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Sustainable Value Added

Measuring Corporate Sustainable Performance beyond Eco-Efficiency

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Contents

Figures and Tables

Frank Figge and Tobias Hahn

Sustainable Value Added.
Measuring Corporate Sustainable Performance beyond Eco-Efficiency

This paper proposes a new approach to measure corporate sustainable performance called Sustainable Value Added. Value is created whenever benefits exceed costs. Current approaches to measure corporate sustainable performance take into account external costs caused by environmental and social damage or focus on the ratio between value creation and resource consumption. As this paper will show it is more promising to develop sustainable measures based on opportunity costs. Sustainable Value Added is such a measure. It shows how much more value is created because a company is more efficient than a benchmark and because the resources are allocated to the company and not to the benchmark. The concept of strong sustainability requires that each form of capital is kept constant. As Sustainable Value Added is inspired by strong sustainability, it measures whether a company creates extra value without causing additional environmental or social impacts. Therefore, it takes into account both, corporate eco- and social efficiency as well as the absolute level of environmental and social resource consumption. Because the level of resource consumption is kept constant, Sustainable Value Added can be expressed in monetary terms. As a result, Sustainable Value Added considers simultaneously economic, environmental and social aspects. The overall result can be expressed in any of these three dimensions of sustainability. In this paper we have chosen the economic dimension for this purpose.

1 Introduction

How sustainable is your company? More and more companies have been confronted with this question over the last decade. To answer this question the contributions of companies to sustainability must be assessed. For this purpose a number of measures have been proposed. On the one hand, some postulate that companies contribute to sustainability only if the value created exceeds the external damage caused. Obviously, the major problem with these approaches is putting monetary values on external environmental and social damages. On the other hand, there are proponents of eco-efficiency. They stipulate that companies should create as much value per environmental impact as possible. However, improvements in eco-efficiency do not necessarily result in a better environmental performance. For example if a company becomes more eco-efficient and therefore also more successful it might end up producing more and thus using more instead of less environmental resources. Consequently, as will be shown, in practice many of these approaches are either difficult to apply or, if they can be applied, their significance is limited (see also Veleva & Ellenbecker 2000). In this paper, we propose a monetary measure of corporate contributions to sustainability – Sustainable Value Added – based on data that is actually available. Sustainable Value Added takes into account both, the efficiency and the absolute level (effectiveness) of resource use. Sustainable Value Added is the extra value that is created while keeping the overall level of environmental and social impacts constant.

The paper is organized in the following way: In the following chapter the current approaches to measuring corporate contributions to sustainability are briefly introduced and discussed. Chapter 3 explains the concept of Environmental Value Added which represents the basis for Sustainable Value Added. The concept of Sustainable Value Added is then developed and explained further in a single impact case (Chapter 4) and a multiple impacts case (Chapter 5). Chapter 6 summarizes the main findings and implications. Chapter 7 illustrates the calculation of Sustainable Value Added for a practical example.

2 Contributions to Sustainability

2.1 The concept of sustainability on the macroeconomic level

Sustainability: Keeping capital stocks intact

The concept of sustainable development has been developed over the last fifteen to twenty years mainly on a macroeconomic level. Central to the concept is the aim to increase or at least stabilize the per capita well-being or utility over time without leaving present or future generations worse off (see for the basic idea Hicks 1946, pp.172 and 184). The concept thus has an intergenerational as well as an intragenerational notion. More formally, when discussing sustainable development economists use different forms of capital[1] to describe sustainability (for the capital theory approach to sustainability see e.g. Harte 1995; Stern 1997; Prugh with Costanza et al. 1999, pp. 49). Usually, this comprises man-made capital (such as produced goods), human capital (such as knowledge and skills), natural capital (such as natural resources), and social capital (relationships between individuals and institutions). It follows, according to the constant capital rule, that development can be called sustainable, if it ensures constant overall capital stocks or at least constant capital services over time (e.g. Hartwick 1977; Solow 1986; Pearce 1988; Pearce & Atkinson 1998, p.253; Hediger 2000). Since there are several different kinds of capital the question, if one form of capital can be substituted by another form of capital needs to be addressed. This is done by the concepts of weak and strong sustainability (Pearce et al. 1989; Neumayer 1999).

The difference between weak and strong sustainability

Weak sustainability implies that all forms of capital are substitutable by each other so that any loss in stock or service of one kind of capital can in theory be substituted by a surplus in other forms of capital (e.g. Pearce & Atkinson 1993; Solow 1993; Cabeza 1996). Critics claim that at least some forms of capital have no substitutes and/or require a certain critical level which cannot be substituted (e.g. Costanza et al. 1991; Daly 1992; Costanza & Daly 1992; Pearce 1996, pp.16; Farmer & Randall 1998). The belief in non-substitutability of at least some kind of capital and therefore the need to conserve critical non-substitutable stocks are central features of *strong sustainability*. It is important to point out in this context, that strong and weak sustainability are not necessarily conflicting but that strong sustainability imposes *additional conditions* to the basic constant capital rule: environmentally strong sustainability requires natural capital to be non-declining while keeping the overall capital stock constant, and socially strong sustainability requires the same for social capital (Pearce & Atkinson 1998, pp.257). The reason for this is that man-made and natural and/or social capital are (at least partly) complements (Daly 1990; Costanza & Daly 1992; Prugh with Costanza et al. 1999, pp. 31). If we assume that e.g. natural capital is scarce and/or close to ecological limits it may not be reduced any further, since it is vital for a productive use of man-made capital (e.g. Ayres & Kneese 1969). It is due to this fact that strong sustainability imposes critical levels or safe minimum standards (Randall & Farmer 1996; Farmer & Randall 1998) for – at least some (Victor 1991; Toman 1994; Endres & Radke 1998) – natural capital (Costanza & Daly 1992; Daly 1995, pp.49; Arrow et al. 1995) in order to avoid irreversible resource losses.

The main difference between weak and strong sustainability is the degree to which substitutability between different forms of capital is considered (for a discussion see Norton & Toman 1997; Stern 1997). Based on the common constant capital rule the two views can be seen as the extreme endpoints of a continuum (full substitutability of all capital forms vs. no substitutability). In economic terms this continuum can be expressed by the marginal rate of substitution. A constant finite marginal rate of substitution indicates that substitution of e.g. natural capital by man-made capital is possible at the same rate regardless of the overall level of consumption or

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[1] The use of the term capital is misleading in this context. The term asset is used in finance and accounting to describe a physical item or a right that is expected to provide a future benefit. It would therefore be preferable to speak of natural assets (e.g. Repetto 1989) rather than of natural capital. We follow, however, the established terminology and use also the term capital.

scarcity of the resource (Neumayer 1999, p.24). On the other hand a growing marginal rate of substitution leads to higher rates the higher the level of overall consumption, and the closer consumption gets to ecological limits. Substitution becomes more difficult the scarcer the ecological resource. Eventually, this may lead to prohibitive high rates of substitution and thus de facto non-substitutability. Some authors point out, that the elasticity of substitution does not necessarily match the resilience and non-linearity of eco-systems (e.g. Common & Perrings 1992; Norton & Toman 1997).

Need for a common numeraire

In order to compare different forms of capital or even to account for different components within a capital form it is necessary to measure capital stocks and flows by finding some common numeraire. Usually, money is used as the numeraire which means that the *value* of capital stocks and flows is addressed. The value of any capital stock depends on technological change. Technological change usually results in higher capital efficiency which leads to more capital services from the same capital stock (Pearce & Atkinson 1998, p.253).

Related to strong and weak sustainability is the question, if sustainability is understood to be a satisficing or a maximizing concept. As a *satisficing concept* the aim of sustainability is to meet specified environmental, social and economic thresholds. If the notion of capital is used to describe sustainability the threshold will usually be to have a constant capital stock. As a *maximizing concept* the aim of sustainability is to maximize capital or, at least, to minimize its decline.

2.2 The concept of sustainability at the firm level

Corporate contributions to sustainability

Whilst originating from the macro level (for an overview on the measures on the macroeconomic level see Hanley 2000), the concept of sustainable development has been more and more applied to single economic entities such as companies (e.g. Gladwin et al. 1995a; Callens & Tyteca 1999). However, finding pertinent measures for the sustainable business or corporation in absolute terms is far from being trivial. This problem can be avoided by following the proposition made by Atkinson (2000, 240) to address theses issues on the microeconomic level in terms of *corporate contributions to sustainability*. As a consequence, the sustainability of a company is judged according to its economic, environmental, and social performance. Similar to the macroeconomic reasoning sketched out above, on the corporate level one also has to consider the degree of substitutability of man-made, natural, human, and social capital. Following this reasoning, on the corporate level the continuum also stretches from strong to weak corporate contributions to sustainability. In extreme, the former assumes no substitutability and thus requires an improved performance in at least one dimension while keeping performance in the remaining dimensions at least constant. This can be seen as the strive towards a Pareto-optimal situation (Feindt 2000, p.485). The latter assumes unlimited substitutability of capital, which allows a deteriorating performance in one dimension to be offset by a better performance in any other dimension.

In the following two sub-sections the two prevailing approaches (Callens & Tyteca 1999, pp.45) to measure corporate contributions to sustainability, i.e. absolute and relative measures, are introduced and discussed briefly. Both approaches compare costs and benefits created by an entity (e.g. a company).

2.2.1 Absolute measures

One way of assessing corporate contributions to sustainability is to subtract the costs from the benefits created by a company. For this purpose both internal and external costs need to be considered. They can be derived from full cost accounting (see e.g. Gray 1992; Rubenstein 1994; CICA 1997). The underlying idea is, that a company contributes to sustainability, if the benefits exceed the sum of internal and external costs. The result is e.g. called net value added (e.g. Huizing & Dekker 1992) or 'Green Value Added' (Atkinson 2000). These measures will usually look at a single company at a time and they will analyze, if certain thresholds have been met. As opportunity costs, i.e. the foregone value of alternatives not pursued, are not taken into account, they interpret sustainability as a satisficing concept.

Absolute measures: Subtracting costs from benefits

Benefits and costs can only be deducted, if they are measured in the same unit. It is for this reason, that environmental (and eventually social) damage are monetarized by these concepts. For example, Huizing & Dekker (1992) and Atkinson (2000) calculate their net or 'Green Value Added' for a single company and ten industry sectors, respectively. In this concept economic performance of a company or sector in terms of value added is adjusted for the external environmental cost caused by the company's or sector's economic activity. Atkinson (2000) further develops the argument and proposes the indicator "corporate genuine savings" which is the net profit rate after being charged for environmental (and social) damage, stemming from full cost accounting.

From a theoretical point of view these concepts provide very powerful measures of corporate contributions to sustainability. However, there are a number of shortcomings and problems:

- The approaches proposed to date require that environmental and social damage are expressed in monetary terms. Monetary valuation of environmental and social damage, however, is difficult and still controversially discussed (see e.g. Costanza et al. 1991; Huizing & Dekker 1992, pp.456; Steer & Lutz 1994, p.18; Funtowicz & Ravetz 1994; Callens & Tyteca 1999; Røpke 1999; Rees & Wackernagel 1999). Whenever data or estimates for the cost of some kind of environmental or social damage are missing or unreliable the measures lose much of their significance. The necessity to express environmental and social damage in monetary terms, severely limits its practicability.
- The approaches usually compare the value created by a company with the environmental and/or social damage caused. They therefore interpret sustainability as a satisficing concept. Compared to measures that interpret sustainability as a maximizing concept they allow to determine, if a company has reached a threshold level of sustainability. The ability to distinguish between companies that are sustainable and companies that are unsustainable constitutes an advantage. However, they will not give any information, if the maximum possible contribution to sustainability has been attained. For this purpose opportunity costs have to be taken into account.
- Individual or institutional preferences influence the conditions of how the three dimensions of sustainability are integrated through substitution and compensation (Edwards 1986; Munasinghe 1994, p.15; Feindt 2000, pp.485). The absolute approaches presented above are based on the assumption of full substitutability, i.e. they are mainly inspired by weak sustainability.

2.2.2 Relative measures

As shown above the monetary valuation of environmental and social impacts in practice is difficult but necessary, if costs are to be subtracted from benefits. Relative measures express corporate contributions as benefits per unit of environmental or social impact and can thus evade this restricting prerequisite. The best known example of a relative measure is eco-efficiency.

Relative measures: Benefits per impact

The notion of eco-efficiency is a direct result of economist's view of environmental problems. Environmental problems represent scarcities and efficiency-orientation is a typical economic response to scarcities.

Today, there are two different uses of the term eco-efficiency. As a *maxim* eco-efficiency refers to the reduction or even minimization of environmental impacts (e.g. Schmidheiny & BCSD 1992, pp.37; DeSimone & Popoff 1998; WBCSD & UNEP 1998; WBCSD 2000). The second notion uses the term eco-efficiency to describe the *ratio* of created value per environmental impact added (Schaltegger & Sturm 1990; Callens & Tyteca 1999). While a state of zero emissions might serve as a compelling political objective, it describes at the same time a state of no economic activity. The goal of a minimization of environmental impacts is therefore incompatible with the notion of efficiency. We therefore use the second notion of eco-efficiency, i.e. eco-efficiency – and analogously social efficiency – as a ratio. Eco-efficiency describes the degree to which a company uses environmental resources relative to its economic activity. Proponents of eco-efficiency claim that improvements in eco-efficiency enhance corporate contributions to sustainability (e.g. Callens & Tyteca 1999). When looking at the relation between sustainability and eco-efficiency one can distinguish between weak and strong improvements of eco-efficiency (Schaltegger & Burritt 2000, pp.53). Strong improvements in eco-efficiency comprise both an improved economic and environmental performance whereas weak improvements of the ratio only require one dimension to be improved.

Eco-efficiency is a ratio

Compared to absolute measures the most striking advantage of relative measures like eco-efficiency is of course, that benefits and costs can be expressed in different units. The relative measure consequently is then expressed in a synthetic unit (e.g. €/ton of CO_2). There are, however, three major shortcomings that present obstacles for relative measures to be used as a measure for corporate contributions to sustainability.

Firstly, relative measures like eco-efficiency do not give any information about effectiveness. In practice, efficiency and effectiveness are often confounded (e.g. Becker & Neuhauser 1975, p.4). Efficiency gives information about *the relation* between the unsought consequences (e.g. environmental impacts) and the desired end (economic performance) (similar to Barnard 1938, p.19, pp.91). Thus the environmental and economic performance of a company *in absolute terms* can not be derived from eco-efficiency ratios. The absolute degree of environmental, social, and economic performance is reflected by effectiveness measures (Schaltegger & Sturm 1990, p.278; Schaltegger & Sturm 1992, pp.25; Stahlmann 1996, p.72; Stahlmann & Clausen 2000). Because substitutability of different forms of capital is disputed, in order to be able to assess corporate contributions to sustainability we need additional information about *eco- and social effectiveness*. As a consequence, corporate contributions to sustainability cannot be judged by mere eco- and social efficiency information as these ratios do not give any indication on changes in economic, environmental, and social effectiveness of a company.

Efficiency does not cover effectiveness

Secondly, an improvement of a relative measure can have a perverse effect. Advances in environmental performance due to improved eco-efficiency might be over-compensated by two effects (Day 1998; Stahlmann & Clausen 1999, p.21; Gray & Bebbington 2000; Ullmann 2001; Dyllick & Hockerts 2002; for the macroeconomic level

Risk of over-compensation

Opschoor 1995; Muradian & Martinez-Alier 2001, p.175): On the one hand a better eco-efficiency can result in a higher demand. This growth effect might lead to an increase in the use of environmental resources which exceeds the level prior to the eco-efficiency improvement (rebound effect) (e.g. Dyllick & Hockerts 2002, p.5). On the other hand, environmental resources which are saved due to an improved eco-efficiency might be employed by other companies which are less eco-efficient. An increase of eco-efficiency might thus result in a decrease of eco-effectiveness and is therefore not a guarantee for a positive contribution to sustainability.

Overall aggregation difficult

Thirdly, eco-efficiency does not cover social aspects (Gladwin et al. 1995b). In addition, even if social aspects would be considered analogously as social efficiency, relative measures only allow to consider environmental and social impacts simultaneously that are expressed in the same unit. There are a number of methods to determine relative weights for some environmental impacts (e.g. Schaltegger & Sturm 1992; Heijungs et al. 1992). To arrive at a sustainability indicator all environmental and social subindicators must be weighted and aggregated (Ragas et al. 1995). It is, however, very doubtful that *all* relevant environmental and social impacts can be integrated in one common unit of environmental and social impact added respectively and that environmental and social impacts can be aggregated in one sustainable impact added (van den Bergh 1999; Callens & Tyteca 1999). If environmental and social impacts are measured in different units environmental and social impacts have to be considered separately and they can not be compared directly. This problem resembles the problem one encounters with absolute measures: To aggregate environmental and social aspects one needs to find a common numeraire, though in the case of relative measures this does not need to be a monetary numeraire.

2.2.3 Shortcomings and challenges of measuring corporate contributions to sustainability

Sustainable measure: Efficiency and effectiveness of all three dimensions

According to the three-pillar concept, sustainability encompasses economic, environmental and social goals (Barbier 1987). The objective of a sustainable measure is to assess the contribution of an entity (e.g. a company) to all three dimensions, environmental, social, and economic (Lawrence 1997; Moser 2001). As has become clear from the shortcomings of the merely absolute and relative measures discussed above, a sustainable measure must consider *the efficiency and the effectiveness of all three dimensions of sustainability simultaneously*.

In addition, such a measure is supposed to indicate both, if an entity has reached a threshold level, i.e. whether it contributes to sustainability (If-question), *and* where resources have to be allocated to deliver the highest degree of sustainability possible compared to other economic entities (Where-question). Investors regularly face a similar decision situation. They must determine, if the benefit of an investment opportunity exceeds its costs and if it is more attractive than other investment opportunities. We can learn from investment decision making, that for this purpose we must distinguish between direct and opportunity costs. Investments are only made if they both cover their direct costs and exceed the benefit that could be achieved, if the capital was invested differently (opportunity cost) (Brealey & Myers 1996, p.115; Solomons 1965, p.156).

		Benefit > Cost? (If-question)	
		considered	not considered
Maximum benefit? (Where-question)	considered	absolute Sustainable Value Added	relative Sustainable Value Added
	not considered	Net or Green Value Added	Value Added

Figure 1. If- and Where-Matrix.

This reasoning can also be applied to measuring corporate contributions to sustainability. Consequently, a sustainable measure should, on the one hand, allow to decide, if the use of a resource by an entity is sustainable, i.e. *if the resource should be used at all*. It should, on the other hand, reflect *where the resource should be allocated for optimal use*, i.e. where the resource attains the maximum surplus per resource unit. This decision situation can be expressed in the matrix depicted in Figure 1.

Introducing opportunity costs

The existing absolute measures (2.2.1 and lower left field of the matrix in Figure 1) try to answer the first question (If-question). They stipulate that an entity contributes to sustainability, if the benefit of a resource use exceeds its full cost, i.e. its internal and external costs. However, the opportunity cost, i.e. the benefit of an alternative use of the resources, is not considered. Only if this analysis was carried through for a number of entities the second question (Where-question) could also be answered by comparing the levels of value creation. However, conceptually such an opportunity perspective is not inherent to the existing absolute measures as can be seen with the example of BSO/Origin, where net value added is calculated for a single company without any consideration of opportunity cost (Huizing & Dekker 1992). Conversely, as pointed out before, these approaches are based on the restrictive prerequisite, that external costs for every environmental and social impact are known. It is this prerequisite, which limits the practical usefulness of these approaches. There are only rough estimates for most environmental externalities and there is an almost unlimited number of social externalities few of which have been priced so far (Steer & Lutz 1994, p.18). "[...] physical data on [environmental] pressures is the best that can be hoped for." (Atkinson 2000, p.243). Absolute measures can therefore only fall back on a very limited number of environmental and social impacts. Consequently there is a considerable risk, that environmental and social impacts that are not taken into account overcompensate these impacts.

A sustainable measure that is to indicate, *if and where* environmental and social resources should be used (upper left field in Figure 1) must consider both external and opportunity cost. As an indicator the *absolute Sustainable Value Added* would measure the residual value after Value Added of a company was adjusted for external environmental and social costs *and* opportunity costs. More formally, this is expressed by:

Sustainable Value Added: Covering direct and opportunity costs

absolute Sustainable Value Added = Value Added – external environmental and social cost – opportunity cost

However, such a measure suffers from the same restrictive condition as the absolute measures described above. Without complete monetary information on the numerous environmental and social external effects it is impossible to come up with meaningful results. In investment decision making the question, if the benefits of an investment opportunity exceed its direct costs is usually treated first. Only if an investment opportunity passes this test, the second test (Does it provide more value than other investment opportunities?) is carried out. When it comes to sustainable measures the question, *if* a resource should be used, can only be answered, if external costs are known. The second issue, *where* the resources should be allocated, can, however, be answered even if external costs are unknown by calculating a *relative Sustainable Value Added* (upper right field of the matrix in Figure 1). We therefore propose to separate the two questions. In the following the second question is in the focus of our attention.

External costs are unknown today

As will be explained in greater detail in the next chapters the environmental and social performance of different entities will be compared with each other to answer the second question. The *relative* corporate contribution to sustainability can thus be measured. The concept of Environmental Value Added (Figge 2001) is used and advanced to express this relative contribution in absolute monetary terms. This relative contribution,

A relative approach in absolute terms

called relative Sustainable Value Added, allows to determine by which entity the resources should be used. However, it does not show, if the use of the resource by this entity is sustainable but *how much more sustainable* (in monetary terms) the use of the resource is in comparison to another entity.

A measure based on strong sustainability

What might appear like a minor technical modification at first, encompasses a major change in focus on what constitutes the value respectively the cost of a resource. Measures that are based on external costs are based on the paradigm of weak sustainability and a situation in which there are two actors, i.e. the producer and the victim of an externality. The externality is priced by finding the amount of money that the producer has or would have to pay the victim, so that the victim accepts the externality. From this perspective all kinds of capital can be substituted. The idea that all externalities can be paid off has often been criticized (e.g. Funtowicz & Ravetz 1994; O'Hara 1998; Rees & Wackernagel 1999; Røpke 1999). Sustainable Value Added[2] is based on opportunity costs and a model with three actors. The value of a resource is determined by its alternative use (opportunity cost), i.e. the value another entity would create by using the resource. If we assume that resources are used by the entities to create value, it is this foregone value one would have to compensate to acquire the resource from other users. Since there is no additional environmental or social impact, on the macro level environmental or social capital is unchanged. Consequently, there is no additional damage for which the third actor, the victim, would need to be compensated. Substitutability thus does not matter, since we do not substitute different forms of capital for each other but rather change the allocation of a *given amount* of capital. Sustainable Value Added is therefore based on the paradigm of strong sustainability. Put in short Sustainable Value Added compensates potential sources of externalities for the avoidance of externalities while traditional approaches compensate victims for the acceptance of externalities.

Based on this logic, in the following we distinguish between substitution and compensation. Substitution addresses the question of whether *different forms of capital* can be replaced with each other (e.g. CO_2 emissions for jobs) (van den Bergh 1999). In contrast, compensation as used in this paper refers to transactions that compensate for an exchange of *different uses of a given resource*. This understanding of compensation refers to a purely allocative question. Thus, capital stocks are unchanged and substitutability of different kinds of capital does not matter.

The remainder of this paper is organized as follows: Chapter 3 introduces the concept of Environmental Value Added (Figge 2001), a concept to express the eco-efficiency of a company in comparison to a benchmark in monetary terms. Chapters 4 and 5 add effectiveness aspects to this basic reasoning. For the sake of ease and readability we first consider a simple impact case where effectiveness aspects are only considered for one environmental resource (Chapter 4) before developing the case for multiple environmental and/or social impacts (Chapter 5). Chapter 6 summarizes the implications and main results of Sustainable Value Added. In the last Chapter we illustrate the calculation of Sustainable Value Added for a sample company.

3 The Concept of Environmental Value Added

Eco-efficiency has been identified above as a very popular relative measure to assess corporate contributions to sustainability. Eco-efficiency (and social efficiency) numbers as they are calculated today are disadvantaged compared to other business information. They are measured in synthetic units (e.g. € per CO_2-equivalents) that are difficult to interpret. However, in principle, the notion of efficiency is not new in economics and many other efficiency concepts are exposed to

[2] When speaking of Sustainable Value Added in the following we always refer to the relative Sustainable Value Added as introduced above (see also Figure 1).

the same drawback. Efficiency considerations are used whenever desired and undesired aspects need to be balanced. A good example are risk-return considerations in financial management. It is usually assumed that investors like return and dislike risk. Investors therefore, when they decide where to invest, take two aspects into account: risk and return. There are a number of ratios that are used to describe the relation of risk to return. The best known ratios are the Sharpe- (Sharpe 1966) and Jensen- (Jensen 1968) and Treynor- (Treynor 1965) ratios. There are two things we can learn from these ratios.

Considering opportunity costs adds information

First, when looking at efficiency it is useful to take opportunity costs into account. As already mentioned above, opportunity costs correspond to the benefits of unrealized alternatives. When assessing investment opportunities, opportunity costs are considered e.g. by comparing the return of investment alternatives to a risk-free return or the return of investments with a similar level of risk. In finance the alternative an investment opportunity is compared to is called a benchmark. It is advisable to also make similar considerations when assessing eco- or social efficiency (Clift & Wright 2000; Taylor & Postlethwaite 1996).

Efficiency-ratios are difficult to interpret

Second, the use of risk-return ratios in practice is disillusioning. The significance of risk-return ratios is, just like eco-efficiency ratios, only accessible to experts. The complexity of existing risk-return ratios is due to the fact that risk and return are measured in two different units and that risk-return ratios are therefore recorded in synthetic units that are difficult to interpret.

In response to difficulties experienced in interpreting risk return ratios Modigliani and Modigliani (1997) have proposed a new risk-return measure. This new measure expresses the relation between risk and return in a monetary unit and facilitates thus its interpretation. As Figge (2001) has shown eco-efficiency can be measured in a similar way.

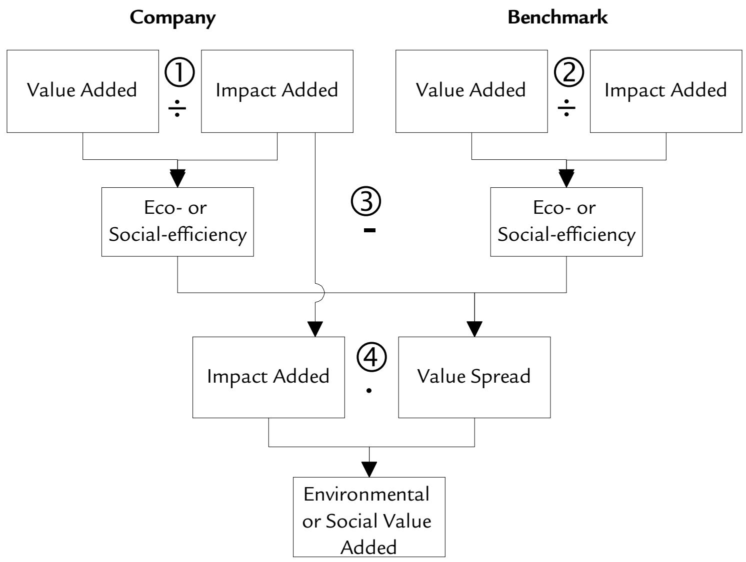

Figure 2. Evaluation steps of the Environmental or Social Value Added (Similar to Figge 2001).

Calculating Environmental Value Added

The Environmental Value Added corresponds to the economic value that is created by a level of eco-efficiency that is above the benchmark's level. The Environmental Value Added measures therefore, analogous to Economic Value Added (Stewart 1991), the economic value of an eco-sur-efficiency. The Environmental Value Added is determined in four steps (see Figure 2).

Step 1: Determination of "traditional" corporate eco-efficiency

In a first step eco-efficiency of the company must be determined. There are a several ratios, that can be used to express eco-efficiency. We here use the ratio $\frac{\text{Value Added}}{\text{Environmental Impact Added}}$ (Schaltegger & Sturm 1990). Environmental impact added represents the sum of all energy and material flows induced by economic activity weighted by their relative harmfulness to the environment (Schaltegger & Sturm 1992). Environmental impacts are measured in physical units.

Step 2: Determination of the "traditional" eco-efficiency of the benchmark

In a second step eco-efficiency of the benchmark must be determined analogously to the eco-efficiency of the company. The choice of the benchmark depends on the desired significance of the comparison. Possible benchmarks are e.g. eco-efficiency of preceding periods, similar companies, a sector or even an entire economy.

Step 3: Calculation of a value spread

To be able to compare corporate eco-efficiency to the eco-efficiency of a benchmark a value spread is calculated, i.e. the eco-efficiency of the benchmark is deducted from the eco-efficiency of the company. Value spread and eco-efficiency of the company and the benchmark are all measured in the same unit (e.g. €/tons of CO_2). The value spread reflects how much more (value spread > 0) or less (value spread < 0) value added per unit of environmental impact added the company has produced than the benchmark. By calculating a value spread a meaningful point of origin is introduced. A value spread of zero shows that the company has the eco-efficiency of the benchmark.

Step 4: Calculation of the Environmental Value Added

The value spread is measured in the unit of the "traditional" eco-efficiency and is thus difficult to interpret. In this last step the value spread is therefore multiplied by the level of environmental impacts of the company. The result is called the Environmental Value Added. The Environmental Value Added reflects in the unit of the value added how much more value added is produced due to the fact that a given level of environmental impacts is "used" by the company instead of the benchmark.

The Environmental Value Added concept can be graphed easily (Figure 3). The slopes of the two lines through points A and B reflect the eco-efficiency of the company (line through point A) and the benchmark (point B). The steeper the slope the more value is created per environmental impact added. A steeper slope reflects therefore a higher level of eco-efficiency. In the example depicted in Figure 3 the company has a higher eco-efficiency than the benchmark. With the

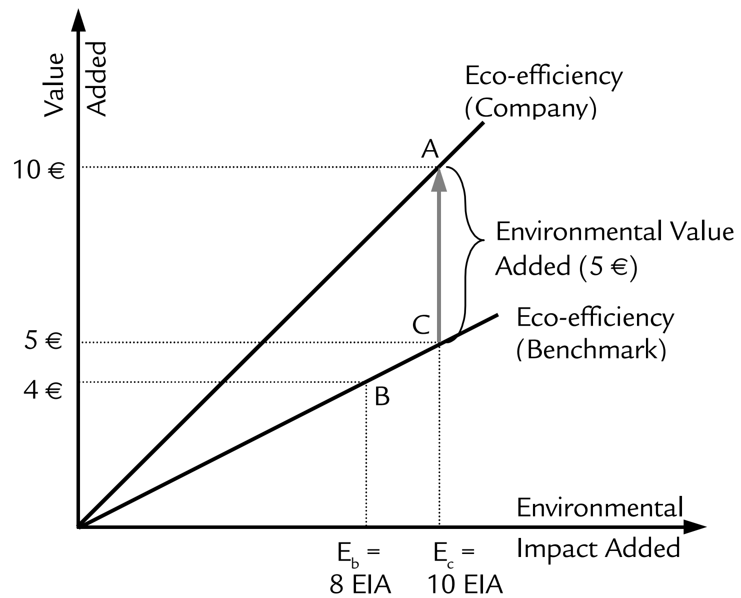

Figure 3. Graphical representation of the Environmental Added of a sample company (Figge 2001).

eco-efficiency of the benchmark 5 € can be produced with 10 units of environmental impacts. The company generates in contrast 10 € with the same environmental impact. It generates therefore an Environmental Value Added of 5 € (line AC).

More technically, the EnVA can be expressed as the product of the value spread and the level of resource use. This results in

$$EnVA = (\text{Eco-efficiency}_{\text{company}} - \text{Eco-efficiency}_{\text{benchmark}})\ \text{Environmental impact added}_{\text{company}}.$$

More formally, this translates to

$$EnVA = \left(\frac{VA_c}{EIA_c} - \frac{VA_b}{EIA_b} \right) \cdot EIA_c \,, \tag{3.1}$$

with VA_c and VA_b being the Value Added, and EIA_c and EIA_b the environmental impact added of the company and the benchmark, respectively.

To analyze the social dimension of corporate contributions to sustainability we propose to define social performance, in analogy to environmental performance, via social bads. Therefore, social efficiency is used here similar to the concept of eco-efficiency (Callens & Tyteca 1999). Consequently we define social performance via social impacts. Less social impacts are preferred to more social impacts, i.e. the less social impacts the higher social performance. Social Value Added can then be calculated analogously to the Environmental Value Added.

Less social bads = more social performance

Economic activity leads to a wide range of environmental and social impacts. Environmental or Social Value Added can be calculated for every single environmental or social impact, respectively. As a result one will obtain a range of EnVAs and SoVAs reflecting every relevant environmental and social impact of a company (e.g. a green-house-potential-EnVA, an ozone- depletion-potential-EnVA, as well as a work-accidents-SoVA or an unpaid-overtime-SoVA). As already mentioned above we will first address a single impact case (chapter 4) in order to explain the main reasoning. In chapter 5 we will then develop the argument further based on a multiple impacts case to show how to deal with the more complex and realistic situation of multiple environmental and social impacts.

The Environmental Value Added concept provides the basis for Sustainable Value Added. It serves to introduce a relative perspective as it assesses the eco-efficiency of a company in comparison to a benchmark. By doing so, it introduces an opportunity cost perspective to assessing corporate contributions to sustainability. The EnVA (or SoVA) indicates the extra value that is gained or lost due to the use of a given amount of environmental (or social) resources in a company in comparison to its use in a benchmark. In addition, it helps to convert eco-efficiency ratios into meaningful monetary terms. However, as shown above, to evaluate corporate contributions to sustainability it is not sufficient to look at eco- and social efficiency. Rather effectiveness aspects have to be taken into account. This will be done in the following chapters.

Effectiveness is still lacking

4 The Single Impact Case

Based on the discussion of the present absolute and relative approaches and the concept of Environmental Value Added we now introduce Sustainable Value Added as a new approach to measure corporate contributions to sustainability. This will include both efficiency and effectiveness considerations. In this chapter we develop the derivation of Sustainable Value Added for a single impact case, i.e. for the time being in order to keep the argument understandable we only consider eco-efficiency, economic and environmental effectiveness, and reduce eco-effectiveness to one environmental impact. In chapter 5 this will be extended to multiple environmental and social impacts.

4.1 Changes in efficiency and effectiveness

As noted above, an increase in eco-efficiency can lead to a decreasing eco-effectiveness. A company that is more eco-efficient might e.g. increase its competitiveness which might result in a higher demand and eventually in an increased consumption of resources. In other words, the improvements in eco-efficiency might be over-compensated by a growth effect (Stahlmann & Clausen 1999, p.21). This effect is illustrated in Figure 4. We here compare the company's change in eco-efficiency between the two periods t_0 and t_1. In addition, the absolute changes in economic and environmental performance (effectiveness) are taken into consideration.

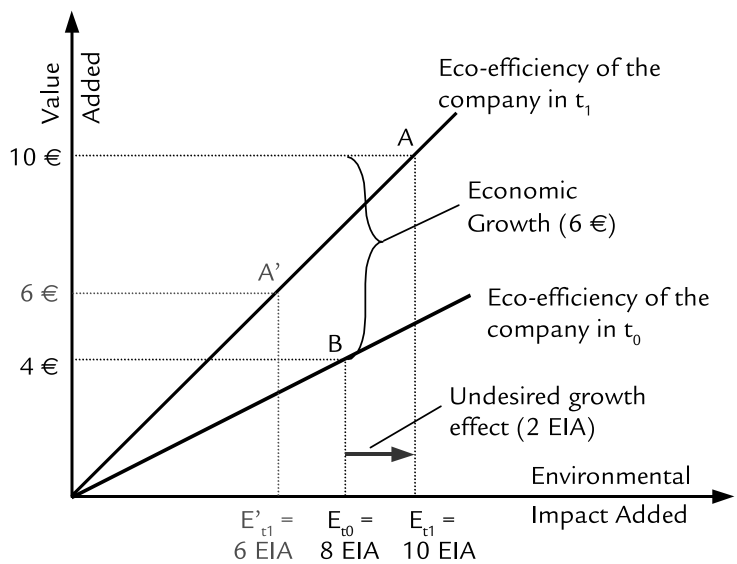

Figure 4. Graphical representation of the growth effect for the simple impact case.

The company in Figure 4 uses 8 EIA in t_0 to create 4 € Value Added (point B in Figure 4). Thus, the eco-efficiency of the company in t_0 is $0.5 \frac{€}{EIA}$. In t_1 the economic output of the company mounts to 10 € Value Added using 10 EIA (point A in Figure 4). This translates into an eco-efficiency of $1 \frac{€}{EIA}$ in t_1. Since we want to find out, if the company has contributed to more sustainability during the period under observation we have to compare the performance of t_1 to the performance of t_0. We observe that eco-efficiency of the company has doubled from t_0 to t_1. With the improved eco-efficiency the company creates a Value Added of 10 € in t_1, which translates in a change in economic output (economic growth) of +6 € (see Figure 4). However, the absolute level of environmental impacts added has also risen from t_0 to t_1: Despite the doubled eco-efficiency the company uses 2 EIA more (undesired growth effect) than in the period before (line $E_{t0}E_{t1}$ in Figure 4). Economic growth has therefore overcompensated the increase in eco-efficiency, eco-effectiveness has therefore decreased, which can be interpreted as an undesired environmental growth effect.

Considering changes in efficiency and effectiveness

We can generalize the assessment procedure just used. To assess corporate contributions to sustainability during a period changes in eco-efficiency and changes in economic and eco-effectiveness must be considered. If economic, environmental *and* social performance attain at least the level of the preceding period strong contributions to sustainability are attained. In Figure 4 environmental performance deteriorates, because the eco-efficiency improvement is over-compensated by economic growth. Thus, up to this point one would be tempted to conclude that there has been no strong contribution to sustainability (Schaltegger & Burritt 2000, p.53). In other terms, the development during the period under observation is not Pareto-optimal, as the improvement in economic output is accompanied by a deterioration of environmental performance.

4.2 Introduction of opportunity costs

So far, opportunity cost are not taken into account. However, as shown above, for the assessment of corporate contribution to sustainability opportunity cost of the use of resources must be considered (see 2.2.3). For this purpose we get back to the concept of Environmental Value Added. As chapter 3 has shown, the Environmental Value Added (EnVA) expresses the (positive or negative) extra value created due to the fact that a given amount of environmental resources is used by the company instead of the benchmark. EnVA is positive (negative), if the company is more (less) eco-efficient than the benchmark. Consequently, the level of economic output that has not been realized because resources were allocated to the company instead of to the benchmark represents the foregone value of the resources use by the company. This foregone value is called opportunity cost.

Opportunity cost = foregone value

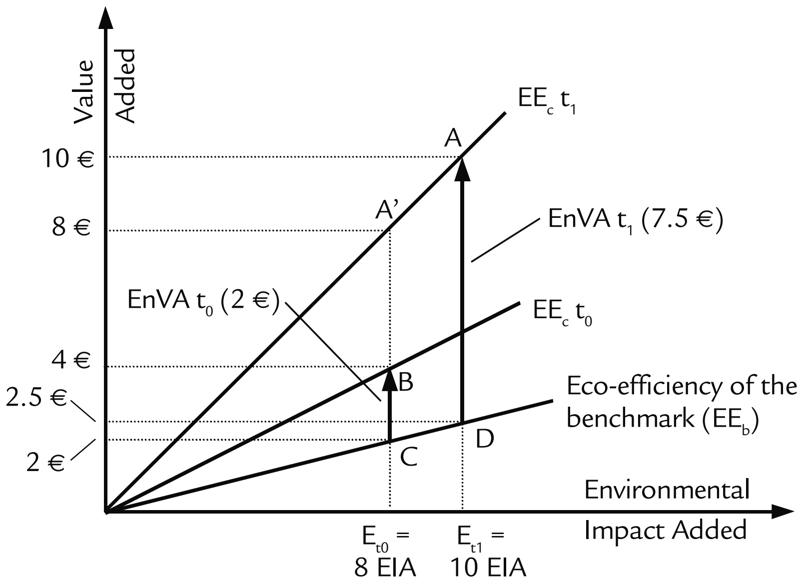

Figure 5. Introduction of the benchmark and calculation of Environmental Value Added.

In Figure 5 opportunity costs are introduced graphically. As we use the same example as before we add as opportunity cost the eco-efficiency of the benchmark, which is given by the line EE_b. In the example the eco-efficiency of the benchmark is $0.25\frac{€}{EIA}$. As stated above in chapter 3, the choice of the benchmark depends on the desired significance of the EnVA. In the context of corporate contributions to sustainability the most obvious question to answer is whether a company has contributed to the sustainability of a national economy during the period of time under observation. Therefore, we propose to choose the national economy as a benchmark. As a consequence, EE_b indicates the eco-efficiency of the national economy which is given by the ratio between the Gross Domestic Product (GDP) and the environmental impacts created by all entities of that economy.

4.3 Calculation of Sustainable Value Added for the single impact case

As shown in 4.1, improvements in eco-efficiency might not be sufficient for strong corporate contributions to sustainability. Eco- (and social) effectiveness must also be considered. In the example above, the improvement of corporate eco-efficiency has been over-compensated by economic growth, causing an undesired deterioration of the environmental performance of the company. However, if we take into account the opportunity perspective we can answer the question whether it was *more* sustainable that the company used the additional resources instead of someone else or not. This is expressed by

Eco-efficiency is not sufficient

Sustainable Value Added. Sustainable Value Added for the single impact case can be explained and calculated in two different ways, leading to the same result. These two ways are now described in detail.

4.3.1 Compensating less efficient users of resources for avoiding environmental impacts

The eco-efficiency of the benchmark indicates how efficiently the national economy uses an environmental resource. To become more sustainable on a national level, resources should be allocated to those companies that are more eco-efficient. As will be shown this can hold true, even if eco-efficiency and thus eco-effectiveness of the company deteriorate during the period under observation.

If we assume that companies use environmental (and social) resources to create value, other, less efficient companies will agree to sell a resource, if this creates more value than using it. Since eco-efficiency shows how much value is created per EIA it also corresponds to the price a company has to pay to convince another company to "give up" the resource. Based on this reasoning the company can compensate for the *additional* environmental impacts it causes by buying environmental (and/or social) resources from benchmark companies. The price for this compensation is given by the eco- (or social-)efficiency of the benchmark, which we have identified as opportunity cost before.[3] It is crucial to note, that in this context compensation does not mean paying victims of external effects to make them accept these impacts like it is done in the absolute approaches introduced above (see 2.2.1). Rather, it means paying the companies of the benchmark to reduce their environmental (and/or social) impacts to the degree that the company has caused a deterioration of its environmental (and/or social) performance. In other words, compensation here means paying the companies of the benchmark for giving up some of the resources they would otherwise use. *As a result the total level of impacts is unchanged.*

Opportunity cost = price of a resource

One could now be led to conclude that all resources should be allocated to the most efficient company to maximize the contribution to sustainability. However, it should be kept in mind that companies must create additional value (economic growth) to compensate for additional impacts. Buying all resources would possibly reduce economic effectiveness. Consequently, the scope to buy environmental impacts added from less efficient users is limited by the economic growth of the company. If the company spends more funds than economic growth on compensating undesired changes in eco- (or social-)effectiveness, this will leave the company worse off in terms of economic effectiveness.

To find out, if the company can pay for the compensation of any additional environmental impact it has caused we must compare the additional funds that are at its disposal (= economic growth) to the cost (= price quantity) of the additional environmental impacts. The price, as explained above, corresponds to the eco-efficiency of the benchmark. The quantity equates to the additional environmental impacts caused. The company can afford the compensation of a deteriorated environmental performance as long as economic growth at least equals the cost of compensation. More formally, this condition is expressed in

Economic growth > cost of additional resources?

$$VA_{t1} - VA_{t0} \geq EE_{b} \cdot \left(EIA_{t1} - EIA_{t0}\right). \tag{4.1}$$

[3] We assume that the eco- (and social-)efficiency of the benchmark does not change during the period under observation. This assumption is quite realistic, if we consider a short period of time and if there are many companies that make up the benchmark. The concept could also consider a changing eco- and social efficiency of the benchmark. This would, however, complicate the reasoning without providing additional insights.

It follows, that for the single impact case a Sustainable Value Added is created, if additional value has been created after negative changes in eco-effectiveness have been compensated for. Sustainable Value Added for the single impact case therefore equals economic growth minus cost of compensation. This is expressed by the following formula:

SusVA = economic growth – cost of compensation

$$\mathrm{SusVA}_{\mathrm{si}} = EG - EE_{\mathrm{b}} \cdot \left(EIA_{\mathrm{t1}} - EIA_{\mathrm{t0}}\right), \qquad (4.2)$$

with $\mathrm{SusVA}_{\mathrm{si}}$ being Sustainable Value Added for the single impact case, EE_{b} the eco-efficiency of the benchmark, $EG = \mathrm{VA}_{\mathrm{t1}} - \mathrm{VA}_{\mathrm{t0}}$ representing economic growth and EIA_{t1} - EIA_{t0} the additional environmental impacts that need to be compensated. For the example depicted in Figures 4 and 5, the $\mathrm{SusVA}_{\mathrm{si}}$ results in $6 € - 0.25 \frac{€}{\mathrm{EIA}}$ (10 EIA – 8 EIA) = 5.5 €.

So far, we have considered the case where an improvement in corporate eco-efficiency from t_0 to t_1 was over-compensated by economic growth. In this context Sustainable Value Added indicates whether economic growth has created enough scope to compensate the undesired growth effect in eco-effectiveness through buying environmental impacts added from benchmark companies. In this example part of the economic growth must therefore be given up. In order to generalize the argument further, we now look at a case where there are both, an improved eco-efficiency and economic growth, but where economic growth has not led to an undesired growth effect in terms of additional environmental impacts. For this purpose, consider point A' in Figure 4. With the same performance level in t_0 and the same improvement of the eco-efficiency as in the case before, in t_1 the company now only grows from 4 € in t_0 to 6 € Value Added in t_1. As a result environmental impacts are reduced from 8 EIA in t_0 to 6 EIA in t_1. Economic effectiveness is therefore still improved (+2 €; though to a lesser degree) and environmental effectiveness now also improves (–2 EIA). Corporate effectiveness improves in all dimensions. Thus no compensation is necessary to achieve a strong contribution to sustainability. In other words, there is no need to buy any environmental impact added from benchmark companies to ensure that the overall level of resource consumption is maintained. However, since we want to find out, how economic effectiveness changes, when eco-effectiveness remains unchanged, the 2 EIA saved are now valued at their opportunity cost. This corresponds to the revenue the company would attain, if it decided to "sell" the EIA it no longer needs to the benchmark companies. The term that constituted a cost above now becomes a revenue. Thus, in this case the $\mathrm{SusVA}_{\mathrm{si}}$ of the company exceeds its economic growth by the value the benchmark companies create with the saved environmental resources. The company now has a second source of revenue. Equation (4.2) still holds true for this case. $\mathrm{SusVA}_{\mathrm{si}}$ here is $2 € - 0.25 \frac{€}{\mathrm{EIA}}$ (6 EIA – 8 EIA) = 2.5 €. Note that in this calculation the term for "cost of compensation" shows up negative, and thus constitute a revenue, so that $\mathrm{SusVA}_{\mathrm{si}}$ > economic growth.

Additional environmental resources: Cost or revenue?

We can now generalize the reasoning developed so far. Sustainable Value Added (here: for the single impact case) examines, if changes in economic, environmental and/or social performance of a company during a given period have contributed to sustainability relative to a benchmark (e.g. relative to the national economy). It expresses in monetary terms *by how much* the performance of a company in a period t_0-t_1 has *contributed to make the national economy more sustainable*. For this purpose an opportunity cost perspective is introduced. Following the requirement that the overall effectiveness has to be maintained the SusVA examines a situation of an overall constant level of resource consumption. It calculates and expresses in monetary terms the extra value a company creates under the condition of a maintained overall level of resource consumption.

By how much has a company contributed to more sustainability?

4.3.2 Calculating EnVA-differentials

This provisional result leads us to the second way to deduce and calculate Sustainable Value Added for the single impact case. As shown in section 4.2 it is crucial to take up an opportunity cost perspective for the calculation of Sustainable Value Added. It is for this reason that we have introduced a benchmark (see Figure 5). As soon as there is a benchmark one can easily calculate the Environmental Value Added. This can be done separately for t_0 and t_1 using formula (3.1). $EnVA_{t0}$ (+2 € in our example) and $EnVA_{t1}$ (+7.5 € in our example) express how much more (or less) value is created by the company relative to the benchmark in the respective period. $EnVA_{t0}$ and $EnVA_{t1}$ are shown graphically in Figure 5 by the two arrows CB and DA, respectively. The Environmental Value Added incorporates two effects – the efficiency effect and the allocative effect. We now discuss these two effects using the example of $EnVA_{t1}$ as shown in Figure 5.

The *efficiency effect* shows how much more value the company would have created in comparison to the benchmark by using only the resources of t_0 with the eco-efficiency of t_1. The resulting extra value is only due to the change in eco-efficiency between t_0 and t_1. Obviously, in this calculation eco-effectiveness is unchanged. We can also express the efficiency effect more formally:

Efficiency effect …

$$\text{Efficiency effect} = EIA_{t0} \cdot \left(EE_{t1} - EE_{b}\right), \tag{4.3}$$

with EIA_{t0} representing the environmental impact added in t_0, and EE_{t1} and EE_b being the corporate eco-efficiency in t_1 and the eco-efficiency of the benchmark, respectively.

The *allocative effect* shows how much extra value is created compared to the benchmark, because the company uses more or less resources in t_1 than in t_0. This effect, too, can be expressed formally:

$$\text{Allocative effect} = \left(EIA_{t1} - EIA_{t0}\right) \cdot EE_{t1} - \left(EIA_{t1} - EIA_{t0}\right) \cdot EE_{b}. \tag{4.4}$$

On the one hand, the allocative effects depends on the eco-efficiency of the company compared to the benchmark. If the company is more eco-efficient in t_1 than the benchmark value can be created by shifting resources from the benchmark to the company. It depends, on the other hand, on how many resources are transferred from the benchmark to the company. It is important to note, that the allocative effect *does not* depend on corporate eco-efficiency in t_0.

… and allocative effect

In addition, note that while corporate eco-effectiveness might eventually decline, the allocative effect reflects a situation in which the amount of environmental impacts *on the macro level* (represented by the benchmark) is constant. This can easily be seen if one takes a closer look at equation (4.4), which has been noted here in a longer form, intentionally. The term $EIA_{t1} - EIA_{t0}$ stands for the change in corporate eco-effectiveness. It becomes clear that the change in eco-effectiveness is added in the first part of the equation (valued with the corporate eco-efficiency in t_1). This shows how much value is created by the company with the additional resources used. To ensure that eco-effectiveness remains constant the additional resources must be bought from benchmark companies. Therefore, the additional resources are deducted valued with the eco-efficiency of the benchmark in the second part of the equation. Thus, the level of resource consumption on the benchmark level is left unchanged.

Together, the efficiency effect and the allocative effect sum up to the Environmental Value Added in t_1. Put differently Environmental Value Added in t_1 can be created because the company has become more eco-efficient during the period under observation (efficiency effect), because it was more eco-efficient in t_1 than the benchmark and has reduced more environmental resources or because it was less eco-efficient in t_1 than the benchmark but has reduced the environmental resources it uses (both allocative

EnVA = efficiency + allocative effect

effects). It can also be shown mathematically (see Annex), that the sum of equations (4.3) and (4.4) can easily be converted into and thus equals equation (3.1).

The Environmental Value Added of t_1 represents the (positive or negative) extra value created relative to a benchmark for the corporate performance at the given time t_1. However, in order to examine corporate contributions to sustainability the change in corporate performance from one period to another is at the center of interest. Therefore, in order to calculate Sustainable Value Added for the single impact case (si), one has to deduct the Environmental Value Added of the preceding period ($EnVA_{t0}$) from the Environmental Value Added of the current period ($EnVA_{t1}$). $EnVA_{t0}$ and $EnVA_{t1}$ can easily be calculated by using equation (3.1). As a result, Sustainable Value Added for the single impact case can also be expressed as

SusVA = additional EnVA created

$$\mathrm{SusVA}_{si} = EnVA_{t1} - EnVA_{t0}. \tag{4.5}$$

In the Annex, it is shown that the expressions (4.2) and (4.5) are equal so that the two ways of calculating the $SusVA_{si}$ always lead to the same result.

We can now also apply these findings to cases where *corporate eco-efficiency is below benchmark eco-efficiency*. For this purpose, imagine that the eco-efficiency of the benchmark in the example given in Figure 5 is now $1.5\frac{€}{EIA}$ (instead of $0.25\frac{€}{EIA}$) and all other parameters being equal. Thus, corporate eco-efficiency has still doubled, economic growth still amounts to 6 € and the undesired growth effect to 2 EIA. However, the cost for compensating the undesired growth effect is now 3 € as the company now has to pay the benchmark companies 1.5 € per EIA. This results in a $SusVA_{si}$ of 3 € resulting from 6 € (economic growth) – 3 € (cost of compensation). When looking at the EnVAs one finds that in t_0 the company has created 8 € less than the benchmark would have created ($EnVA_{t0}$ = –8 €), while in t_1 due to its improvement in eco-efficiency the company's level of value creation only falls short 5 € of the benchmark level ($EnVA_{t1}$ = –5 €). The EnVA-differential and thus the $SusVA_{si}$ results in +3 € which shows the value of a better but – when compared to the benchmark – still unsatisfactory performance of the company. Corporate eco-efficiency has increased enough to compensate for the loss in eco-effectiveness. The company, however, still falls short of the benchmark level of eco-efficiency.

If one looks at this example from a slightly different angle, an interesting result emerges. Imagine that despite its improved eco-efficiency in t_1 the company would curb its economic output to 3 € in t_1 compared to 4 € in t_0. At the first glance, this translates to a loss in economic effectiveness compared to t_0. However, calling in the opportunity cost perspective it soon becomes clear that the 5 EIA saved would generate a revenue of 7.5 € that overcompensates the loss in economic effectiveness. Thus, $SusVA_{si}$ in this case would be +6.5 € due to a positive allocative effect. This example shows that an increase in corporate eco-efficiency does not justify economic growth as long as the eco-efficiency of the company is still below the eco-efficiency of the benchmark.

Changes in efficiency: Just better or good enough?

Generalizing the findings of this chapter, we can recapitulate that Sustainable Value Added (here: for the single impact case) expresses the (positive or negative) extra value created by a company adjusted for changes in eco- (or social-)effectiveness. In other words, SusVA reflects the extra value created for a constant overall level of resource consumption. It thus adopts the constant capital rule which lies at the very heart of notion of sustainable development. The Sustainable Value translates into monetary terms by how much a company has contributed to make an entity (e.g. the national economy) more sustainable. A positive SusVA indicates a positive and a negative SusVA a detrimental contribution to sustainability.

From the development of Sustainable Value Added for the single impact case one can deduce a number of additional consequences. It has become clear that the question whether an improvement in corporate eco-efficiency has contributed to more sustainability can only be answered by considering opportunity costs. It follows that changes in corporate effectiveness, too, have to be judged from a benchmark view. Thus, in order to assess corporate contributions to sustainability it is indispensable to consider corporate and benchmark eco-efficiency – indicating how efficiently resources are used – *and* the allocative efficiency – showing to which degree resources have been allocated to the most efficient users (analogous Leibenstein 1966). As a consequence, Sustainable Value Added establishes a micro-macro link, i.e. it links a single company's activities to the sustainability of a larger economic entity it belongs to. However, it clearly remains within the corporate perspective as it assesses and values single companies' contributions to more sustainability. The question of how much a company contributes to sustainability requires to consider changes in corporate efficiency and effectiveness from the firm's as well as from a benchmark perspective. As could be shown above, for this purpose it is fruitful to examine whether the company succeeded in creating a positive extra value while keeping eco- (and social) effectiveness on the overall benchmark level unimpaired.

A micro-macro link

As stated at the very beginning of this chapter we so far assumed only one single (environmental) impact caused by economic activity. This is of course unrealistic. The following section will therefore generalize the findings of the single impact case to multiple (environmental and social) impacts.

5 The Multiple Impacts Case

For the multiple impacts case social impacts are taken into account, too. To analyze social efficiency and effectiveness we have defined social performance, as mentioned above, via social bads. Social Value Added can then be calculated analogously to the Environmental Value Added as shown above in section 3. For every environmental and social impact an Environmental – and analogously – a Social Value Added can be determined separately.

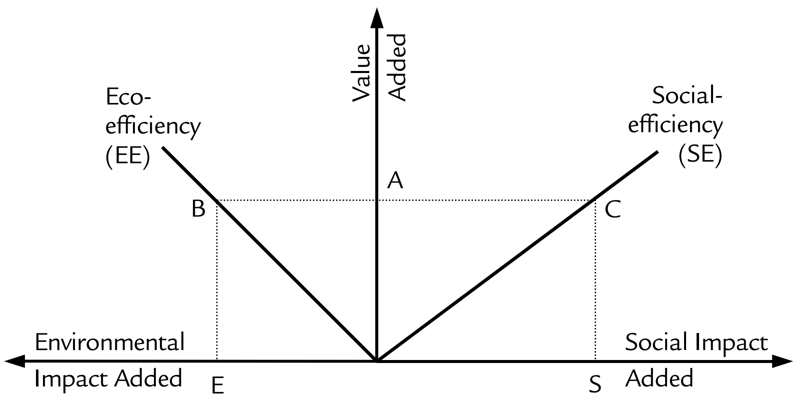

Figure 6. Eco- and social efficiency and economic, environmental and social performance.

For the extension of Sustainable Value Added to the multiple impacts case it is important to note that eco- and social efficiency both relate a level of environmental respectively social impacts to a common level of economic activity. This can be illustrated graphically by depicting eco- and social efficiency with a common axis for the economic performance. Figure 6 reproduces eco- and social efficiency of a sample company. Eco- and social efficiency are represented by the lines through points B and C. Point A represents

Multiple impacts – One level of economic activity the common level of economic activity and point E the environmental and point S the social impact caused by the economic activity.

If we follow this logic further we arrive at a situation where we consider *n* environmental and *m* social impacts which are caused by the economic activity of the company. This serves to represent the complete bundle of environmental and social resources used by a company to create a certain level of economic output. As a consequence, every environmental or social impact of the company or the benchmark is characterized by a specific eco- (EE_i) or social efficiency (SE_j), and eco- (EIA_i) and social effectiveness (SIA_j). Obviously, efficiency and effectiveness always relate to a specific period (t_0 or t_1 in our examples) and for each period and each impact the Environmental and Social Value Added can be calculated. For example, $EnVA_{i,t0}$ expresses how much more or less value a company has created relative to a benchmark in period t_0 by using a given level of the environmental resource *i*. Analogously, $SoVA_{j,t1}$ stands for the excess value created by the use of the social resource *j* in t_1. This is in line with the reasoning for the single impact case sketched out in detail in the last chapter.

In order to determine Sustainable Value Added for the multiple impacts case one can fall back on the reasoning developed above for the example of the single impact case. Whenever economic growth exceeds the cost of compensation for any negative changes in eco-effectiveness (e.g. an undesired growth effect) Sustainable Value Added for the single impact is positive (see equation (4.1)). In the multiple impacts case, as all environmental and social impacts are considered, more than one undesired growth effect might have to be compensated. Therefore, for the multiple impacts case this condition translates as follows. A positive Sustainable Value Added *for the multiple impacts case* occurs as long as economic growth exceeds *the sum* of all costs and revenues from the compensation of any changes in eco- and/or social effectiveness. In other words, the cost of compensation for every additional environmental (EIA_i) and/or social impact (SIA_j) are summed up and compared to economic growth. More formally this condition is expressed by

Economic growth > cost of compensation?

$$VA_{t1} - VA_{t0} \geq \sum_{i=1}^{n} EE_{i,b} \cdot \left(EIA_{i,t1} - EIA_{i,t0}\right) + \sum_{j=1}^{m} SE_{j,b} \cdot \left(SIA_{j,t1} - SIA_{j,t0}\right), \tag{5.1}$$

with VA_{t1} and VA_{t0} being the Value Added of the company in t_1 and t_0, *n* and *m* the number of relevant environmental and social impacts, $EIA_{i,t0}$ and $EIA_{i,t1}$ representing the eco-effectiveness for environmental impact *i* in t_0 and t_1, and $SIA_{j,t0}$ and $SIA_{j,t1}$ the social effectiveness for social impact *j* in t_0 and t_1, and with $EE_{i,b}$ and $SE_{j,b}$ as the eco- or social efficiency of the benchmark for environmental resource *i* and social resource *j*, respectively. In general terms, the two sum functions on the right side of expression (5.1) stand for the sum of all costs and revenues from changes in any corporate eco- or social effectiveness, respectively. Thus, the formula for Sustainable Value Added for the multiple impacts case results as

SusVA = economic growth with constant eco- and social effectiveness

$$SusVA = EG - \sum_{i=1}^{n} EE_{i,b} \cdot \left(EIA_{i,t1} - EIA_{i,t0}\right) - \sum_{j=1}^{m} SE_{j,b} \cdot \left(SIA_{j,t1} - SIA_{j,t0}\right), \tag{5.2}$$

with EG = (VA_{t1} – VA_{t0}) representing economic growth. It is now obvious, that the formula developed above for the single impact case (see equation (4.2)) represents just a special case of the general formula for Sustainable Value Added shown in equation (5.2). It follows, that Sustainable Value Added in general is calculated by deducting the total sum of all costs and revenues from changes in corporate eco- or social effectiveness from the economic growth of the company.[4] A positive SusVA indicates that a company has succeeded to create an extra value

4 We assume, that SIA and EIA can be traded on a market (the benchmark) and the seller of the SIA or EIA will ask for a price that corresponds to the value that EIA or SIA can create, if used in his company. This ratio (value

compared to a benchmark while keeping the *overall resource consumption at the level of the preceding period for all resources which are used* by the company. Instead of remunerating victims for accepting externalities environmental and social resources are (partly) reallocated between different users. As a consequence, this *does not imply* any substitution of different forms of capital. Money transfers serve only to make the affected users accept the reallocation. Thus, the sum of costs and revenues for which economic growth is adjusted in equation (5.2) reflects the net amount of money which results after settling all changes in corporate eco- and social effectiveness with benchmark companies. Establishing a micro-macro link, this equates to the net contribution of the company to the economic growth of the benchmark (e.g. measured by GDP in the case of an entire economy). The sum of all Sustainable Value Addeds of the companies of the benchmark describes the net economic growth of the benchmark, i.e. the economic growth for an unchanged level of environmental and social impacts.

How EnVA and SoVA add up to SusVA

Sustainable Value Added can also be calculated by using the Environmental ($EnVA_i$) and Social Value Added ($SoVA_j$) for each impact. Remember, that the SusVA can be interpreted as economic growth minus the sum of all costs of compensation for any change in eco- or social effectiveness. From the single impact case (by slightly transforming equation (4.2)) we know that the cost of compensation for one single environmental or social impact is given by EG – $SusVA_{si}$. From equation (4.5) we know, that Sustainable Value Added for the single impact case ($SusVA_{Si}$) itself can be expressed as $EnVA_{i,t1}$ – $EnVA_{i,t0}$ or $SoVA_{j,t1}$ – $SoVA_{j,t0}$, depending on whether an environmental or social impact is considered. It is now obvious, that Sustainable Value Added for the multiple impacts case can also be calculated through

$$SusVA = EG - \sum_{i=1}^{n}\left(EG - SusVA_{si,i}\right) - \sum_{j=1}^{m}\left(EG - SusVA_{si,j}\right), \qquad (5.3)$$

as the cost or revenue related to a change in use of environmental resource *i* and social resource *j* is represented by ($EG - (EnVA_{i,t1} - EnVA_{i,t0})$) or ($EG - (SoVA_{j,t1} - SoVA_{j,t0})$), respectively. As shown in the annex equations (5.2) and (5.3) can easily be transferred into one another so that the two ways to calculate Sustainable Value Added always lead to the same result.

6 Main Findings and Further Implications

Complementarity of the three pillars

The three pillar concept is the underlying interpretation of sustainability in this paper. It is, however, not sufficient to identify the three pillars. Moreover, the relation between the three pillars must be clarified. This is usually done by the concepts of weak and strong sustainability. Weak sustainability assumes unlimited substitutability of the three pillars, while strong sustainability assumes that economic, environmental and social resources are at least to some degree complementary and that there are therefore limits to their substitutability. If there is a complementary relation between the three pillars, sustainability is only reached when environmental, social and economic goals are attained simultaneously.

Sustainable Value Added, the measure presented in this paper, takes a very prudent stance. It assumes on the one hand that we do not know, if or to which degree resources can be substituted. A combination of a higher economic and a lower environmental and/or social performance might be acceptable for some decision-makers but it will not meet general approval. From this point of view only a company that enhances simultaneously economic, eco- and social effective-

created per environmental or social impact added used) corresponds to eco- and social efficiency of the benchmark. Moreover, we assume, that environmental and social impacts can be bought separately at that price. This last assumption should be quite realistic, whenever there is a great number of companies with different eco- and social-efficiencies.

ness contributes to sustainability. On the other hand it presupposes that social and environmental resources are used by companies to create economic value and that companies will therefore agree to refrain from using a resource, if they are compensated for the foregone value.

First sustainable measure based on opportunity costs

Sustainable Value Added integrates these two basic aspects. It only allows corporate eco- or social effectiveness to decline if these negative effects are settled by reallocating resources from other users to the company and paying them for refraining from producing environmental or social damage.[5] This is done by taking into account an opportunity perspective. As a consequence, *on the benchmark level* the total amount of environmental and social impact added remains constant, and there is no substitution of any forms of capital. Taking up the *company perspective*, Sustainable Value Added expresses in monetary terms whether the company has been able to create a positive extra Value Added after it has taken into account any changes in eco- and social effectiveness for every single relevant environmental or social impact. Thus, Sustainable Value Added represents an extra Value Added adjusted for changes in corporate eco- and social effectiveness. A positive Sustainable Value Added only occurs if there is a positive remainder in economic output after all changes in eco- and social effectiveness have been settled and the development during the period under observation can then be Pareto-optimal. Thus a strong contribution to sustainability has been achieved. Moreover, as Sustainable Value Added is expressed in monetary units (like €), the measure not only allows to assess whether a company has exhibited a strong contribution to sustainability. It also serves to express in monetary terms *to which extent* the company has contributed positively or negatively to sustainability. By taking into account changes in corporate eco- and social efficiency as well as changes in corporate economic, eco- and social effectiveness the concept of Sustainable Value Added represents a measure to give a comprehensive picture of corporate contributions to sustainability. This includes that it also clarifies the role as well as the limits of improvements in corporate eco- and social efficiency in the context of sustainable development.

Sustainable Value Added in environmental or social terms

Sustainable Value Added measures the surplus value adjusted for changes in eco- and social effectiveness and has thus been expressed in monetary terms like the €. This reflects the change in economic output when environmental and social effectiveness are unchanged. However, stakeholders which pursue environmental goals like environmental pressure groups might be more interested to learn if and by how much the environmental impact is reduced when economic output and social burdens are kept constant. In order to meet such claims, Sustainable Value Added can also be expressed in terms of a specific environmental or social impact, i.e. in physical units. For this purpose the monetary Sustainable Value Added has to be divided by relevant eco- and social efficiency of the benchmark, respectively. If it is e.g. divided by the eco-efficiency of an impact (e.g. CO_2) it shows how many environmental impacts can be reduced while keeping the effectiveness of the economic, social and the remaining environmental dimensions constant. In other words, by converting Sustainable Value Added into physical units it is shown by how much a specific environmental burden caused by a company (e.g. CO_2) can be reduced by using the sustainable surplus (which is measured by monetary Sustainable Value Added) for paying other polluters for refraining from their polluting activities.

[5] In this context it is crucial to keep in mind that compensation here does not mean paying victims of external effects to make them accept these impacts. Compensation for calculating the relative Sustainable Value Added means paying other, less eco- or social-efficient users of resources to reduce their environmental and/or social impacts in order to at least maintain an overall level of environmental and social effectiveness.

Sustainable development posits that capital stocks must be kept constant in order to ensure intragenerational and intergenerational prosperity (constant capital rule). Following this logic, the existing approaches to measuring sustainability have mainly focused on resource stocks. As it looks at corporate performance during a period Sustainable Value Added deals with resource flows. For the development of the concept we have used the underlying assumption that a constant consumption of environmental and social resources over time equals a unchanged level of sustainability. Obviously, there are cases where keeping present level of resource consumption may not lead to sustainable outcomes. In such cases resource flows have to be steadily reduced in order to achieve constant stocks of critical capital. This is done by introducing flow reduction targets. Such targets can easily be considered into the calculation of Sustainable Value Added. For this purpose the formula (5.2) for calculating Sustainable Value Added for the multiple impacts case is slightly modified. By introducing resource specific reduction factors α_i and β_j for environmental and social resource flows respectively the formula is extended to integrate resource flow reduction targets as shown in equation (7.1).

Integrating targets for reduced resource consumption

$$SusVA = EG - \sum_{i=1}^{n} EE_{i,b} \cdot \left(EIA_{i,t1} - \alpha_i EIA_{i,t0}\right) - \sum_{j=1}^{m} SE_{j,b} \cdot \left(SIA_{j,t1} - \beta_j SIA_{j,t0}\right) \qquad (7.1)$$

Consider a case where CO_2 emissions are to be reduced by 10 % each year. For integrating this target when calculating Sustainable Value Added α_{CO2} would be 0.9. As a consequence, the cost of compensation for a change in CO_2 emission would only be zero or positive and thus not lower Sustainable Value Added if the absolute level of CO_2 emission was reduced by 10 % each period. Such an introduction of reduction targets brings the more flow-oriented approach of Sustainable Value Added inline with the stock based concept of sustainable development.

Environmental, Social and Sustainable Value Added can only be calculated with the help of a benchmark. The significance of the result, i.e. the kind of information Sustainable Value Added will provide, will of course depend on the benchmark chosen. It is of crucial importance in this context, that environmental and social resources can really be used by the benchmark and provide a viable alternative to the use of the resources by the company. The average eco- and social efficiency of a national economy will typically serve as a benchmark, if the contribution to the sustainability of a company to that country is analyzed. The underlying idea is, that environmental and social resources would be allocated to other companies of that country. In this context it is important to understand a positive Sustainable Value Added is of course not a guarantee, that undesired changes in corporate eco- and social effectiveness will be really settled. Rather it shows that there are enough funds created to pay for the reduction of the additional environmental or social damage by compensating less efficient users for giving up their impact causing activities. There are three conditions to a reduction of environmental and social impacts. Firstly, there have to be enough funds available to pay others to reduce their impacts. Secondly, the company has to be willing to really spend these funds. Thirdly, there has to be some kind of market or trading scheme for environmental and social impacts. A positive Sustainable Value Added indicates that there are enough funds created to pay for the reduction. It obviously does not give any information on the willingness to spend these funds or if there is a market or trading scheme.

Choice of benchmark

Sustainable Value Added goes beyond existing measures of contribution to sustainability in that it considers opportunity costs. As it has been presented in this paper up to this point it falls behind existing measures in that it considers *only* opportunity costs. The focus of this paper has been on calculating *relative* Sustainable Value Added. We are excluding external costs deliberately, because we believe that the huge difficulties to quantify external costs of environmental and social impacts (Stern 1997, p.154) are the main reason why the measures are not applied in practice. If external costs are known both external

Beyond opportunity costs

costs and opportunity costs should be included in the analysis to find out both, if the use of a resource is per se sustainable and where the resource should be used to maximize its contribution to sustainability.

The methodology introduced in this paper can be adapted to take into account both external and opportunity costs. One would then calculate the absolute Sustainable Value Added (see Figure 1). Formally, this would be done by deducting external cost and opportunity cost from the Value Added created by a company. A positive result would indicate both, a sustainable use of the resources and an over benchmark contribution to sustainability.

The price of weak and strong sustainability

Furthermore, including external costs in the standard graphical representation[6] reveals an interesting phenomenon (see Figure 7). In our example eco-efficiency of the company exceeds opportunity costs (C>B) and we therefore observe a positive Environmental Value Added. Opportunity cost, however, exceeds external costs (B>A). It would therefore be "cheaper" to remunerate the victims of the externality, than to pay another company for the reduction of the environmental impacts. As explained at the beginning of this paper Sustainable Value Added as presented in this paper is based on the assumption of strong sustainability. Paying victims for accepting externalities is, however, based on weak sustainability and indemnifying victims would therefore result in a loss of eco- and/or social effectiveness. The difference between opportunity costs and external costs (line AB) reflects therefore the "price" of strong over weak sustainability.

It must be noted that opportunity costs are not necessarily higher than external costs. There can thus also be a price of weak over strong sustainability and it would be cheaper for companies to pay for the reduction of environmental impacts than for their acceptance. This example shows that strong sustainability is not necessarily more restrictive or more costly for business than weak sustainability.

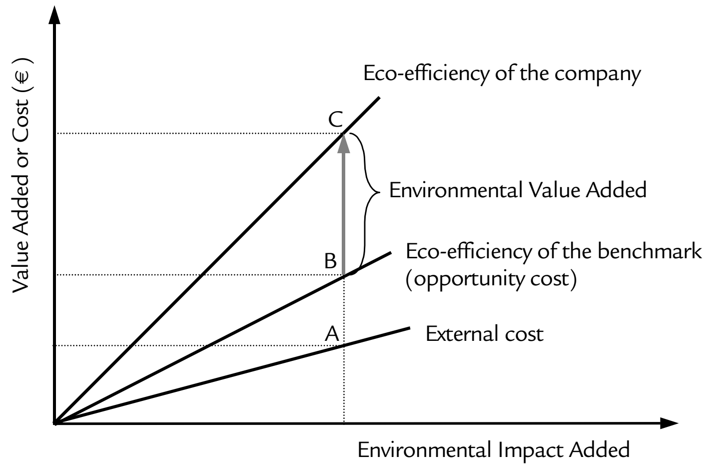

Figure 7. Environmental Value Added and external cost.

Discussing all six possible combinations[7] of the single impact case and transferring them to the multiple impacts case would go beyond the scope of this paper. There are, however, two important conclusions, that can be drawn from this analysis. Firstly, if we presuppose weak sustainability taking only opportunity costs into account might result in a suboptimal use of resources. This is the case, whenever external costs are below opportunity costs and it would thus be cheaper to pay the victim for the acceptance than other companies for the avoidance of an externality. In this case a least-cost analysis should provide useful insights. Secondly, if a resource can not be substituted whatsoever, indemnifying victims for externalities is not a viable option. Companies can then only try to identify companies that use resources less efficiently in order to buy from them reductions of environmental and or social impacts. The price of these reductions is reflected by opportunity costs. External costs are in that case unimportant.

[6] For the sake of simplicity we fall back on the simple impact case.
[7] We assume that eco-efficiency of the company, eco-efficiency of the benchmark and external costs can not be identical.

7 A Practical Example

By calculating Sustainable Value Added for a practical example in this chapter we show that Sustainable Value Added is a measure that can easily be derived from data that exist in the market. For the sake of ease and understandability we calculate Sustainable Value Added of one sample company for the multiple impacts case considering one environmental impact (emission of CO_2 equivalents) and one social impact (work accidents). The national economy serves as benchmark.

A two impacts case

7.1 Necessary Data

The following table shows the data that is necessary to calculate Sustainable Value Added. This data is typically found in corporate annual reports (Value Added of the company), environmental reports (emission of CO_2 equivalents), reports to professional associations (number of work accidents), and national accounts or national statistical offices (benchmark data).

Data sources

	Company		Benchmark (National Economy)
	2001	2002	
Value Added/GDP [€]	41,872,356.--	45,582,934.--	11,565,050,302.--
CO_2 equivalents [t]	**74,950**	**75,103**	18,241,404.26
Work accidents [number]	**73**	**80**	25,346

Table 1. Necessary data for the sample company.

Table 1 shows the data which is necessary for calculating Sustainable Value Added for the sample company.

7.2 Calculation

In a first step we are calculating Sustainable Value Added for the single impact case ($SusVA_{si}$) before deriving overall Sustainable Value Added of the sample company in a second step.

$SusVA_{si}$ is calculated separately for the environmental impact (CO_2) and the social impact (work accidents) considered. As shown in equation (4.2) for the calculation of $SusVA_{si}$ we need four pieces of information:

- Economic growth,
- Eco- respectively social efficiency of the benchmark,
- Eco- respectively social effectiveness in 2002,
- Eco- respectively social effectiveness in 2001.

To calculate *economic growth* of the company we subtract Value Added in 2001 from Value Added in 2002. *Eco- respectively social efficiency of the benchmark* is calculated by dividing GDP by the total environmental or social impacts of the national economy, respectively. *Eco- respectively social effectiveness* of the company are given by the environmental or social impacts caused by the company in the respective year.

	Company		Benchmark (National Economy)
	2001	2002	
Economic growth [€]	**3,710,578.--**		-
Eco-efficiency [€/t of CO_2]	558.7	606.9	**634.0**
Social efficiency [€/work accidents]	573,593.9	569,786.7	**456,287.0**
Change in eco-effectiveness [t of CO_2]	153		-
Change in social effectiveness [work accidents]	7		-

Table 2. Efficiencies and changes in effectiveness.

The data needed for the calculation of $SusVA_{CO2}$ and $SusVA_{work\ accidents}$ for the sample company are printed in bold in Tables 1 and 2. For this calculation we come back to the formula introduced in equation (4.2).

$$SusVA_{si} = EG - EE_b \cdot (EIA_{t1} - EIA_{t0}) \tag{4.2}$$

We first calculate $SusVA_{CO2}$. As Table 2 shows the company has experienced an economic growth of 3,710,578 €. From the argument above, we know that $SusVA_{CO2}$ will be positive, if economic growth exceeds the cost of compensation for changes in CO_2 emissions (change in eco-effectiveness). Table 2 shows that our sample company has emitted an additional 153 t of CO_2 equivalents. In order to keep overall CO_2 emissions constant the company has to buy CO_2 equivalents from benchmark companies. Benchmark companies will agree to sell CO_2 emissions, if the price they are proposed matches the value they would have created with the emissions. Thus, the cost of compensation for the sample company is calculated by multiplying the CO_2-efficiency of the benchmark with the change in eco-effectiveness of the company. This calculation is shown in equation (6.1), which applies the general formula given by equation (4.2) to the case of our sample company. In our case the cost of compensating an additional 153 t of CO_2 emissions amounts to 97,002 €. Consequently, $SusVA_{CO2}$ is 3,613,576 €.

Calculating $SusVA_{CO2}$

$$\begin{aligned} SusVA_{CO2} &= 3{,}710{,}578\,€ - 634.0\,\tfrac{€}{t} \cdot (75{,}103\,t - 74{,}950\,t) \\ &= 3{,}710{,}578\,€ - 634.0\,\tfrac{€}{t} \cdot 153\,t \\ &= 3{,}710{,}578\,€ - 97{,}002\,€ \\ &= 3{,}613{,}576\,€ \end{aligned} \tag{7.1}$$

$SusVA_{work\ accidents}$ is calculated analogously. Obviously, economic growth stays the same as for the calculation of $SusVA_{CO2}$. Change in social effectiveness is calculated by subtracting the number of work accidents in 2001 from work accidents in 2002. The sample company has caused an additional 7 work accidents. The cost of compensation in this case amounts to 3,194,009 €. This is the amount of money our sample company has to pay benchmark companies to reduce the number of accidents by 7. $SusVA_{work\ accidents}$ thus results in 516,569 € (see equation (7.2)).

Calculating $SusVA_{work\ accidents}$

$$\begin{aligned} SusVA_{work\ accidents} &= 3{,}710{,}578\,€ - 456{,}287\,\tfrac{€}{accidents} \cdot (80\ accidents - 73\ accidents) \\ &= 3{,}710{,}578\,€ - 456{,}287\,\tfrac{€}{accidents} \cdot 7\ accidents \\ &= 3{,}710{,}578\,€ - 3{,}194{,}009\,€ \\ &= 516{,}569\,€ \end{aligned} \tag{7.2}$$

In the second step we are now able to calculate the overall Sustainable Value Added of the sample company. For this purpose we use the formula given by equation (5.3). As in our case we consider only one environmental and one social impact *n* and *m* are both 1.

$$SusVA = EG - \sum_{i=1}^{n} \left(EG - SusVA_{si,i}\right) - \sum_{j=1}^{m} \left(EG - SusVA_{si,j}\right) \quad (5.3)$$

Overall Sustainable Value Added is positive as long as economic growth exceeds the sum of all costs of compensation for the single impact cases just calculated. As $SusVA_{si}$ equals economic growth minus cost of compensation, cost of compensation is given by economic growth minus $SusVA_{si}$. For the calculation of overall Sustainable Value Added we deduct all costs of compensation from economic growth. This calculation is shown in equation (7.3). For our sample company overall Sustainable Value Added is 419,567 €.

Calculating overall SusVA

$$\begin{aligned} SusVA &= 3{,}710{,}578€ - (3{,}710{,}578€ - 3{,}613{,}576€) - (3{,}710{,}578€ - 516{,}569€) \\ &= 3{,}710{,}578€ - 97{,}002€ - 3{,}194{,}009€ \\ &= 419{,}567€ \end{aligned} \quad (7.3)$$

As mentioned in Chapter 6, Sustainable Value Added can also be expressed in environmental or social terms. This can be done by dividing SusVA just calculated by the eco- or social efficiency of the benchmark, respectively. For our example SusVA in terms of CO_2 amounts to a reduction of 662 t of CO_2 equivalents (419,567 €/634.0 $\frac{€}{CO_2}$). In terms of work accidents, SusVA translates to the reduction of about 1 work accident (419,567 €/456,287.0 $\frac{€}{\text{Work accidents}}$).

SusVA in terms of CO_2 and work accidents

7.3 Interpretation

If we look at the initial data it is hard to judge whether our sample company has contributed to sustainable development. While the company has grown (+3,710,578 € Value Added), both environmental (+153 t of CO_2 equivalents) and social (+7 work accidents) impact have increased. Thus, at first glance one could be tempted to deny that there has been a strong corporate contribution to sustainability as both eco- and social-effectiveness have dropped. Looking at eco- and social efficiency does not provide any unambiguous insight, either. As shown in Table 2, eco-efficiency has improved from 558.7 $\frac{€}{CO_2}$ to 606.9 $\frac{€}{CO_2}$. However, at the same time social efficiency has dropped from 573,593.9 $\frac{€}{\text{Work accidents}}$ to 569,786.7 $\frac{€}{\text{Work accidents}}$. On the basis of this information it is impossible to come to a clear result on the sample company's contribution to sustainability.

A mixed picture

Sustainable Value Added the new measure developed in this paper shows that the sample company has contributed positively to sustainable development of the national economy. With overall CO_2 emissions and work accidents unchanged the company produces an additional value added of 419,567 €. If Sustainable Value Added is expressed in terms of CO_2 Value Added and work accidents are kept constant. From this perspective the contribution of the sample company to sustainable development totals a reduction of 662 t of CO_2. If we apply the same logic to the number of work accidents, Value Added and CO_2 emissions are unchanged and 1 work accident can be reduced.

A positive contribution to sustainable development

A mixed picture as found with our sample company is very common in practice. This assessment problem can nonetheless be solved. It has become clear that in order to be able to judge corporate contributions to sustainability a comparison to the benchmark is indispensable.

At first sight, it is quite surprising that we find a positive contribution to sustainability for the sample company. If we take a closer look the reasons for this result become clearer.

- The company has experienced economic growth (positive effect).
- Eco-efficiency of the sample company has improved (positive effect). However, eco-efficiency is still below the benchmark level (negative effect). The company has emitted more CO_2 (negative effect).
- Social efficiency of the sample company has dropped (negative effect). However, social efficiency is still above the benchmark level (positive effect). The company has caused more work accidents (negative effect).

The calculation of overall Sustainable Value Added allows to determine whether the positive effects have outweighed the negative effects. This is the case for our sample company: Because the company has grown, eco-efficiency has improved, and the deteriorated social efficiency is still above the benchmark level, it is possible to settle all undesired changes in eco- and social effectiveness. Thus, there remains a surplus value added which is indicated by the overall Sustainable Value Added.

8 Conclusion

The Sustainable Value Added presented in this paper constitutes an unprecedented way to measure corporate contributions to sustainability. The concept can be used in practice, as it is based exclusively on information that is available in the market today. It requires information on the eco- and social efficiency of the company and a benchmark as well as on the economic performance of the company. Environmental and social impacts do not have to be monetarized.

Sustainable Value Added is measured in monetary terms but it is not only a monetary measure. Rather, Sustainable Value Added considers efficiency *and* effectiveness of all three dimensions of sustainability. Because it shows the amount of value created while ensuring a constant environmental and social performance, Sustainable Value Added is based on the paradigm of strong sustainability. Put differently, Sustainable Value Added represents the extra value created by a company adjusted for all changes in eco- and social effectiveness. Compensation in this context does not mean paying victims of external effects to make them accept these impacts, which would imply weak sustainability and thus substitutability of different forms of capital. In contrary, compensation for calculating Sustainable Value Added means paying other, less eco- or social-efficient users of resources to reduce exactly the environmental and/or social impacts in question. This results in a constant overall level of eco- and social effectiveness. As only identical environmental or social impacts are considered in that kind of compensation substitutability between different forms of capital does not matter. From the perspective of the former users of the resources selling the avoidance of environmental and social impacts will be more profitable than their previous activity.

Sustainable Value Added as developed in this paper is limited to the effect that it does not indicate, if a company is sustainable. It shows, however, how much a company has contributed to more sustainability. This contribution can be expressed in either economic, environmental or social terms. When expressed in economic terms, Sustainable Value Added expresses in absolute monetary terms the sustainable performance of the company relative to a benchmark.

Sustainable Value Added thus allows to find out whether a company has in fact contributed to sustainability or if it just enhanced its eco- and/or social efficiency. Sustainable Value Added thus provides valuable information for a range of decision makers. *Governments* are highly interested in the question by how much companies contribute to the environmental, social, and economic objectives of a country. Sustainable Value Added provides this micro-macro link. *Financial analysts* need information about the relevant scarcities companies are exposed to. Sustainable Value Added helps to identify and value these scarcities and shows how they can efficiently be overcome. The valuation can take place in monetary units – a unit financial analysts are used to. Valuation of scarcities is a key interest of the companies themselves, too. Today companies put a great effort in *reporting* their economic, environmental, and social performance. Sustainable Value Added allows to integrate different environmental and social aspects as well as an overall integration of the three pillars of sustainability. It therefore represents a meaningful indicator of corporate sustainable performance. The fact that Sustainable Value Added can also be expressed in environmental or social terms allows companies to report their sustainable performance in the unit that reflects best the interests of their various stakeholders. Last but not least, for *corporate decision makers* Sustainable Value Added is of strategic as well as of operational relevance. On the strategic level it can help companies to set those priorities that promise the highest sustainable value creation. In operational management Sustainable Value Added can be used to control and compare corporate performance on different levels (e.g. sites, processes, products, or units).

A sustainable measure to be adopted in practice has to be easy to understand and communicate and meaningful at the same time. Sustainable Value Added shows these characteristics and therefore has the potential to become a key figure for sustainable decision making.

Annex

Environmental Value Added results from the sum of the efficiency effect (equation (4.3)) and the allocative effect (equation (4.4)). This can be seen by adding the two effects. The sum equals Environmental Value Added as given by equation (3.1).

$$\text{Efficiency effect} = EIA_{t0} \cdot \left(EE_{t1} - EE_{b}\right) \tag{4.3}$$

$$\text{Allocative effect} = \left(EIA_{t1} - EIA_{t0}\right) \cdot EE_{t1} - \left(EIA_{t1} - EIA_{t0}\right) \cdot EE_{b} \tag{4.4}$$

$$(4.3)+(4.4) = \left(EIA_{t1} - EIA_{t0}\right) \cdot EE_{t1} - \left(EIA_{t1} - EIA_{t0}\right) \cdot EE_{b} + EIA_{t0} \cdot \left(EE_{t1} - EE_{b}\right)$$

$$= EIA_{t1} \cdot EE_{t1} - EIA_{t0} \cdot EE_{t1} - EIA_{t1} \cdot EE_{b} + EIA_{t0} \cdot EE_{b} + EIA_{t0} \cdot EE_{t1} - EIA_{t0} \cdot EE_{b} = EIA_{t1} \cdot EE_{t1} - EIA_{t1} \cdot EE_{b}$$

$$= \left(EE_{t1} - EE_{b}\right) \cdot EIA_{t1} = \text{EnVA} \tag{3.1}$$

The two ways to calculate Sustainable Value Added for the single impact case as represented in equations (4.2) and (4.5) are equal and always lead to the same result.

$$\text{SusVA}_{\text{si}} = EnVA_{t1} - EnVA_{t0} \tag{4.5}$$

$$= \left(EE_{t1} - EE_{b}\right) \cdot EIA_{t1} - \left(EE_{t0} - EE_{b}\right) \cdot EIA_{t0} = \left(\frac{VA_{t1}}{EIA_{t1}} - EE_{b}\right) \cdot EIA_{t1} - \left(\frac{VA_{t0}}{EIA_{t0}} - EE_{b}\right) \cdot EIA_{t0}$$

$$= VA_{t1} - EE_{b} \cdot EIA_{t1} - VA_{t0} + EE_{b} \cdot EIA_{t0} = VA_{t1} - VA_{t0} - EE_{b} \cdot \left(EIA_{t1} - EIA_{t0}\right)$$

$$= EG - EE_{b} \cdot \left(EIA_{t1} - EIA_{t0}\right) \tag{4.2}$$

Equations (5.2) and (5.3) represent two equal ways the calculate Sustainable Value Added in general.

$$\text{SusVA} = EG - \sum_{i=1}^{n}\left(EG - SusVA_{\text{si},i}\right) - \sum_{j=1}^{m}\left(EG - SusVA_{\text{si},j}\right) \tag{5.3}$$

$$= EG - \sum_{i=1}^{n}\left(EG - \left(EnVA_{i,t1} - EnVA_{i,t0}\right)\right) - \sum_{j=1}^{m}\left(EG - \left(SoVA_{j,t1} - SoVA_{j,t0}\right)\right)$$

with $\text{EnVA}_{i,c} = EIA_{i,c} \cdot EE_{i,c} - EIA_{i,c} \cdot EE_{i,b}$ and $\text{SoVA}_{j,c} = SIA_{j,c} \cdot SE_{j,c} - SIA_{j,c} \cdot SE_{j,b}$ it results

$$= EG - \sum_{i=1}^{n}\left(EG - \left(EE_{i,t1} \cdot EIA_{i,t1} - EE_{i,b} \cdot EIA_{i,t1} - \left(EE_{i,t0} \cdot EIA_{i,t0} - EE_{i,b} \cdot EIA_{i,t0}\right)\right)\right)$$

$$- \sum_{j=1}^{m}\left(EG - \left(SE_{j,t1} \cdot SIA_{j,t1} - SE_{j,b} \cdot SIA_{j,t1} - \left(SE_{j,t0} \cdot SIA_{j,t0} - SE_{j,b} \cdot SIA_{j,t0}\right)\right)\right)$$

$$= EG - \sum_{i=1}^{n}\left(EG - \left(VA_{t1} - EE_{i,b} \cdot EIA_{i,t1} - \left(VA_{t0} - EE_{i,b} \cdot EIA_{i,t0}\right)\right)\right)$$

$$- \sum_{j=1}^{m}\left(EG - \left(VA_{t1} - SE_{j,b} \cdot SIA_{j,t1} - \left(VA_{t0} - SE_{j,b} \cdot SIA_{j,t0}\right)\right)\right)$$

$$= EG - \sum_{i=1}^{n}\left(EG - \left(EG - EE_{i,b} \cdot EIA_{i,t1} + EE_{i,b} \cdot EIA_{i,t0}\right)\right) - \sum_{j=1}^{m}\left(EG - \left(EG - SE_{j,b} \cdot SIA_{j,t1} + SE_{j,b} \cdot SIA_{j,t0}\right)\right)$$

$$= EG - \sum_{i=1}^{n}\left(EE_{i,b} \cdot EIA_{i,t1} - EE_{i,b} \cdot EIA_{i,t0}\right) - \sum_{j=1}^{m}\left(SE_{j,b} \cdot SIA_{j,t1} - SE_{j,b} \cdot SIA_{j,t0}\right)$$

$$= EG - \sum_{i=1}^{n} EE_{i,b} \cdot \left(EIA_{i,t1} - EIA_{i,t0}\right) - \sum_{j=1}^{m} SE_{j,b} \cdot \left(SIA_{j,t1} - SIA_{j,t0}\right) = \text{SusVA} \tag{5.2}$$

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