (plan, do, check and act) - aims to ensure the Productivity improvement, not only for the purpose of programs of classic productivity improvement, but also seeking environmental improvement in a dynamic and interactive process.

Regarding the environmental compliance, it has been seen its essence is in the reduction of the waste in the generating source, since from the perspective of the Green Productivity one can understand the residue as an indicator of low productivity. In what concerns the integrated approach, this is one of the strong points of productivity in focus, referring to employee participation and the team perspective as sources of improvement of the work environment, worker health and safety. In view of the focus on Green Productivity, it is understood that its basis is in the context of manufacturing goods where productivity (producing more with less) is aligned with the reduction of environmental impacts, showing that the environmental protection is the result of the level of improvement of the organization's productivity. In this sense, it can be seen that such Productivity in organizations is established based on the relationship between these two pillars: productivity and environmental impact, conceptuated briefly below.

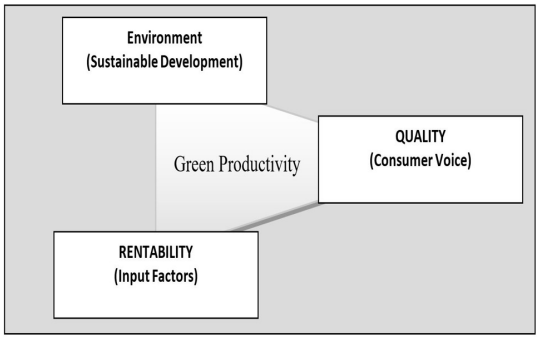


Figure 1. The triple focus of Green Productivity. Source: APO (2006).

2.1.1 Productivity

Nowadays, the survival and growth of organizations depend fundamentally on their competitiveness, which, in turn, must be achieved necessarily by improving productivity. In this sense, productivity is linked to the efficiency of a productive process, being this efficiency relative to the best or worst use of resources. According to Sink (1985), the concept of productivity is given to a physical production system expressed by the relation between what is obtained at the output and what is consumed at the input. In this same context, Contador (1998) defines productivity as being the capacity to produce starting from a certain quantity of resources, where productivity is measured by the relation between the level of production and the productive resources applied to it.

The classical concepts of productivity presented converge focusing on the productive process. However, the concept of productivity can be extended to a business perspective. To that end, Tangen (2002) states that several authors define business productivity as the relationship between inputs and outputs, that is, the relationship between the volume of production of the company and the volume of factors used in that production. These factors include not only those embodied in the production of a good, but all those that have been involved in the organization for the generation of production, such as labor, management expenses, among other factors.

Productivity is an indicator of performance; In this sense, it is important to highlight that it can be measured at three levels: operational, company and national. At the operation level, it reflects the Taylorist concept of increasing the productive capacity of the resources involved in an operation. At the company level, it reflects the relationship between billing and total costs. At the level of the nation, it reflects the concept of per capita income (Contador, 1998). For the purposes of the present study, the measurement of productivity at the organizational level stands out.

Productivity in an organization can be measured in different ways, and physical or monetary measures can be employed, as well as producing absolute or relative results. In this perspective, Garcia (2007) broadly outlines that productivity can be measured by the relation between the actual results of the production and the productive resources applied to it (or production / resources), such as: Tons produced / man-hour, kilograms / kilowatt-hours, tonnes of

soybeans / hectare (where year is implied for harvest), cars produced / employee-year, tons of steel / man year, etc. The author still clarifies that productivity can be measured for each resource singly, making it possible to evaluate the behavior and performance of each one or considering all the resources used to generate a given production (goods or services).

Within this perspective, there is a classic general formulation used to measure productivity in a given period of time and with a monetary focus. According to Campos (1999), productivity can also be monetarily defined as the quotient between the organization's turnover and the costs incurred to generate that income, as illustrated by Equation 1, where Pt means the productivity of the period; Ft the turnover in period t, and Ct the costs occurred in period t for the given billing

$$P_t = \frac{F_t}{C_t} \quad (1)$$

The contribution given by Equation 1 is the fact that it itself includes all internal factors of the company, besides emphasizing the customer as a decisive factor of productivity. Provided that the customer does not want to buy, however large the efficiency of the company, productivity will fall as billing fall.

The measurement of productivity is important because it allows the identification of production failures and their possible corrections, thus allowing the management of the industry to take mitigating measures. However, measuring the productivity through this perspective leads organizations to focus only on improving their production process, optimizing the use of their production resources and financial gains, forgetting that their productive activities are generating sources of significant environmental impacts. In this context it conceptualize itself the other construct of Green Productivity as follows: the environmental impact resulting from organizational activities.

2.1.2 Environmental impact

In the national context, the most relevant environmental impact concepts consider that the main characteristic of the environmental impact is not any change in the properties of the environment, but rather changes produced by the men and their activities in the constitutive relations with the environment that exceed the absorptive capacity of this environment (Moreira, 2002). For Sánchez (2011), the environmental impact can be caused by a human action that implies in the suppression or insertion of certain elements of the environment and overload.

In this perspective, it can be observed that, in general, the most significant environmental impacts are found in the industrialized regions, or, even more clearly, they come from the productive activities of these types of organizations. The industrial organizations generate environmental impact since their installation in a given geographic space until their possible deactivation. These impacts need to be quantified because they present negative variations, being large or small. For this, there are several methods of identification, analysis and measurement of environmental impacts. For (Oliveira & Moura, 2009), there are different methodological lines developed for the evaluation of environmental impacts, namely: spontaneous methodologies (ad hoc); Checklist; Matrix of interactions, networks of interactions (networks); Quantitative methodologies; And simulation models. Among the types of methodologies presented, the methodologies of listing stand out in the context of environmental impact assessment in industry organizations. This is because they allow a simple and objective evaluation. Among the methodologies of listing, it is possible to emphasize in this sense Analysis of Failure Modes and their Effects (FMEA).

The FMEA method has as main objectives the prevention of the most important environmental problems and the impediment or minimization of the consequences generated by the possible problems. Vandenbrande (1998) explains that the classical FMEA process can be easily adapted to a study of the potential risks of the environment. This is because when using a gravity scoreboard, the environmental priority number can be calculated in the same way as the number of risks. However, based on the Vandenbrande (1998) methodology, Andrade & Turrioni (2000) proposes that the FMEA be applied in the organizations to analyze the environmental aspects and impacts caused by their activities, and can be considered as ECO - FMEA.

The Vandenbrande (1998), as well as the Andrade & Turrioni (2000), bring the ECO - FMEA of foundation to several studies in the Brazilian context, regarding sectors and economic activities generating of significant environmental impacts, such as: machining (Martins & Zambrano, 2003); Microelectronics (Oliveira & Freitas, 2011); Fuel station (Costa & Freitas, 2012), among others. The application of this method in the cited studies demonstrates the viability of using the ECO - FMEA tool to analyze the environmental aspects and impacts of the industry. Finally, once presented the concept and focus of Green Productivity, hereafter it is discussed on its applicability.

2.2 Applicability of Green Productivity

The concept of productivity and its application methodology (APO, 2006) provided subsidies for several studies and applications. Based on this,it has been observed in literature the existence of several

empirical, theoretical and empirical - theoretical works. To that end, the theoretical framework identified shows that among the 19 works surveyed between 1999 and 2013, 26% are of a theoretical nature; 53% empirical and 21% theoretical-empirical. As far as the theoretical works are concerned, they have focused since the appeal for a perspective changing of conventional productivity perspective to Green Productivity, its linkage with business management and its tools (Bleischwitz & Von Weizsäcker, 1999; Suder, 2006) until the proposition of models to diagnose Green Productivity in the manufacturing process, in order to measure it, with the objective of verifying its viability of application (Henson & Culaba, 2004; Tuttle & Heap, 2007). Another important theoretical work, with a different focus on the others, sought to elucidate the difference between Green Productivity and another concept or similar tool, the eco-efficiency, mainly in the aspect related to the measurement way of both (Findiastuti et al., 2011; Singgih et al., 2010).

The theoretical works had as principal contribution to clarify the concept of Green Productivity and its implications in the organizational context, thus providing a theoretical basis for other research on the subject, that is, those of an empirical or even theoretical-empirical nature. In relation to the empirical studies, which represented 53% of the studies identified in the literature, these varied from case studies that seek to clarify the management of Green Productivity, to identify influencing factors in the implementation of GP practices, to link waste reduction in the context with productivity increasing (Logamuthu & Zailani, 2010; Mohanty & Deshmukh, 1999; Singgih et al., 2010). And studies aimed at evaluating, implementing and measuring of Green Productivity in industries and specific country situations (Cao, 2007; Lin et al., 2013).

In this sense, we highlight the use of Green Productivity with implementation in countries; Studies in communities and industries. At the country level, Green Productivity was applied for measurement purposes in the specific case of China's manufacturing sector, from 1991 to 2000 (Cao, 2007). In the community, GP was applied in order to minimize problems of sanitation and chemical use in agriculture (Hang & Hong, 2001). Regarding the implementations in the industrial sector, there is an application of the GP methodology in the cooking oil industry (Saxena et al., 2003); In the analysis and estimation of environmental loads related to the life cycle of beverage vending machines (Sampattagul et al., 2004); In the implementation to analyze resource consumption and evaluation of environmental pollutants in an aviation company (Moharamnejad & Azarkamand, 2007); And the use of a Green Productivity index in pepper production (Sittichinnawing & Peerapattana, 2012).

Empirical studies demonstrate the versatility of Green Productivity in the scope of its application, evincing an applicability in both micro (business) and macro (country level) contexts. As the main contribution of the empirical studies identified, it is possible to clarify how the environmental variable fits in the perspective of Green Productivity, evincing its importance and showing the aspects that must be taken into account in this context, such as: water consumption, Energy, environmental pollutants, environmental loads, use of chemical products, among others. The empirical work identified also addresses the economic focus of the GP, but links it to environmental aspects, thus gaining a direction for sustainable development.

As for the empirical theoretical works (21%), they are considered like this because they bring some contribution and theoretical innovation in the context of Green Productivity, at the same time as this contribution is empirically applied to prove its consistency. It was verified that these works are propositions and respective applications of measurement indexes of Green Productivity and implementation methodologies (Kim & Hur, 2003; Paranis, 2003; Gandhi et al., 2006; Avishek et al., 2008). These works bring as contribution the filling of the gap left by only the theoretical studies or only empirical. However, as a limitation of these works, it was verified that none presented a methodology that can be applied in organizations, in order to identify the current situation of a company studied from the perspective of Green Productivity and in which level of GP this one possibly will be found, In order to propose improvements to maintain or improve the level of productivity identified.

Finally, such a theoretical scenario demonstrates the need for more studies that mature and improve such a tool, especially regarding the measurement of Green Productivity. The following topic will expatiate in more detail about the measurement of Green Productivity.

2.3 Measuring the Green Productivity

The Green Productivity can be measured according to Findiastuti et al. (2011), in three levels: micro, macro and meso. In the micro context, the measurement of Green Productivity is inserted in a productive process or in an organization as a whole; With regard to the macro, it refers to a certain sector of the economy; And the meso, at the country level. Chart 1 shows the work identified in the literature that specifically

Chart 1. Identified works in literature related to the measurement of GP.

Author	Objective of the study	Contributions	Limitations
Kim & Hur (2003)	Present an index that is an indicator of Green Productivity and that allows to compare products, services and productive processes.	Theoretical and Empirical study. - Supply of theoretical basis for the measurement of Green Productivity from an index, the IGP (Green Productivity Index); - Define that the Green Productivity is the result of the inversely proportional relation between two constructs (productivity and environmental impact).	- Quantitative work that did not present, into the perspective of the GP, a qualitative analysis that would aid in the description of the productive process of the studied petrochemical company and in which the index was applied; - It considers only as constructs of the GP the productivity and the environmental impact, which have specific forms of measurement for its use in the IGP.
Hur et al. (2004)	To propose a measurement and improvement approach of the GP through the calculation of the IGP and RGP for the comparison of alternatives of Green Productivity in the process of manufacture of polystyrene.	Theoretical and empirical study - Development of theory and practice of GP metrics; - Provides base for researchers in thedefinition of GP indexes for calculation of Productivity performance in productive processes.	- From the perspective of the GP, a qualitative analysis is lacking to assist in the evaluation of a productive system; - The proposal is restricted to the IGP definition at the production process level. - It does not evaluate GP aspects at the organization level.
Sampattagul et al. (2004)	Analyze and estimate numerically the environmental loads related to the life cycle of the beverage vending machines.	Empirical study - Dissemination of the application of RGP metrics to evaluate alternatives that can minimize environmental impacts; - Use of GP to evaluate the reduction of environmental loads during the manufacture of a product.	- The applied methodology did not consider in the metric the economic aspects of the life cycle of the machines; - The proposal is restricted to the use of GP at the product level; - It does not evaluate aspects of the GP at the organization level, which could influence the environmental loads.
Henson & Culaba (2004)	It proposes to develop a diagnostic model for the quantification of GP in manufacturing processes through software as an intelligent support for decision taking.	Theoretical study; - It shows that GP generates opportunities to improve resource utilization and waste reduction in industry; - Integration of tools in the application of GP.	- Limited analysis to the environmental construct, lacking to incorporate economic aspects; - Application of the GP restricted to the production process.
Gandhi et al. (2006)	Application of IGP for the choice of product alternatives.	Theoretical and empirical - Adapting the model of Kim & Hur (2003) in order to use the IGP to compare products; Until then it had only been used to compare processes.	- Definitions of environmental impacts were restricted to only three variables; - Only production costs are included in the calculations; - Use of Green Productivity just to evaluate product, it does not involve aspects of the organization as a whole.

Source: Elaborated by the authors based in literature review.

Chart 1. Continued...

Singgih et al. (2010)	Apply Green Productivity to reduce waste and increase productivity.	Empirical study - Linkage of waste reduction (aspect linked to the environmental protection and reduction of resource consumption) to the productivity into the perspective of GP.	- Restricted results to the economic quantification of residues and their linkage with productivity; - Application of the GP restricted to the production process.
Sittichinnawing & Peerapattana (2012)	Calculate the IGP for the production of pepper.	- Implementation of IGP in agriculture; - It highlights and quantifies the productivity and environmental impacts to calculate the IGP.	- IGP applied only for the productive process.
Lin et al. (2013)	Measuring the Green Productivity in 70 countries in a period from 1981 to 2007.	Empirical study - The breadth of the studied countries allows the definition of a panorama in the studied period.	Difficult understanding of the quantitative methodology applied, due to the number of data presented.

Source: Elaborated by the authors based in literature review.

addresses the measurement of Green Productivity at these levels.

The work presented in Chart 1 shows the measurement of the Green Productivity at the micro level (almost all the identified works) and meso level (Lin et al., 2013). It should be highlighted that there were no studies applied to sectors of the economy, that is, the measurement at the macro level, that is, the one responsible for measuring Green Productivity in several companies in the same sector, thus being able to express the situation of these companies and, consequently, the one of the sector within the prerogatives of the GP.

In the studies previously listed, with regard to measurement at micro level, it was verified as a limitation the measurement of Green Productivity with a restricted objective of comparing or analyzing processes or products, without amplifying such results for the other aspects of the organization. This fact can lead to the mistake that a company that has a productive process or products that satisfy the prerogatives of Green Productivity is a company that walks towards sustainability through a high level of Green Productivity, since the organization is not only composed by process Productive and can not be evaluated solely by their product.

Within an organization, in addition to productive activities, there are numerous other activities that can be sources of environmental impacts and generate waste, which willing incorrectly may offer risks. Hence the need for a model that seeks to measure Green Productivity in organizations, which will fill the gaps observed in the work of Chart 1: lack of work measuring the Green Productivity in organizations and studies which are done in sectors. It is verified that the non-existence of this model leads to the application of the measurement of the GP only with focus on product or process, which generates the impossibility of studies that characterize the Organizational Green Productivity and, consequently, the most complete profile of a certain sector in reference to the Green Productivity.

In this sense, the present study seeks to propose a model that allows to evaluate the level of Green Productivity in organizations. However, for the elaboration of the model proposed in this work we opted for an approach for the measurement of the level of Green Productivity in organizations based on the main contribution of Kim & Hur (2003), in which presents that the GP can be given by Relation between productivity and environmental impact. It is worth noting that the present proposal is based on this relationship between productivity / impact and not on the applicability of the index proposed by these authors, obtained by the formula: GP = P / IA.

Finally, once the Green Productivity and its prerogatives for measurement are presented, the methodological procedures adopted to reach the proposed objective will be explained hereinafter.

3 Methodology

In face of the problem raised and the proposed objective, the present research is characterized as exploratory of the bibliographic type. Exploratory for its main purpose that is to develop, clarify and modify concepts and ideas in order to the formulation of a problem for study, besides exploring a theme still

under in construction and with a relatively low number of works carried out in the area (Hair et al., 2005).

Regarding the bibliographic survey is concerned, it was characterized by an orderly set of procedures to search for solutions of a given problem attentive to an object of study (Lima & Mioto, 2007). For Lima & Mioto (2007) the bibliographic survey has been used with great frequency in exploratory studies whose object of study is little studied, thus allowing a wide range of information, besides allowing the use of scattered data in numerous publications and also help in the construction or in a better definition of the conceptual framework that surrounds the object of study.

For this, the object of study defined for the bibliographic research was the Green Productivity and its forms of measurement. As a procedure, it was adopted the search for keywords in titles and summaries of databases made available by CAPES (2013) journals portal and Google Academic. The keywords used were: "green productivity"; "Measuring green productivity"; "Green productivity measurement"; And "green productivity index". As for the databases, the following interdisciplinary ones were chosen: Academic Search Premier (EBESCO), Elsevier, Springer, Annual Reviews, Wiley Online Library, Cambridge Journals Online, OECD Library, Oxford Journals, and Scielo. The articles were searched between 1992 and 2013. Altogether, nineteen articles were found, between theoreticals and empiricals, that served as a support for the description of Green Productivity and the proposal of the model for measuring the level of GP in organizations.

The nineteen papers found were analyzed and classified into three categories: theoretical, empirical and empirical theoretical. For each category the respective contributions and limitations were observed. Subsequently, the works related to the measurement of the Green Productivity were analyzed separately, aiming to identify the existing gaps in the measurement models found in this literature.

Once the limitations of the existing models were identified, the proposed model was developed, opting for an approach to measure the level of Green Productivity in Organizations based on the main contribution of Kim & Hur (2003) whose content shows that the GP can be given by the inversely proportional relation between productivity and environmental impact. It is worth noting that the present proposal is based on this relationship between productivity / impact and not on the applicability of the index proposed by such authors, as it already explicited aforementioned. In this way, it is presented, hereinafter is the construction of a metric for identification and evaluation of the Green Productivity level in organizations.

4 Proposed model for the measurement of the Green Productivity level in organizations

Green Productivity is the result of the inversely proportional relationship of magnitudes such as productivity and environmental impact. In this sense, it is noticed that the Green Productivity has its essence in the higher productivity and the lesser environmental impact. Therefore, the higher the productivity and the lesser the environmental impact, the higher the level of Green Productivity. From this perspective in regarding to the company as a whole, it is concluded that the level of Green Productivity in the organizational sphere is the result of the inversely proportional relation of the productivity of the company (organizational productivity) in a certain period of time and the environmental impact caused by its activities in this same period, being able to assume the following levels: low, medium and high.

From this perspective, the level of Green Productivity in organizations can be measured from the relationship between these two variables, calculated as detailed as follow.

4.1 Organizational productivity calculation

In order to calculate the productivity of the organization, the data analysis procedure adopted will be quantitative. In this sense, the productivity of the company should be calculated in the last 12 months, in order to allow an understanding of organizational productivity behavior over time and to identify its current level of organizational productivity.

The monthly productivity will be defined by Equation 1 in which Pt means the organizational productivity in period t; Ft, the organization's turnover in period t; and Ct, the cost incurred in period t to obtain the billing.

In Equation 1, the cost (Ct) will be obtained by the sum of the costs that the organization had in t for Ft, which includes costs of production; Costs of company administration and environmental costs. Making it clear that is considered as environmental costs all expenses directly or indirectly related to the protection of the environment and that will be activated based on their useful life, such as: amortization, depletion and depreciation; Acquisition of inputs to control, reduce or eliminate pollutants; Waste treatment of products; Disposal of polluting waste; Treatment for recovery and restoration of contaminated areas; Labor used in the activities of control, preservation and recovery of the environment; fines; Among others (Carvalho et al., 2000).

Considering that each type of organization has specific costs arising from its activities, these costs

should be identified through financial reports, balances, among others, and then classified and added together (with the help of Spreadsheet) in order to obtain the total cost (Ct).

Once the Equation 1 is applied to the 12 months, a productivity will be obtained for each month. For analysis purposes, the level of productivity considered by the company's planning, that is, the level of productivity that the company wishes to obtain in the respective period analyzed, is considered equivalent to 1. In this sense, in order to classify the monthly productivity of the organization into high, medium and low levels, it is necessary, through a simple three rule, to transform the productivities found in equivalent productivities, applying the Equation 2.

$$P_{(Equiv.m)} = \frac{\Pr m}{Pmáx} \quad (2)$$

where: $P_{(Equiv.\ m)}$ is the equivalent productivity of the month; Prm, the productivity of the month, that is, the actual productivity of the month m; Pmax, the level of productivity considered by the company's planning as ideal for the analyzed period.

In this sense, once the productivities are transformed into equivalent productivities - from the application of Equation 2 -, these will be classified as: very low, low, medium, high, and very high. This classification will be given on a scale of 0-1. It is worth noting that due to the linkage of organizational productivity to environmental impact from the perspective of Green Productivity, the five levels will be summarized in three, from the grouping of the two extremes, As shown in Chart 2.

Once calculated the productivity levels of the organization studied and its current level of productivity (productivity at month 12, classified according to Chart 2) is identified, we start with the calculation of the environmental impacts from its activities.

4.2 Calculation of environmental impact

The environmental impact can be calculated through the ECO-FMEA, which will be used to identify, evaluate and measure the aspects and impacts generated by the company. The aspects and impacts of the company should be identified in the productive and administrative activities and, aftwards, analyzed, in order to obtain the intensity of the impacts generated by the organization as a whole. Figure 2 shows the FMEA application form, adapted from the model developed by Oliveira & Freitas (2011), that can be applied in industries.

Each field of the presented form must be filled in as follows:

a) Activities developed: List the developed activities in the production and administration of the company studied;

b) Environmental aspects: It is considered as an environmental aspect the element resulting from the activity of the company that can interact with the environment. In this case, one can describe an action, for example, generation of liquid effluents, that produces as an impact the pollution of the environment;

c) Impacts: Modification of the environment, resulted of the action in the activities of the company. It is the result of aspects in the environment;

d) Potential Case: Description of the action that may result in the generation of the impact;

e) Evaluation: made by the criteria: magnitude (M), frequency (F) and detection (D), as well as the calculation of the IRA (ARI) or total, given by the sum of the previously criteria described

Company Logo	Description of the FMEA application form							DOC No.:	
								PP.:	
								REV.:	
SUBJECT: IDENTIFICATION AND EVALUATION OF THE ASPECTS AND IMPACTS									
Developed Activities	Identification			Evaluation:					
	Environmental Aspects	Impacts	Potential Case	M	D	F	Total	Intensity of Impact	Current form of control
Actv. 1									
Actv. 2									

Figure 2. Model of ECO-FMEA application form. Source: Adapted from Oliveira & Freitas (2011).

Chart 2. Scale of analysis of organizational productivity.

Productivity	Productivity variation	Grouping of levels	Level of productivity
Very Low	0-0.2	(0 ≤P ≤0.2)	Low
Low	0.2-0.4	(0.2<P ≤ 0.8)	Medium
Medium	0.4-0.6		
High	0.6-0.8		
Very High	0.8-1	(0.8 < P≤1)	High

Source: Elaborated by the authors.

(M + F + D.). According to Oliveira & Freitas (2011), the magnitude criterion represents the severity of the impact, considering its spatial extent (dimension of damage) and reversibility (capacity to remedy); Frequency represents the probability of occurrence of the impact, and Detection represents the ease with which the impact is detected, thus avoiding a taking of major proportions, and if the company's initiatives are sufficient to avoid contain or repair the impact. The magnitude, Frequency and Detection can be scored as shown in Charts 3, 4 and 5 respectively;

f) Intensity of Impact: Filled in according to the result presented in the Total item. If the result is between 1 and 3 ($1 \leq TOTAL \leq 3$), the field will be filled with the term "Low", because its classification according to the criteria used indicates low magnitude and frequency and an immediate detection with solution in a short or medium Term, representing a small or no impact. If the Total has a result between 4 and 6 ($4 \leq TOTAL \leq 6$), this field must be filled with the term "Medium or Moderate", because this result indicates that one of the criteria presented an average level, being enough to be taken Containment or control actions. If the Total has a result between 7 and 9 ($7 \leq TOTAL \leq 9$), this field must be filled with the term "High", since this number indicates that some of the criteria presented a high level, requiring special measures of Containment or control action;

g) Current form of control: The initiatives adopted by the organization to prevent, mitigate or prevent that the impact reaches large proportions.

Once the ECO-FMEA form is filled in, the overall impact of the organization (IA) will be obtained by the arithmetic average of the "Total" item of each impact and therefore represented by its intensity. For this

Chart 3. Criteria for scoring Magnitude of environmental impacts.

Magnitude	Criteria	Evaluation
Low	Negligible / restricted impact to the place of occurrence,eversible with immediate actions, without possibility of personal damages.	1
Medium	Considerable impact to the place of occurrence, reversible with mitigating actions, with reversible personal damages.	2
High	Impact of large extension and / or irreversible consequence, even with mitigating actions, with irreversible personal damages.	3

Source: Oliveira & Freitas (2011).

Chart 4. Criteria for scoring the frequency of environmental impacts.

Frequency	Criteria	Evaluation
Low	Impact improbable to occur.	1
Medium	Impact probable to occur.	2
High	Expected impact to occur.	3

Source: Oliveira & Freitas (2011).

Chart 5. Criteria for scoring the Detection of environmental impacts.

Detection	Criteria	Evaluation
Low	Immediate detection and company initiatives are sufficient to prevent the impact occurs.	1
Medium	Immediate detection and company initiatives are sufficient to contain and / or reduce the impact.	2
High	Immediate detection without company initiatives or these are not enough to prevent, contain or reduce the impact.	3

Source: Adapted Vandenbrande (1998).

purpose, the analysis made of the intensity of the organizational impact is given according to Chart 6.

Once the forms are applied and identified on the basis of Chart 6 - indicative of the intensity of the impact of the organization studied - then the Green Productivity level is measured, obtained by the inversely proportional relation between the variables: productivity and environmental impact.

4.3 Measuring the organizational Green Productivity level

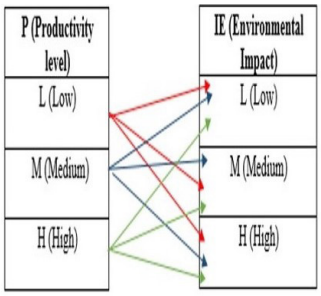
Based on Kim & Hur (2003), it is understood that Green Productivity is a result of the relationship between productivity and environmental impact, which are two inversely proportional variables. This is because the concept of GP brings in essence that organizations can contribute to sustainability obtaining high productivity and generating a low environmental impact. Considering that the variable productivity in the organization can assume a low, medium and high level (see Chart 2); And the environmental impact generated by the company can be low, medium and high (see Chart 6), it is possible to identify the levels of Green Productivity, from the crossing of these variations, as it is shown in Figure 3.

Once the combinations are identified, these represent the levels of Green Productivity in which a given organization may find itself in a certain period of time. And, highlighting the fact that Green Productivity aims to contribute to sustainability from a better productivity and low impact, such combinations are evaluated from this point of view. In this sense, it can be verified that the productivity variable contributes positively with respect to sustainability, since the higher its level, the lower the consumption of production inputs, production reject generation, solid waste, gaseous emissions, liquid effluents and other factors from the activities performed in the organization. As for the impact, this contributes negatively from the point of view of sustainability, since the higher it is, it will be higher the damages caused to the environment and society. In view of this analysis, Chart 7 shows the evaluation of productivity levels and the impacts within this context.

In order to do this, Chart 8 presents the crossings and their respective evaluations from the point of view of sustainability, presenting as a result the respective levels of GP that this can assume as well as the possible situations in which the company may be found (Optimum, Good, Regular, Bad and Awful), in function of the levels of Green Productivity.

Chart 8 will allow that at the end of the application of the proposed model, it will be possible to identify the level of Green Productivity of the company studyied, as of its current productivity (low, medium or high level) and environmental impact (low, medium, High), calculated previously, and thus to give support to the organizations to the identification of measures that come to contribute to the improvement of this level.

In Figure 4 that follows it appears as an unfolding of the table, demonstrating in drawn areas, from the scales used to analyze productivity (see Chart 2) and environmental impact (see Chart 6), the possible situations in which the company may find itself (Optimum, good, regular, bad and awful), in function of the levels of Green Productivity (low, medium and high) that this can assume. In this way, a company that has a high level of Green Productivity can be in an optimal situation (high P and low AI) or good



PRODUCTIVITY LEVEL	ENVIRONMENTAL IMPACT	COMBINATION
L (Low)	L (Low)	(L, L)
	M (Medium)	(L, M)
	H (High)	(L, H)
M (Medium)	L (Low)	(M, L)
	M (Medium)	(M, M)
	H (High)	(M, H)
H (High)	L (Low)	(H, L)
	M (Medium)	(H, M)
	H (High)	(H, H)

Figure 3. Crossing of the variation of productivity and environmental impact levels. Source: Elaborated by the authors.

Chart 6. Scale of analysis of the organizational impact.

Intensity of impact org.	Variation of the general impact of org. (IA)
Low	$1 \leq IA \leq 3.9$
Medium	$4 \leq IA \leq 6.9$
High	$7 \leq IA \leq 9$

Source: Elaboration from Oliveira & Freitas (2011).

Chart 7. Evaluation of productivity levels and impact on sustainability.

PRODUCTIVITY	Analysis from a sustainability perspective	ENVIRONMENTAL IMPACT	Analysis from a sustainability perspective
L (Low)	(-) negative	L (Low)	(+) positive
M (Medium)	(+ -) more or less (positive or negative)	M (Medium)	(+ -) more or less (Positive or negative)
H (High)	(+) positive	H (High)	(-) negative

Source: Elaborated by the authors.

Chart 8. Evaluation of Green Productivity levels in the face of sustainability.

Productivity			Environmental impact			Situation of the company	Green Productivity level (GP)
Level (P)		Interval	Level (IA)		Interval		
H (High)	(+)	(0.8 < P≤1)	L (Low)	(+)	(1 ≤ IA ≤ 3.9)	OPTIMUM	HIGH
M (Medium)	(+ -)	(0.2< P ≤ 0.8)	L (Low)	(+)	(1≤ IA ≤ 3.9)	GOOD	
H (High)	(+)	(0.8 < P≤1)	M (Medium)	(+ -)	(4 ≤ IA ≤ 6.9)	GOOD	
L (Low)	(-)	(0 ≤ P ≤0.2)	L (Low)	(+)	(1 ≤ IA ≤ 3.9)	REGULAR	MEDIUM
M (Medium)	(+ -)	(0.2< P ≤ 0.8)	M (Medium)	(+ -)	(4 ≤ IA ≤ 6.9)	REGULAR	
H (High)	(+)	(0.8 < P≤1)	H (High)	(-)	(7 ≤ IA ≤ 9)	REGULAR	
M (Medium)	(+)	(0.2< P ≤ 0.8)	H (High)	(-)	(7 ≤ IA ≤ 9)	BAD	LOW
L (Low)	(-)	(0 ≤ P ≤0.2)	M (Medium)	(+ -)	(4 ≤ IA ≤ 6.9)	BAD	
L (Low)	(-)	(0 ≤P ≤0.2)	H (High)	(-)	(7 ≤ IA ≤ 9)	AWFUL	

Source: Elaborated by the authors.

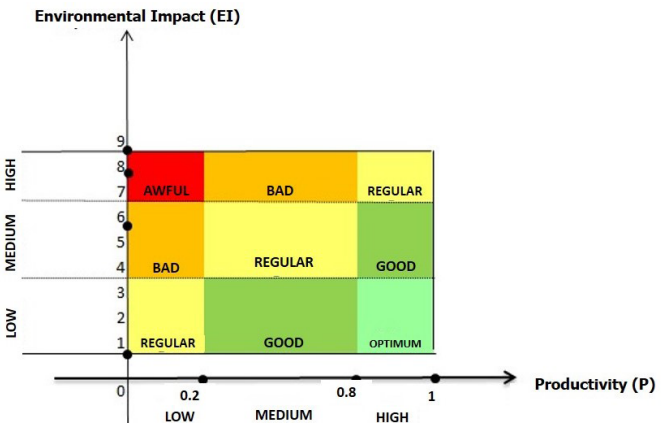


Figure 4. Situations of the company according to the levels of Green Productivity (GP). Source: Elaborated by the authors.

(high P and medium IA / medium P and low AI); The one with a medium level of GP may be in a regular situation (low P and IA or medium P and IA, or high P and IA); and finally, the company that is at a low level may be in a bad situation (low P and medium IA or medium P and high IA) or awful (low P and high IA).

The Figure 4 and Chart 8 allow that at the end of the application of the proposed model the values found, corresponding to the current organizational productivity of the company and the current impact generated by it, form a combination (P, IA), thus making it possible to identify the current situation of the company from the perspective of Green Productivity and its current GP (P, IA) level, which will give support to the organizations for the identification of measures that come to contribute to the improvement of this level and direct it in the search for the organizational sustainability.

5 Final considerations

The proposed model can be used in any type of organization, especially in those ones with profit seeking. Its theoretical contribution comes from

filling a gap in the literature which referring to the measurement of Green Productivity at levels (high, medium, low), as well as the situation of the company before such levels (optimum, good, regular, bad and awful). It is also worth mentioning that the model is flexible as far the type of tool used to evaluate the environmental impact generated by organizations; That even considering its high analytical power, the FMEA - used in this proposal - can be replaced. However, such substitution should be done by tools that show as result of their analyses the three levels of impacts: high, medium and low, which will allow to maintain the crossings and final analyses of the model.

The proposed model presents as practical contribution the identification of the levels of Green Productivity in the organizations possibly studied, allowing them to understand which actions or activities generate environmental impacts and, consequently, reduce their efficiency, increase their costs, reflecting in their productivity.

Finally, even considering the relevance and contributions of the proposed model, it is worth noting some possible limitations regarding its operationalization: the lack of systematized data about the company, mainly referring to the environmental dimension, and, on the other hand, the resistance on the part of the companies in supplying such information for the generation and foundation of academic works. This situation is changing, even if slowly, due to the increasing pressures that the companies are suffering, mainly which are coming from the market.

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