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REVIEW ARTICLE

DEVELOPMENT OF A MULTIDIMENSIONAL SUSTAINABILITY PERFORMANCE MEASUREMENT MODEL FOR ROAD FREIGHT TRANSPORT

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ABSTRACT

This paper aims to develop a performance measurement model that can be used to obtain an overall rating of the performance of a company with the inclusion of four dimensions which are, economic, environmental, social and operational. This model measures the fields of each dimension to allow an overall score. Which permit identification of areas where there is need for improvement, and thus manage overall performance of the company while having a detailed view. The tool can provide very useful interpretations for both researchers and practitioners. The model we propose has a double originality on the one hand it is multidimensional, and because of this it allows you to have a single performance measurement system to evaluate the overall performance of the organization. On the other hand while this model is suitable for measuring the performance of road transport companies, it is a generic model it can also be used to measure the performance of any other Sectors it is sufficient to identify the input items. This model will allow companies operating in the road freight transport to have an easy model to use while measuring four dimensions to get an overall score. A case simulation shows the applicability of the model, and the variation in results can greatly influence the overall rating of the performance measurement.

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INTRODUCTION

With the situation of a growing global population, accelerating global development and associated increasing resource use and environmental impacts, it seems increasingly evident that business as usual is not an opportunity for a sustainable future (Toure *et al*., 2014). Consciousness of the need to value ecological systems and natural capital required for human benefit is not new (Costanza *et al*., 1997). However, it is not yet common practice in business to value the natural resources. A holistic approach is required to tackle the challenges of a sustainable future: responses to environmental changes will essentially need to be in parallel with economic and social change. These types of changes require a basic shift in the purpose of business and about every aspect of how it is performed. Business model innovation offers a prospective approach to deliver the required change through re-conceptualizing the purpose of the firm and the value creating logic, and rethinking perceptions of value (Bocken *et al*., 2014).

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The assertion is that with careful business model redesign it is possible for conventional businesses to more readily incorporate sustainability into their business and for new start-ups to plan and pursue sustainable business from the outset, as suggested by Stubbs *et al*., (2008) and Porter *et al*., (2011), and business model innovations can support a systematic, current creation of business cases for sustainability (Schaltegger *et al*., 2012). Business model innovation is increasingly accepted as a key to delivering greater social and environmental sustainability in the industrial system (e.g. Lüdeke-Freund, 2009). While there is extensive literature on the theory of business models for delivering sustainability (e.g. Stubbs *et al*., 2008 conducted a literature review), and examples on specific companies (Baines *et al*., 2007). Sustainability is a confusing concept that has evolved progressively over the last three decades, according to Faber *et al*. (2005). There isa surplus of definitions and opinions about the concept of sustainability (Lindsey, 2011). The concept of sustainable development involves the integration of economic prosperity, environmental protection and social progression (Benn *et al*., 2011). Particularly during the last decade, sustainability assessment via indicators and indexing methods has gained appreciation. There have been diverse studies which have proposed different methods for sustainability assessment.

When evaluating the performance of sustainability, all three dimensions of sustainable development performance, economic, environmental and social sustainability performance, need to be taken into account (Qu *et al*., 2015). In the accessible literature on sustainability, sustainable development performance and its indicators are discussed under the three dimensions of economy, environment and society, and they are analyzed using three theoretical frameworks: resource-based value theory, institutional theory and stakeholder theory (Qu *et al*., 2015).

Sustainable development is becoming increasingly important in the development of business strategies. Consequently, transport activities come under particular attention due to its significant role in economic development process and its impacts on the environment. Achieving sustainability in transport sector becomes more challenging given the growing demand for any kind of transport activities (Afsaneh *et al*., 2015). Transport sector has proven to be particularly difficult territory for the progress of sustainable development policy. Transportation is a complex and porous social, technical, and economic system, difficult to deal with it comprehensively. To the extent that policy guidance has been developed to address sustainability issues in general, it usually has only touched on a fraction of the myriad ways that transportation is integrated into larger systems of human activity. Meanwhile, current trends are not encouraging. Every other sector contributes strongly to sustainable development, with the exception of the transport sector (Trodahl *et al*., 2007; Heinrichs *et al*., 2014; Velazquez *et al*., 2015).

In particular the road transportation sector is a key activity in our daily lives. It directly contributes 5% to 10% of the gross domestic product in most countries, and indirectly allows the other sectors a social and economic development. In terms of transport volumes and performance, road transport of goods is by far the most important mode of transport (Touzi *et al*., 2014). The dense road network, as well as its flexibility and speed, road transport is inevitable and cannot be replaced by other means of transport. The logic that applies to the transport of passengers on the route (Vergragt and Quist, 2011) is also true for the road transport of goods. The road transportation plays a major role in providing sustainable services while responding to the emerging challenges. These challenges include both external influences from external factors and internal influences within the organization (e.g. financial limitation, lack of leadership, professional staff, etc.). The challenges are creating a global need for the integration of a sustainability concept within the road transportation process (Gunarathna *et al*., 2014). The concept of sustainable transportation involves the same debate about meaning and uncertainty, according to Black (2010), there is still no political gold scientific agreement on a sustainable transportation definition. In this context we resumed several definitions of sustainable transportation in the literature: Sustainable transportation is seen as transportation that meets mobility needs while also preserving and enhancing human and ecosystem health, economic progress, and social justice now and for the future (Afsaneh and al., 2015). Sustainable transportation system as "one that does not agriculture endangers public health or ecosystems and meets mobility needs consist with (a) use of renewable resources at below their rates of regeneration and (b) use of non-renewable resources at below the rates of development of renewable automatically opens" (OECD, 2002). There is little research on measuring performance of sustainable transportation in the field of road transport of goods. The literature in this area is rather oriented policy implementation or planning issues (Vieira *et al*., 2007) rather than of performance measurement. Based on the gap in the literature about measuring performance of sustainable road transportation, the purpose of this article is to propose a model of performance measurement of sustainable road transportation which responds both to the Triple Bottom Line as well as to the operational dimension to allow for an overall assessment of the performance of the company, which led to a proposed model for sustainable development. This paper is organized as follows: a Sustainability measurement in section 2. The Methodology and framework is presented in section 3. Finally, Discussion and Conclusion is presented in Section 6.

Sustainability measurement

The measure of performance can be defined as "*the process of quantification of the efficiency and effectiveness of the action*" (Neely *et al*., 2005). Kaplan (1990) argues that the measure of performance is the prerequisite for the improvement of performance. There are many reasons for which the companies measure their performance, which can be usually found in the literature of performance measures. The literature provides a long list, first of all the measures of performance are essential for the management and navigation of organizations around the world markets turbulent and competitive, they allow organizations to follow the progress of their strategy, to identify areas for improvement, identify the problems to train new goals and objectives, confirm the priorities , evaluate the success of an organization, and then assist the operational staff to make a report of performance (Lee *et al*., 1998; Holmberg, 2000; Kueng, 2000; Kennerley *et al*., 2003; Gunasekaran *et al*., 2004; Neely *et al*., 2005; Gunasekaran *et al*., 2007; Gleich, 2011; Bracci *et al*., 2015). The necessity and the advantages of systems for measuring performance are therefore unquestionable (Robson, 2004; Gleich, 2011; Glavan, 2011).

For 25 years of other concerns have emerged for managers for various reasons, such as regulatory compliance, the image of the company, the social and environmental impact, transparency and communication with stakeholders, the pressure of the community and the competitive advantage, in a modern organization (Rao, 2014).

The concept of corporate sustainability has taken on importance in recent years (Linnenluecke *et al*., 2010; Hahn *et al*., 2011). The term sustainability has been used in reference to an organization's skill at maintaining and concomitantly demonstrating positive economic, social and environmental performance over the long term (Jamali, 2006). This approach is also named "Triple Bottom Line" (TBL) concept, as proposed by Elkington (2004). Searcy (2011) states that to monitor corporate sustainability, it is necessary to have a sustainability performance measurement system

(SPMS) that measures progress toward identified goals and has a long-term focus while addressing those issues associated with the (TBL). Various authors investigated - the linkage between the three dimensions (mainly economic and environmental and partially social) and maintained that the implementation of environmental and/or social initiatives provides potential economic advantage (Schaltegger *et al*., 2002; Ellen *et al*., 2006; Carter *et al*., 2008; Schaltegger *et al*., 2010; Zailani *et al*., 2012; Golicic *et al*., 2013; Van Hoof *et al*., 2013; Wong, 2013; Yusuf *et al*., 2013). The authors acknowledge the scope for economic gains in addition to meeting regulatory compliance (Golicic *et al*., 2013).

There are those who argue that the implementation of environmental or social initiatives can result in substantial costs (Pullman *et al*., 2009; Wu *et al*., 2011; Epstein *et al*., 2012; Ross *et al*., 2012). However, focal companies might be able to justify the long-term economic benefits of designing environmental and social, and present a business case for sustainability, where firms program financially benefited from engaging in sustainability practices (Epstein *et al*., 2003; Schaltegger *et al*., 2006; Carroll *et al*., 2010; Schaltegger *et al*., 2011). Measuring sustainability is a crucial activity that is integrated into the process of decision-making and organizational management. The evaluation of sustainability can be measured by index or set of indicators. Whatever kind of sustainability indicator used, its role will be the same: to help policymakers assess corporate sustainability performance and to provide information to plan future actions (Bellen, 2005; Moldan *et al*., 1997; Gallopín, 1997; Commission on Sustainable Development, 2002; McCool *et al*., 2004).

In response, efforts have been made firstly by organizations and also by researchers to establish sustainable development indicators and measures throughout the company. In the same vision wesee an increase in business publishing their report environmental and social performance (Epstein, 2004). Despite these efforts, the measurement of sustainability performance has not yet reached full maturity in the same direction as the environmental tools, such as the assessment of the environmental impact and strategic environmental assessment (Gasparatos *et al*., 2008; Ramos *et al*., 2010). There is still facing significant challenges.

For instance, many organizations have started measuring the sustainability with three main goals: transparency and communication to stakeholders, improvement of operations and strategy alignment (Taticchi *et al*., 2014) despite this effort, most of the frameworks mentioned above are based on individual elements of the triple bottom line (TBL) concept identifying the need to sustainability approach with both generic and industry-specific measures of performance. Despite the considerable advances in the models of performance measure, there remain several challenges to overcome. We are exposing the main limits of the sustainable performance measurement systems (SPMS). Any measure of performance of an enterprise begins with a question mark on the producers and the recipients of the evaluation. The assessments regarding the strategies of enterprises relating to the implementation of sustainable development and their results cannot escape it. The overall performance of the enterprise may be formally evaluated by actors external to the company (notation, rankings and prices, surveys of reputation tc.); it can also be carried out inside the enterprise to provide information to decision makers in view of piloting their strategy. The devices putting forward the concept of "overall performance" propose to assess the performance on three dimensions (economic, environmental, and social). To respond to the problem of the consistency of a measure of integrated performance and of the progress of the "global" which are sometimes more marked in the extension of the scope covered within the environmental dimension, and the load balancing between the dimensions or the financial objectives remain preponderant in an organization.

We propose a multidimensional model for road transport enterprises that want to put in place a performance measurement system composed of the three dimensions of sustainable development (economic, environmental, social) and of the operational dimension, for their permit to have a device helping to evaluate and control an overall performance.

Methodology and framework

A number of research approaches for sustainability performance measurement have been proposed, most of these approaches focused on three dimensions (environmental; social and economic) for dealing with the sustainability performance measurement (Delai *et al*., 2011; Santoyo-Castelazo *et al*., 2014). Few researchers proposed approaches combined several dimensions (Delai *et al*., 2011; Jeon *et al*., 2013; Gunarathna *et al*., 2014). Thus, this paper fills this gap in current literature by establishing an integrated model for dealing with sustainability performance using the three dimensions of sustainability adding the operational dimension. The framework will base on five main steps: (1) dimensions identification; (2) fields definition; (3) performance measurement model design (4) Structural model (5) Model Validation

Step (1): Dimensions identification

The identification of the most common sustainable performance system dimensions was conducted based on literature resources and industrial expert point of view. Initially and based on the critical review of the literature, three dimensions (Environmental (ENV); Social (SOC); Economic (ECO)) are identified. Our objective is developing a sustainability performance model, taken into account the operational performance at the same time. Hence, the idea to choose the operational performance as a fourth dimension. Thus, we identify four dimensions (Environmental (ENV); Social (SOC); Economic (ECO) and Operational (OP)).

Step (2): Fields definition

Based on a large number of literature resources and industrial expert judgments, we define a number of fields for every dimension in adequacy of their nature. Data from the identified multiple industries have been collected for listing fields for every dimension, as agreed upon by all the industries, in the sustainability performance measurement. In addition, several

Table 1. Summary of various criticisms and limitations of the SPMS

Criticisms and limitations	Explanation
Model of multidimensional measure	The existing models do not allow to measure the three dimensions of the TBL in addition to the operational dimension
Level of assessment	The existing models are used in the best of cases to have an evaluation with a scale of 3 to 5 levels, which remains little on everything to compare different companies
The interactions between the different dimensions	The existing tools are not capable of measuring the interactions between the different segments of the performance {they measure these dimensions separate for then the compile without taking account of the interrelationships between them. In the best of cases, some tools (the crossover indicators of the Global Reporting Initiative GRI) evaluate the interactions between two dimensions: economic/social or economic/environmental}
The arbitration in the choice of indicators	The indicators are not constructed in the course of a collaborative process and strategic with the agreement of the leadership and the participation of the stakeholders of the company
Absence methodological consensus in the choice of indicators	By allowing free choice of indicators to businesses this to influence the overall assessment and does not allow to have a comparison between coherent enterprise
The quality of information in the reports to measure performance of the enterprises	The quality of information in the reports to measure performance of enterprises in most cases, are oriented more corporate image and does not reflect the everyday realities of businesses.
Prevalence of subjective judgments	In general, the delineation of performance measures is associated with a significant subjective component. Measures that are useful for one type of organization may be good deal for another

Table 2. Dimension and fields identification

Dimension	Code	Fields
Environmenta	ENV1	Noise Pollution
l	ENV2	Air pollution
	ENV3	Water and soil pollution
	ENV4	Energy consumption
	ENV5	Waste and Recycling
Social	SOC1	health
	SOC2	Security
	SOC3	Training and awareness, regional involvement and territorial
	SOC4	Cohesion, equity, justice
Economic	ECO1	wealth creation
	ECO2	Financial exchange with external stakeholders
	ECO3	financial contribution in its environment
	ECO4	Innovations in commercial offers
Operational	OP1	Transport cost
	OP2	Collaborative transportation
	OP3	efficiency and flexibility
	OP4	delivery reliability and reactivity
	OP5	Customer Satisfaction

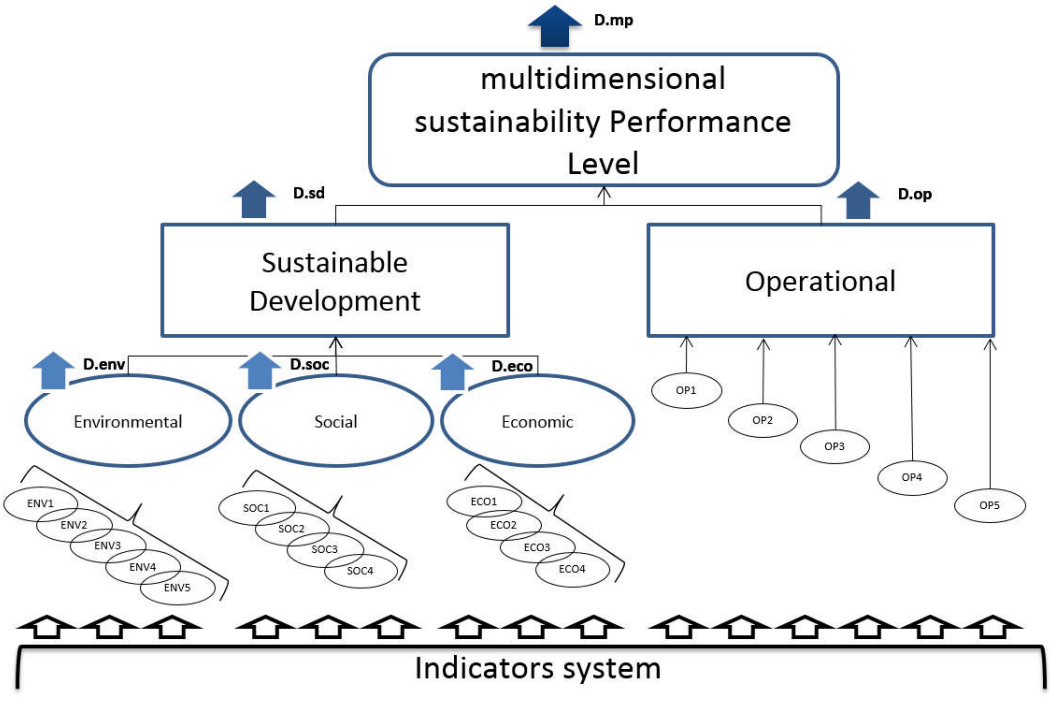


Figure 1. Multidimensional sustainability performance measurement model

indicators (i.e. five hundred indicators) were included in the initially identified list. In this way, various most common fields of sustainability were listed based on inputs from reports, industrial experts and literature resources. Thus, we define eighteen fields. Table 2, presents the results of this brainstorming, all collected fields in different sustainable performance system dimension.

Step (3): Design of a multidimensional sustainability performance measurement model

Our sustainable performance measurement model is based on the idea of the measurement of sustainability performance level, and in parallel the measurement of the operational performance level, and then obtains a multidimensional sustainable performance level. The model is alimented by a group of indicators which are defined by the user of the model in adequacy with the fields already given by the system, and the activity sector of the organization.

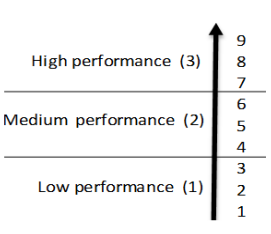
- D.mp: multidimensional performance
- D.op: operational performance
- D.sd: sustainable development performance
- D.env: environmental performance
- D.soc: social performance
- D.eco: economic performance

Step (4): Structural model

The multidimensional sustainability performance measurement model is structured following the logic explained in figure (model). For this we need to evaluate performance on various phases, firstly the system require value judgment of each field via indicators already chosen, secondly the performance of each dimension (eco, soc, env and op) has to be measured. Then obtain the final performance level. Our system has for objective to give an overall performance value judgement based on a scale from 1 to 9 (this scale allow more strictness while performance measurement). The technical structure of the model is given by three algorithms which are explained bellow:

Multidimensional performance determination algorithm (from D.op & D.sd to D.mp)

This algorithm based on the idea of a minimal required conditions for according a certain performance level (i.e. a low operational performance level with a high sustainable development performance level cannot allow a multidimensional high performance level, and vice versa), and permit obtain a final score for the multidimensional performance from the operational, and the sustainable development performance.



DL.op: operational performance level
DL.op={1;2;3}
DL.op=1 if D.op={1;2;3}
DL.op=2 if D.op={4;5;6}
DL.op=3 if D.op={7;8;9}
DL.sd: sustainable development performance level
DL.sd={1;2;3}
DL.sd=1 if D.sd={1;2;3}
DL.sd=2 if D.sd={4;5;6}
DL.sd=3 if D.sd={7;8;9}

Figure 2. Scale multidimensional performance measurement

D.mp = {1, 2, … ,9}; D.op = {1, 2, … ,9}; D.sd = {1, 2, .. ,9};

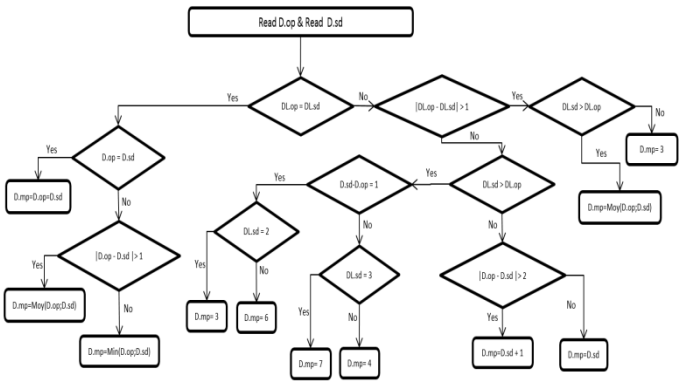


Figure 3. Multidimensional performance determination algorithm (from D.op& D.sd to D.mp)

Sustainable development performance algorithm

At this stage the sustainable development performance is determined through the triple bottom line performance, and this by choosing the minimal value. (Figure 3)

D.sd = min (D.env, D.soc, D.eco)
D.env = {1, 2, .. ,9}; D.soc = {1, 2, … ,9}; D.eco = {1, 2, . .,9};

Operational performance algorithm

The operational performance is obtained by the same logic as multidimensional performance, which is the minimal required conditions for access to determined performance level, this from the value judgement of their five fields (i.e. if only one of the five fields has a value less than 3 the performance level cannot be higher than 6), but the algorithm is different, her bellow explained:

OPi = {1, 2, …, 5};$\forall i \in \{1, \ldots, 5\}$

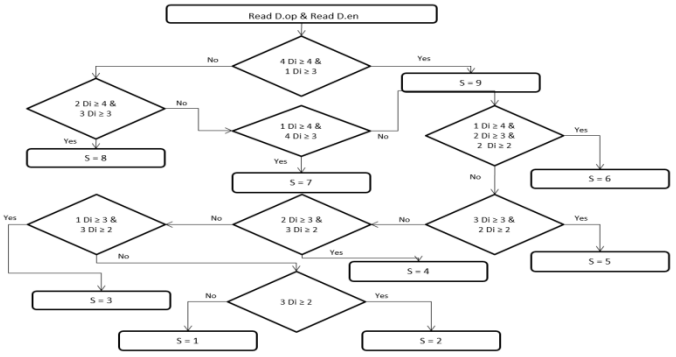


Figure 4. performance determination algorithm (D.op&D.en)

Environmental performance algorithm

The environmental performance is obtained exactly by the same logic and algorithm of operational performance, considering that they have the same number of fields. (Figure 4)

D.env = {1, 2, … , 9}; ENVi = {1, 2, …, 5};$\forall i \in \{1, \ldots, 5\}$

Social performance algorithm

The social performance is gotten by the same logic as multidimensional performance but with a different algorithm, her bellow explained:

D.soc = {1, 2, … , 9}; SOCi = {1, 2, …, 5}; $\forall i \in \{1, \dots, 4\}$

Economic performance algorithm

The economic performance is given by exactly the same algorithm of social performance, considering that they have the same number of fields. (Figure 5)

D.eco = {1, 2,… , 9}; ECOi = {1, 2, …, 5}; $\forall i \in \{1, \dots, 4\}$

Step (5): Model Validation

The main objective of this step is to validate the consistency and the reliability of the proposed model (Figure 1), the approach start by the determination of a number of scenarios, which represent different cases of companies' situations. In our case we decide to enlarge our set to twenty scenarios from different situation (Table 3), which are generated randomly and modified by the work group in the only objective to have a representation of each situation.

Si: scenario $i \forall i \in \{1, \dots, 20\}$

In order to determine the multidimensional performance level, we start by the treatment of our data elements, accordingly to the proposed algorithms (Figure 2, 3, 4) and following model logic (Figure 1). The table in bellow show the results of this analysis.

Analyze and Discussion

In this section of the paper, we present in the (Figure 6, 7, 8) an analysis of one scenario from each performance level (low, medium, high), for analyze and discussion.

Low performance

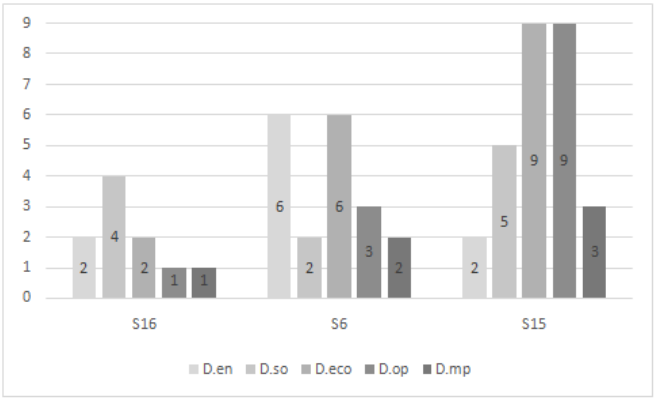


Figure 6. graphical representation of low performance scenarios

Table 3. Set of scenarios

	Scenario / Code	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Environmental	ENV1	1	2	4	4	2	4	4	2	5	4	5	5	2	3	2	2	1	2	4	2
	ENV2	3	1	5	3	4	3	4	1	4	4	5	4	3	4	1	1	2	1	1	3
	ENV3	1	2	4	2	5	2	5	2	4	5	5	4	2	3	3	2	3	3	3	2
	ENV4	5	3	3	3	4	5	4	3	5	4	3	5	3	2	1	1	1	1	2	3
	ENV5	2	2	2	2	4	3	5	4	5	5	4	5	4	2	3	1	2	3	1	4
Social	SOC1	4	5	5	3	1	1	4	3	5	5	3	4	2	3	3	2	3	3	4	3
	SOC2	2	4	5	3	5	5	3	2	5	4	4	3	3	4	3	3	4	3	5	3
	SOC3	5	1	3	5	1	4	5	2	3	3	4	5	3	2	3	3	2	2	2	5
	SOC4	1	5	2	3	5	1	4	5	3	5	5	4	4	2	3	2	2	2	1	3
Economic	ECO1	5	5	4	2	1	3	5	4	3	4	3	1	4	1	5	2	3	3	1	3
	ECO2	5	1	1	3	2	4	4	5	3	3	3	1	4	2	3	2	3	3	1	3
	ECO3	4	1	3	3	3	2	3	5	5	5	5	2	3	1	5	2	2	2	1	5
	ECO4	3	5	3	3	1	3	5	3	5	4	5	2	5	1	4	1	1	2	5	5
Operational	OP1	4	5	5	2	1	2	4	5	5	2	1	2	4	5	5	2	1	2	1	4
	OP2	4	5	4	1	2	1	5	5	4	1	2	2	4	2	4	1	2	1	2	3
	OP3	5	5	4	2	3	3	5	5	4	2	3	3	5	5	4	2	3	3	1	4
	OP4	4	3	5	1	1	1	4	3	5	1	1	3	4	3	5	1	1	1	1	2
	OP5	5	4	5	1	2	3	4	4	5	1	2	3	5	4	5	1	2	3	1	5

Table 4. Result obtained from scenarios

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
D.en	2	2	6	6	6	6	9	3	9	9	9	9	6	6	2	2	2	2	2	6
D.so	2	2	6	7	2	2	9	6	8	9	9	9	6	6	5	4	6	4	1	7
D.eco	9	2	2	5	2	6	9	9	8	9	8	2	9	1	9	2	2	4	1	7
D.sd	2	2	2	5	2	2	9	3	8	9	8	2	6	1	2	2	2	2	1	6
D.op	9	9	9	1	2	3	9	9	9	1	2	5	9	6	9	1	2	2	1	6
D.mp	3	3	3	4	2	2	9	3	8	5	5	3	7	2	3	1	2	2	1	6

The three chosen scenarios representing low performance (S6, S15, and S16) shows that, even if the organization have a high performance level of one or two dimensions, still the necessity for more performance on the other dimensions to get a high multidimensional performance level.

Medium performance

The three chosen scenarios representing medium performance (S4, S11, and S20) shows that, even if the organization have a low or medium operational performance level, can obtain a moderate score on multidimensional performance level, when the three sustainable development dimensions performance are medium to high.

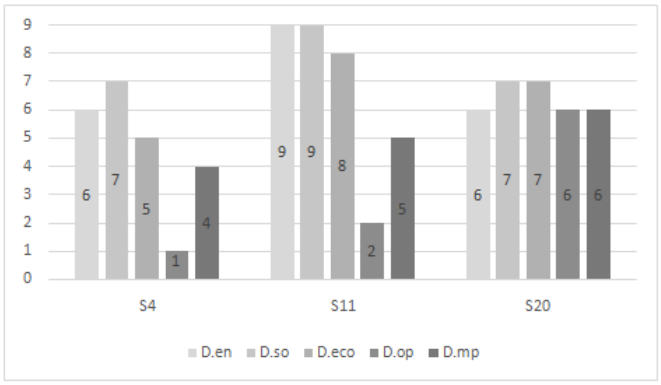


Figure 7. Graphical representation of medium performance Scenarios

High performance

The three chosen scenarios representing high performance (S7, S9, and S13) show that, there is no other way to get a high multidimensional performance level, only by being a high performance organization on the four dimensions.

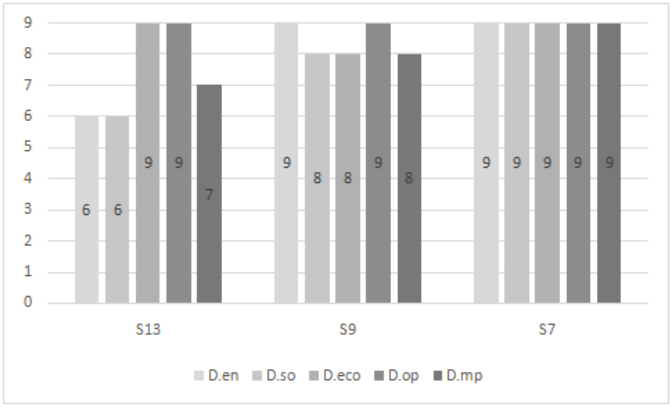


Figure 8. Graphical representation of high Performance scenarios

Conclusion

In the professional environments, Companies have been worried to report on their sustainability performance and some effort has been made to establish initiatives to guide them in doing so. Though, sustainability measurement has not yet fully matured and is still facing some important challenges. Most initiatives have not an integrative focus measuring only the environmental dimension of sustainability. There still is a lack of consensus around what should be measured and how. Finally, sustainability management and measures are generally built for reporting purposes and they are carried out separated from company's performance measurement systems, thus, having little relevance to managers' daily routine and decision making process.

In this context, this paper propose a multidimensional sustainability performance measurement model, to measure in a simple and efficient way all the dimensions of the companies they that are operational or sustainable. It was developed based on the analysis of the shortcomings and strengths of extant sustainability literature review and it constitutes an attempt to shed light on a generic model it can also be used to measure the performance of any other Sectors it is sufficient to identify the input items.

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