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A new Visualization Approach for Sustainability

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Abstract: Organizations sustainability is increasingly measured by the general public. But does a suitable way always exist to present both the target sustainability as well as the current sustainability in a stakeholder oriented manner? Today especially the management needs a tool, which is efficient and easy to understand to reach a stakeholder oriented sustainability presentation. In our contribution we discuss advantages and disadvantages of existing approaches to visualize sustainability. Moreover, we present our triangular pyramid of sustainability, which is the result of a new three-dimensional visualization approach. It solves many problems of existing sustainability visualization approaches. In a nutshell, our contribution presents a visualization approach that enables manager to determine the quality and quantity of sustainability as well as to conduct sustainability comparisons between and within organizations but also between different periods

Keywords: Triangle of Sustainability, Triple Bottom Line, Visualization, Grand Management Information Design

1 Introduction

Organizations are increasingly measured by means of their sustainability and use the positive associations of the stakeholder for both as marketing tool but also as instrument to present their products in a positive way. Due to the numerousness influencing factors and potential key performance indicators it is not easy to present sustainability results in a stakeholder oriented manner. Especially, the strategic management must be able to get crucial sustainability information as well as to generate ad hoc reports. This is a very important point in terms of competitiveness. A visualization of both the influencing factors but also the existing sustainability would be preferable. Despite, existing approaches fulfil these expectations insufficiently. Therefore, the management needs a tool that is efficient and easy to use to be able to make high quality decisions on strategic level concerning sustainability. Within the scope of basic research our contribution presents a graphical approach to close the mentioned gap above. Therefore, we introduce existing approaches and discuss their advantages and disadvantages. The outcome of this is that the visualization of all three pillars of sustainability in a two dimensional room is strongly

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connected with interpretation or visualization problems. As solution, we shift the visualization problem in a three-dimensional space. As a result, our approach eliminates the disadvantages of existing approaches. The way to visualize sustainability as triangular pyramid keeps the similarity to both the triangle of sustainability but also to the Triple Bottom Line.
With our approach, the management gets a visualization method which is similar to existing approaches and able to visualize sustainability quantitatively and qualitatively. Furthermore, our approach supports manager to conduct sustainability comparisons between and within organizations but also between different periods.

2 Analysis of Existing Approaches

2.1 Theoretical Background

The term "sustainable development" or shorter "sustainability" is defined in the report "Our Common Future" as "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [Un 87]. This abstract definition was extended about the three pillars of sustainability environmental, economic and social on Rio Conference in 1992. In 1998, the extended definition was mentioned in the final report of the committee of inquiry [De 98]. The Global Reporting Initiative (GRI) provides an interpretation of the content of the three pillars of sustainability in terms of a guideline to generate standardized sustainability reports. "Environmental" describes the impact on living and non-living natural systems and includes the elements air, earth and water. Unlike environmental, "economic" deals with impacts that influence economic conditions on local, national or international level. "Social" includes labor practices, human rights, society and product responsibility [Gl 13]. The extension of the sustainability definition mentioned above is also known as Triple Bottom Line (TBL) [Pu 12] and led to different graphical representations. In the following, we introduce some of these visualizations.

2.2 Approaches to Visualize Sustainability

The traditional representation of a sustainability triangle is an equilateral triangle as shown in figure 1. Each vertex represents one of the three sustainability aspects. The identical length of every edge shows the equal importance of all sustainability aspects. [In 14]

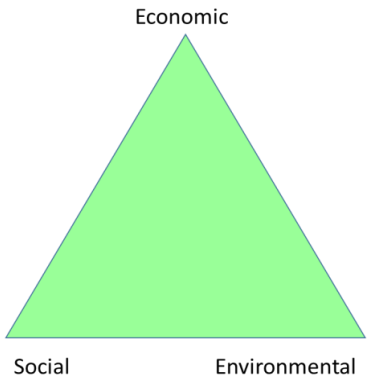

Fig. 1: The traditional sustainability triangle (adapted from [Aa 14]).

A similar representation of the sustainability triangle shows figure 2. Unlike the traditional sustainability triangle, the sustainability perspectives in figure 2 are not represented by the vertexes but by the sides of the triangle. Inside the triangle the sustainability perspectives get mixed. This illustrates that the sustainability perspective influence each other [Kl 09].

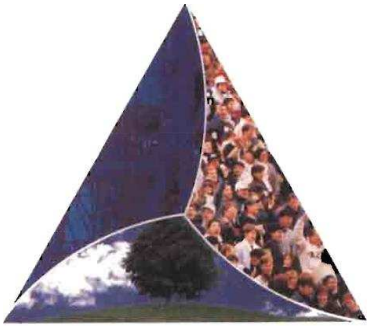

Fig. 2: The sustainability triangle of committee of inquiry [De 98].

The representation in figure 3 is an extension of the triangle approach. It is obviously that sustainability lean on three pillars: Social, economic and environmental. This static representation emphasizes the necessity of all pillars to avoid any tilt of sustainability.

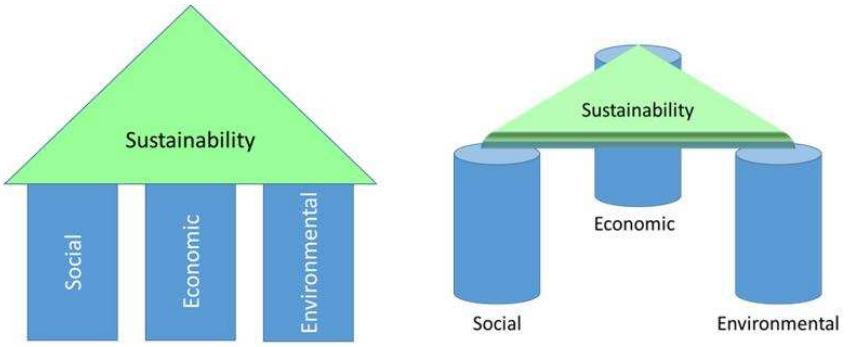

Fig. 3: The traditional visualization of sustainability in terms of pillars (on the left) and its representation in a three dimensional space (on the right) (adapted from [Kl 09]).

Another not triangle based representation of sustainability is shown in figure 4 in terms of an intersection model. Each circle represents a sustainability perspective. The intersections generated by at least two circles illustrate the trade-off between specific sustainability perspectives [Kl 09]. In a literal sense the sustainability is just located in the middle of the illustration and is generated by the intersection of all three sustainability aspects [OE 00].

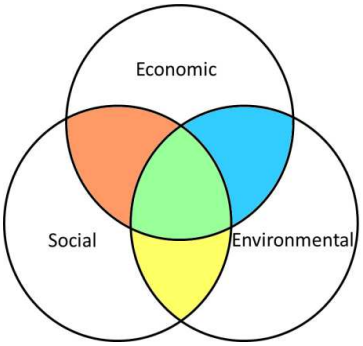

Fig. 4: The intersection model of sustainability (adapted from [Kl 09]).

2.3 Domain of Sustainability Visualization

The triangle of sustainability can be used to position business lines of action and different indicators along the triangle sides depending on their relevance [N. 98]. Adding additional information on the triangle sides is an extension of this triangle approach. Every triangle side is with regards to the content divided into both an efficiency area and an effectiveness area. This partition supports the discussion about the positioning of different targets on the

triangle sides. Within this approach, the vertexes represent the effectiveness targets economic, environmental and social. [DH 02]
An approach using the triangle area is the fractal triangle. The idea of this approach is that both the acting of humans as well as their initialized mass flow should be oriented on the example of the nature. The meaning and interpretation of the triangles created by fractal division is determined by the two shortest distances of the triangle to the specific vertexes. This approach allows the classification of sustainability questions within the triangle [Kl 09].

The triangle of Gibbs as shown in figure 5 is a mathematical approach which makes it possible to calculate a concrete value for each sustainability perspective. Identically to some approaches mentioned before, the vertexes in the triangle of Gibbs represent the three sustainability perspectives. Each triangle side has the function of a scale from 0 to 100 percent. For each point within the triangle the specific sustainability values can be calculated using parallel translation. A characteristic of this approach is that adding the three sustainability values always leads to 100 percent. An implication is the following formula:

$$x + y + z = 100\%, \text{with } x, y, z \in [0\%, 100\%] \quad (1)$$

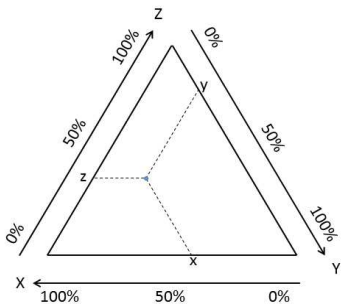

Fig. 5: The triangle of Gibbs (adapted from [Kl 09]).

3 Problems

In the following, we like to introduce visualization problems connected with the mentioned visualization approaches as well as with the triangle of Gibbs. In order to reach sustainability both representations, the traditional sustainability triangle and the committee of inquiry, put the focus on the visualization of the equal importance and on the corporation of all sustainability perspectives. Changes in one or more sustainability perspectives as well as their impacts cannot be visualized because of the triangle sides which are defined as equilateral. Figure 3 shows the sustainability perspectives as

fundament of the sustainability above. If the middle pillar or the outer pillars in figure 3 are removed, the sustainability will be stable anymore. This is a contradiction to the idea that all perspectives must be fulfilled to reach sustainability at all. This problem is eliminated in the three-dimensional representation but creates the impression that all sustainability perspectives must have identical values to reach sustainability. An improvement of one sustainability perspective leads to a higher pillar and the outcome of this would be a tilt.
Within intersection model the sustainability perspectives are visualized by three overlapping circles. Unlike the pillar or triangle representations, the intersection model allows to assign sustainability aspects to more than one sustainability perspective. A problem is to find the specific degree of intersection. On the one hand, too little intersection creates both the impression of small sustainability importance as well as increasingly independent and isolated sustainability perspectives. On the other hand, too strong interaction leads to sustainability perspectives which are not or only weak distinguished from each other [Kl 09].

This shortcoming is eliminated at the triangle of Gibbs. All points within and on the triangle sides as well as the vertexes can be visualized as components of the specific sustainability perspectives. According to the definition (equation 1), the sum of all sustainability perspectives is 100 percent. This is a disadvantage for interpretation. This approach allows the segmentation of one sustainability value into three values, but only as relative and not absolute values, one for each sustainability perspective. This limitation leads to visualization problems, because a comparison between absolute values is not possible.

It has to be mentioned that the visualization approaches explained above have different focuses. Moreover, each of the introduced approaches comes along with disadvantages as well as inherent risks of misinterpretation. This is mostly caused by the attempt to visualize all three sustainability perspectives within a two-dimensional space. From a mathematical point of view the third sustainability aspect cannot expressed independently from the other one. The third aspect is always determined by the other one. Consequently, our contribution aims to develop a visualization approach which supports:

- First, a representation of changes in one or more sustainability perspectives.
- Second, a visualization of sustainability as result of three sustainability perspectives.
- Third, the presentability of sustainability which takes dependencies between sustainability aspects into account.
- Fourth, a calculation of one sustainability value.
- Fifth, the presentability of equal importance of all sustainability perspectives.

4 Contribution

According to TBL, sustainability can be seen as a function, which has three variables. These are the pillars of sustainability. Equation 2 shows this relationship, whereas S_{result} expresses the resulting sustainability. x_{social}, $y_{environmental}$, and $z_{economic}$ stand for the concrete values of the social, environmental and economic pillar of sustainability.

$$S_{result} = f(x_{social}, y_{environmental}, z_{economic}) \tag{2}$$

As we have shown in the last chapter, existing approaches try to visualize three variables in a two-dimensional space. The resulting problem is that at least one variable dependent on the other two. In our contribution, we present a solution transferring the visualization in a three-dimensional space.

4.1 Assumptions

In order to enable the transfer of the visualization into a three-dimensional space as well as to limit the following explanations on the graphical representation, we have to make two assumptions.

First, we assume that it is possible to calculate a cumulative and normalized key figure for each pillar of sustainability. Therefore, it is possible to calculate a value between 0 and 100 percent for the social, environmental as well as for the economic pillar. This assumption is in line with the triangle of Gibbs, where values are in a range between 0 and 100 percent, too [Kl 09]. For example, we can determine the value of the overall key figure for the social pillar (x_{social}) summing up the partial results of the subdomains $i = 0 \rightarrow n$ which are a product of an influencing factor (k_i) and a quotient of the current value (x_i) and its maximum value (x_i^{max}), look at equation 3. The key values for the environmental ($y_{environmental}$), and economic pillar ($z_{economic}$), can be determined in the same way. In order to identify the relevant subdomains for each pillar, we suggest the GRI-Guidelines [Gl 13] as starting point. In organizations the required values can be delivered potentially by departments which are responsible for finance, controlling, social responsibility and environment. However, a detailed discussion about this is not part of our contribution.

$$x_{social} = \sum_{i=0}^{n} k_i \times \frac{x_i}{x_i^{max}} \tag{3}$$

Second, we assume that the pillars of sustainability are independent form each other. Hence, changing one pillar of sustainability has no impacts on the other pillars. For example, restructuring a production process as part of a process improvement could increase the output but also the operational result without influencing both the social and the environmental pillar of sustainability. In addition, a new environmental protection agenda could probably be influence the economical pillar, but it is not determined whether it will be positive or negative. The operational result can decrease because of higher costs

or increase because of a better image and the resulting sales quantity.

4.2 Visualization

Considering our assumptions, we can map the three pillars of sustainability into an orthogonally, three-dimensional coordinate system. The axis X_{social} corresponds to the social, $Y_{environmental}$ corresponds to the environmental, and $Z_{economic}$ corresponds to the economical pillar of sustainability. We can identify the point $P^S\langle x_{social}|y_{environmental}|z_{economic}\rangle$ plotting the key figure values of sustainability onto the corresponding axes. However, for a better compatibility with existing approaches, we do not take P^S into account. In our contribution, we look at the three points $P^X\langle x_{social}|0|0\rangle$, $P^Y\langle 0|y_{environmental}|0\rangle$, and $P^Z\langle 0|0|z_{economic}\rangle$ which are located on the coordinate axes. Connecting these points, leads to the three-dimensional triangle T^{XYZ}, which looks familiar to other visualization approaches, look at figure 6.

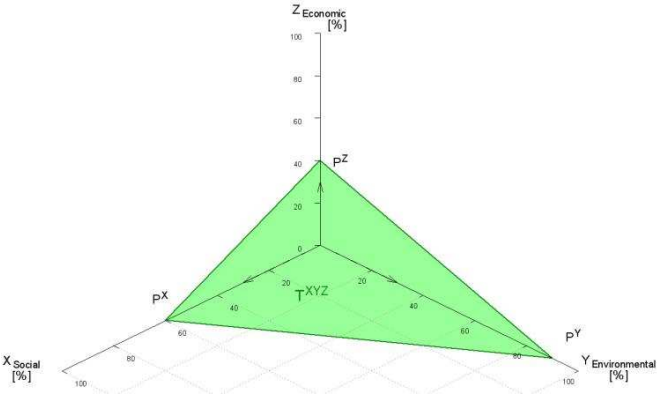

Fig. 6: Three-dimensional triangle of sustainability.

The triangle T^{XYZ} visualizes the cooperation between the three pillars of sustainability. The surface area of this triangle depends directly on the values of the corresponding key figures. If one key figure value increases, the surface area of the triangle increases, too. Furthermore, it is possible to draw three more triangles considering the origin of coordinates $P^0\langle 0|0|0\rangle$. These triangles are T^{XY0} with the points P^X, P^Y, and P^0, T^{X0Z} with the points P^X, P^0, and P^Z, and T^{0YZ} with the points P^0, P^Y, and P^Z, look at figure 7.

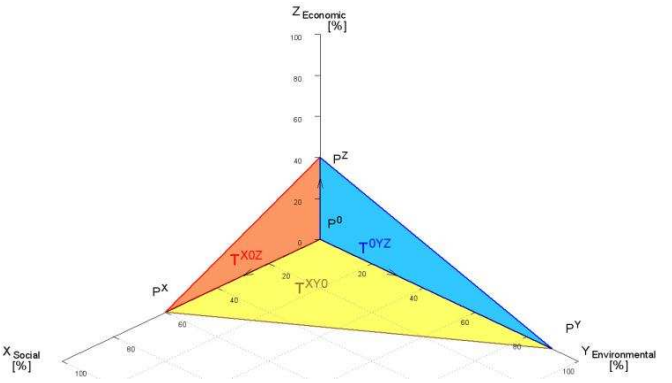

Fig. 7: Triangles of the cooperation between the pillars of sustainability.

The triangle T^{XY0} represents the cooperation between the social and environmental pillar of sustainability and is independent from the economic pillar. In the same way, triangle T^{X0Z} represents the cooperation between the social and economic pillar of sustainability and is independent from the environmental pillar, and triangle T^{0YZ} represents the cooperation between the environmental and economic pillar of sustainability and is independent from the social pillar.

We get a three-dimensional field, a triangular pyramid TP^N consisting of the points P^X, P^Y, P^Z, and P^0 by connecting these triangles. We call it triangular pyramid of sustainability.

5 Special Cases of the Visualization

In this chapter, we show the characteristics of triangular pyramid of sustainability TP^N. Our analysis turned out five special cases:

- First, exactly one key figure value of the pillars of sustainability becomes zero. In this case, the triangular pyramid of sustainability "collapses" to a two-dimensional triangle, which is spanned by two coordinate axes. If $x_{social} = 0$ the resulting triangle will be T^{0YZ}, if $y_{environmental} = 0$ the resulting triangle will be T^{X0Z}, and if $z_{economic} = 0$ the resulting triangle will be T^{XY0}.
- Second, exactly two key figure values of the pillars of sustainability become zero. Under this term, the triangular pyramid of sustainability "collapses" to a segment between the origin of coordinates P^0 and point P^S. It applies: $y_{environmental} = z_{economic} = 0 \rightarrow P^S = P^X$, $x_{social} = z_{economic} = 0 \rightarrow P^S = P^Y$, and $x_{social} = y_{environmental} = 0 \rightarrow P^S = P^Z$.

- Third, all three key figure values of the pillars of sustainability become zero. In this special case, the triangular pyramid of sustainability is equal to the origin of coordinates P^0.

However, in all three cases mentioned above we have to avoid using the word sustainability, because the missing of one or more pillars is a contradiction to the basic assumptions of the TBL.

- Fourth, all three key figures of the pillars of sustainability have the same value (unlike zero). In this term, the triangle T^{XYZ} become an equilateral triangle and equals the equilateral triangle of sustainability, look at figure 8.

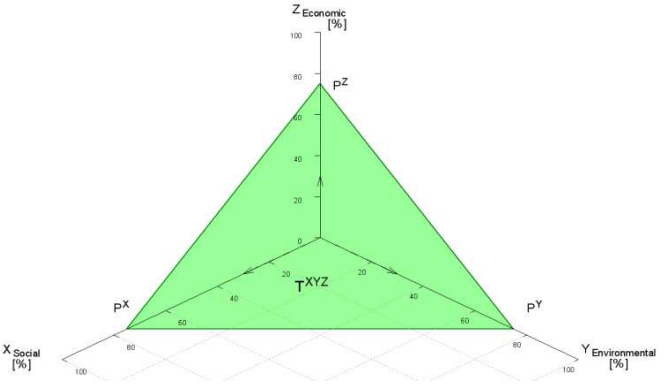

Fig. 8: Three-dimensional equilateral triangle of sustainability.

- Fifth, all three key figures of the pillars of sustainability have the value 100 percent. When all pillars of sustainability reach their maximum key figure value, $x_{social} = y_{environmental} = z_{economic} = 100\%$, the spread of the triangular pyramid of sustainability is as high as possible. This case describes an ideal situation. We call the resulting pyramid the ideal triangular pyramid of sustainability with equilateral base area TP^{N*}, look at figure 9.

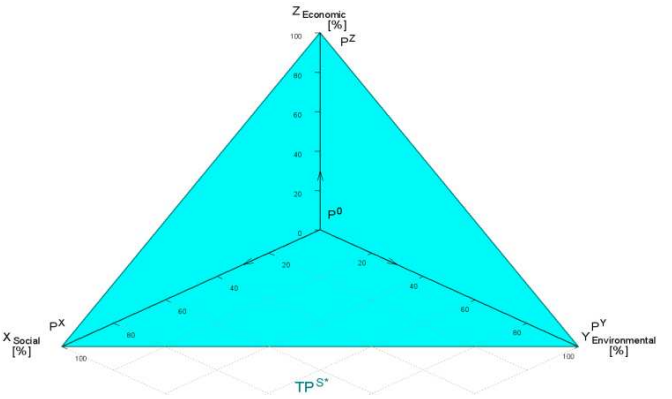

Fig. 9: Ideal triangular pyramid of sustainability with equilateral base area.

6 Discussion

In chapter two, we present several visualization approaches of sustainability and discuss their pro and cons. Now, we compare our triangular pyramid of sustainability with these.

It is impossible to visualize the change of one or more pillars of sustainability with the classic triangle of sustainability or the triangle of the committee of inquiry, because of equilateral triangles. In contrast, our triangular pyramid of sustainability allows this behavior (requirement 1). In addition, an equality of all pillars can be visualized, like described in special case 4. Moreover, our approach also emphasizes the equal importance of all pillars (requirement 5) by defining an optimum, look at special case 5.

The traditional pillar model of sustainability suggests that sustainability is in part independent of the pillars, like a roof of a house. If one or two pillars are missing, the roof will still exist. Our approach defines a strict relationship between the three pillars of sustainability and the sustainability itself qualitatively and quantitatively (requirement 3), look at special case 1 up to 3. In addition, the problem of a tilt by different key figures values is also eliminated without ignoring the dependence between the pillars and the overall sustainability.

According to the intersection model, figure 4, our triangular pyramid of sustainability also indicates the intersections between the pillars of sustainability with the triangles T^{XY0}, T^{X0Z}, and T^{0YZ} and emphasizes the cooperation of the pillars (requirement 2). Furthermore, our triangular pyramid of sustainability solves the problem of the undefined rate of intersections. The area of our triangular pyramid of sustainability can be calculated with the key figure values of the pillars of sustainability (requirement 4).

The main criticism point of visualizing the sustainability with the triangle of Gibbs is that

all points at the triangle of Gibbs always sum up to 100 percent. This fact suggests that the sustainability is always at 100 percent, too. The triangle of Gibbs allows assessing the quantity of the pillars of sustainability, but a comparison between concrete values of sustainability is impossible. Our approach enables to quantizing the sustainability using basic mathematical knowledge. Therefore, it is possible to make comparisons between different triangular pyramids of sustainability as well as the ideal triangular pyramid of sustainability, under the condition of equal influencing factors of all subdomains.

Although, our approach has some improvements in comparison to existing methods, but we also have to mention, that there is no software implementation, yet. We describe the theoretical background of our visualization approach. A quick solution could be realized with Excel. A more complex implementation should integrate interfaces to data suppliers, reporting tools as well as other application systems. This practical aspect is left for future work.

7 Conclusion and Future Work

First, we clarify the problem and convey the theoretical basics. Next, we present existing methods to visualize sustainability as well as their interpretations. Furthermore, we analyze the existing methods regarding their pros and cons and present a list of requirements based on our findings. In the main part of our contribution, we develop an own visualization approach, which allows to display the sustainability in the form of a triangular pyramid in a three-dimensional space. We verify our approach against some special visualization cases as well as against our list of requirements.
In conclusion, we developed a management tool, which fulfil the requirements mentioned in chapter one. This tool allows a qualitative and quantitative visualization of sustainability and supports the management to conduct sustainability comparisons between and within organizations but also between different periods. Our triangular pyramid of sustainability favors existing approaches, like the triangle of sustainability.

Future work has to deal with developing an efficient application of our approach. Determining a concrete key figure of sustainability S_{result} is also left for future. For example, both variations, the area of the triangle T^{XYZ}, as well as the volume of the pyramid TP^{N} are conceivable. Furthermore, the operationalization of the key figures x_{social}, $y_{environmental}$, and $z_{economic}$ for the pillars of sustainability, and defining a function method $f(x_{social}, y_{environmental}, z_{economic})$ are topics for future work. In addition, we prefer a more general discussion about our assumptions as well as the usability of three-dimensional figures.

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