Development of a Sustainability Model for Manufacturing SMEs based on the Innovative Doughnut Economics Framework

Markus Stopper, Anja Kossik, and Bernd Gastermann

***Abstract*—CEOs or entrepreneurs leading industrial SMEs are often confronted with the challenge of how to balance seemingly contradictory intentions: ecological and social issues on one side and requirements for profitability and cost efficiency on the other. A model that is newly developed for this type of seemingly contradictory interests is introduced in this paper. First, traditional Sustainability Models and their historic background are described and compared to the new and dynamic model of so-called "Doughnut Economics". The Doughnut Model describes the contextual framework for a sustainably working economic system. Furthermore, the Green Manufacturing concept is discussed. Green Manufacturing outlines the options for industrial companies on how to develop certain processes in such a way that the consumption of resources will be minimized and negative environmental impact will be avoided. By re-contextualizing the abovementioned concepts and models and using them as a theoretical basis, this work adapts their general intentions to the specific requirements of small and medium-sized industrial enterprises. It outlines suggestions on a more ecological, economic as well as socially sustainable approach to corporate governance for entrepreneurs and General Managers.**

***Index Terms*—Sustainability model, Green manufacturing, Doughnut Economics, Manufacturing SMEs, Boundaries for sustainability**

I. Introduction

WHEN the UN published their first sustainability report in the late 1980s their paper indicated a paradigm shift. Until then, each generation could be sure that their work and their achievements would contribute to a better future for their offspring. Based on data collected for a global environmental report in the 1970s, it turned out that such a development could not be guaranteed any longer. Inconsiderate exploitation of natural resources and the growing impact of a rapidly increasing world population made the experts paint a rather dark picture for the future of humankind. Therefore, the attitude towards unlimited growth and expansion changed considerably. From that time onwards the goal was set to provide future generations with global conditions that ensure a lifestyle that is still livable.

Meanwhile, international sustainability initiatives try to define how the economy can thrive without further compromising the environment and how companies should take on higher responsibility for the wellbeing of the society in which they are embedded. During the last decade, politics, especially in the European Union, tightened the legal frameworks for environmental and social conduct of enterprises considerably. Especially the manufacturing industry as the most energy and resource consuming sector of the economy is confronted with a growing number of restrictions and guidelines. And even though regulatory constraints regarding environmental issues are getting stricter and the European welfare state has rather high standards of social security, politics are always lagging behind the more fast-paced global developments. Genuine sustainability is still only achieved, if companies pledge themselves to the cause on a voluntary basis, thereby closing the gap between just meeting basic legal requirements and actual thinking in long-term consequences.

In the course of this paper an innovative sustainability framework called "Doughnut Economics" will be presented. This framework provides the basis for the development of a model dedicated to manufacturing SMEs. It will be tailored to the specific needs of such companies, which due to their size and capacity restrictions cannot afford the financial and personnel resources of multinational corporations specifically assigned to sustainability issues. In SMEs it does not make any sense to pool all ecological and social issues in one specialized department or staff function. On the contrary, these issues have to be intricately interwoven into all internal and external processes, stakeholder interactions, the corporate culture and the leadership style. Only then, holding up to self-imposed standards can also become a decisive competitive edge.

II. Application for European SMEs

The economy within the European Union shows some unique features: 99.8% of all enterprises in the EU28 fall into the SME category.

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A vast majority of them are either operated by the owner or are family businesses [1]. Especially in the German speaking countries family businesses are shaping the economic environment. 84% of industrial enterprises are family owned. These companies are characterized by special features:

- Concurrence of ownership and management
- High local connectedness
- Personal relation to customers and employees

According to the Federation of German Industries these companies are singled out by their fast decision making processes, their flexibility in regard to market changes as well as their high customer loyalty [2].

Therefore, such company structures often display a long-term intergenerational leadership and corporate culture based on traditional values. This attitude is highly suited for the implementation of strategic sustainability measures.

III. Sustainability Models

The origins of the sustainability concept go far back into the past. The Saxon forester Hans Carl von Carlowitz (1645-1714) already conveyed the concept of sustainability on the forest industry. Facing the threat of a raw material crisis, his work "Sylvicultura oeconomica" dated 1713 explained for the first time that only as much wood should be lumbered as can grow back by planned reforestation. The principle of sustainability is therefore supposed to ensure that a natural system can maintain its essential characteristics on a long term basis. Based on this historical background sustainability has originally been interpreted as "a resource-economical principle, which allowed a resource to be used permanently profitable" [3].

During the 20th century a geopolitical discussion regarding the problems of environmental pollution, the consequences of overpopulation and the ruthless exploitation of resources was started. Nowadays the UN World Environment Conference Stockholm in 1972 is regarded as a milestone and as the actual beginning of international environmental policy.

In 1983 the United Nations set up the World Commission on Environment and Development (WCED) as an independent expert commission based in Geneva. Their mission was to give their perspective regarding a stable and environmentally friendly global long-term development up to the year 2000 and beyond.

In 1987 the so-called Brundtland Report with the title "Our Common Future" was published, which obtained its name from the Commission Chairman and former Prime Minister of Norway, Gro Harlem Brundtland [4]. We owe a frequently quoted definition of "sustainability" to this policy paper, which tries to unite various political interests by treating environmental objectives and the economic and social development as equally important: "Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs" [4]. This definition is mainly criticized because it is too vague and thus allows too much room for interpretation. A universal or generally accepted definition of the term has not yet been found.

Rather, the respective definition of sustainability matches the context, from which it originates. When interpreted from a political viewpoint, for example, it can be regarded as "stable, ecological and social structures that are crucial for the 'self-continuation potential' of the society" [5]. A definition attempt from the economic perspective by Iris Pufé says: "Sustainability does not mean to generate profits, which then flow into environmental and social projects, but to already be profitable in an environmentally and socially responsible way" [3].

Therefore, it seems to be reasonable, not to talk about a "term" but rather about a "concept", which according to the Dictionary of Sustainability, displays the following common aspects [6]:

- Sustainability is always oriented towards the present and future and thus has a temporal reference.
- Resources, tangible/intangible assets, economic/ ecological units, etc., are to be protected, especially if they are non-renewable.
- The continued existence of a reference object has to be ensured in the short and the long term.

In this context, it also seems to be interesting to note that - especially in colloquial speech - the key word sustainability (or sustainable) is already conspicuous by its "inflationary use" [7]. It is also considered to be a relative term. This means that a state A can be more "sustainable" as a comparative state B. Some authors, however, see it as an absolute. A state or a development can therefore either be sustainable or not: "A crucial important property of sustainability is that the concept is an absolute, as are pregnant and unique, to use two common examples. A sustainable world is not one that is slightly more environmentally responsible than it was yesterday." [8]

Instead of defining the term, the use of sustainability models has become popular. Therefore, the most accepted will be discussed in the subsequent sections. As it is also the case in the corresponding literature, the terms "sustainability" and "sustainable development" are subsequently used synonymously.

A. Classic Models

In this section the most common traditional sustainability models and their evolution will be introduced briefly, such as described in [9].

Three Pillar Model: The Agenda 21, which was passed at the first United Nations Conference on Environment and Development in Rio de Janeiro in 1992 represents an action program for global sustainable development. As a result, the concept of sustainability was formally adopted as the guiding principle of politics, based on the insight that global environmental protection is only possible if politics draws the same attention to economic and social aspects.

The three basic dimensions of sustainability are therefore ecology, economy and social affairs. Already in the 1990s, these three aspects were first related to each other in the so-called sustainability triangle. The triangle has, however, not prevailed due to a lack of long-term significance.

The Enquête-Commission "Protection of people and the environment" established by the German Bundestag [10] developed the "Three Pillar Model" in 1995.

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It points out the interdisciplinary character of sustainability, the three pillars are on an equal footing and equivalent to each other, forming "a three-dimensional perspective" [11] for a sustainable social policy.

Integrative Model: The Integrative sustainability model represents an evolution of the above described two classical concepts. These are discussed controversially as the extensive complexity of sustainability is insufficiently represented for example by the three separate pillars. Also the countless interactions between ecological, economic and social realities and developments are not comprehensively covered. Therefore, the understanding of the term has evolved: Nowadays, sustainability is mostly represented in an integrated way. Three overlapping circles form an intersection in the middle representing sustainability, thereby emphasizing the mutual relations and interdependences of the three aspects.

This model was designed in the course of a study by the German Federal Environment Ministry, the Centre for Sustainability Management (CSM) at the University of Lüneburg and Econsense, the Forum for Sustainable Development of the Federation of German Industries (BDI). Also the University of Karlsruhe has been instrumental in the development of this approach [12].

Triple Bottom Line Model: While the previous models – especially known in Europe – mainly have a political and environmental background, the well-known Triple Bottom Line (TBL) model was developed in the Anglo-American culture based on an economic vantage point. The "Three P's" (People, Planet and Profit) are the basis of this accounting concept. The concept was presented to the general public by John Elkington, an American author and opinion leader in terms of sustainable economic development [13].

The term "bottom line" refers to the English expression for the final line of a balance sheet. Below the bottom line it can be seen, whether a company has generated either profit or loss in the previous fiscal period. According to Elkington, the objective of sustainable enterprises is not only to be financially profitable, but to also to equally display positive results with regard to environmental protection and social justice. The companies are expected to provide some kind of overall full cost accounting in addition to solely economic considerations of their general activity. Thereby also direct and indirect costs caused by effects on the environment and society need to be assessed [13].

The TBL model sees the responsibility of enterprises not only towards their shareholders by maximizing their profits, but towards all of the stakeholders by balancing their interests. In this context "a stakeholder in an organization is (by definition) any group or individual who can affect or is affected by the achievement of the organization's objectives" [14].

B. Modern Models

Other than the traditional models, newer models either use a much more systemic view or additional sustainability dimensions respectively, in order to describe the complexity of problems. A very innovative approach is the dynamic model of the so-called "Doughnut Economics", which was developed by the researcher Kate Raworth in collaboration with the Oxfam initiative [15].

Systemic Approach: Complex systems like our biosphere only very rarely react according to a linear cause-effect principle. Solving problems using a systemic approach assumes that a problem cannot be considered as isolated, but that the whole system and its interactions and interdependencies always need to be included.

For the evaluation of the effects of human/environment interaction and for the development of long-term forecasts and models that are as realistic as possible serving as an action and decision framework, a systemic view of the sustainability issue has emerged in recent years.

In his review article, the American researcher Jianguo Liu summarized such innovative approaches [16]. Among the most important issues that require a systemic approach are, for example, air pollution, loss of biodiversity, the assurance of food and energy supply, the spread of diseases and the scarcity of water. These issues are often explored and addressed separately; however, they are interconnected via the three dimensions: On an organizational level as well as in space and time.

Various integrated frameworks have been developed in order to investigate and to quantify these effects in recent years. These include: environmental footprints, human-nature nexus, planetary boundaries (see also [17]) and tele coupling (investigating socio-economic- and environmental effects over spatial distances).

Typical examples for systemic effects in this context are changes in land use and CO_2 emissions caused by biofuel production. This example shows the increasing demand of the western industrial nations for "environmentally friendly biofuel", which, however, on the other side goes hand in hand with the illegal deforestation of tropical rain forests for oil palm cultivation, especially in Brazil and Indonesia, as well as increases in global food prices for maize and rapeseed.

The aim of systemic approaches is to investigate and to evaluate the long term so-called "cascade" and "spillover" effects, which describe implications for a systems not by direct but by systemic interactions.

Fourth Dimension Approach: If sustainable development is understood as a process-oriented approach with a normative and ethical basis, then far more than the previously discussed three classic dimensions "social, ecological and economical" need to be included. Second-order concerns must also be considered. As they are relevant for all three original dimensions to the same extent, they were summarized in a separate fourth dimension by Steurer [18]. The authors identified the following second-order issues:

- transparency
- participation of different societal groups
  (as the actual meaning of "sustainability" should commonly be defined within participatory, consensus-building processes)
- reflectivity
  (e.g. continuous learning processes based on systematic monitoring and evaluation)

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- integration
  (economic, social and environmental aspects in all societal spheres and levels, including the corporate one – this aspect is referred to as Triple Bottom Line)
- intergenerational equity
  (taking on a long-term, forward-looking and inter-generational perspective)

This approach, with an emphasis on the interaction between companies and their stakeholders, is based on a dynamic, continuously evolving understanding of the concept of sustainability.

The Doughnut Model: The innovative and dynamic „Doughnut Economics“ framework was first presented by Raworth in 2012 [19]. Regarding the ecological viewpoint the concept is based on a publication by Rockström [17]. The Swedish group defined nine essential ecological subsystems that have to remain balanced in order to guarantee the long-term survival of the whole planetary ecosystem. They also tried to establish threshold values and key indicators for each of these subsystems. Already upon their publication in 2009 three of them – biodiversity, climate change and nitrogen cycle – had passed their respective critical threshold levels. The 11 different aspects of the social dimension were defined based on the Rio+20 criteria and indicate the minimum social standards as discussed by the participants of this conference. They comprise basic human rights like satisfying the basic needs in regard to food and water supply as well as a basic infrastructure, the access to education and health care, the right to work and the equality of women and minorities.

The Doughnut framework lays out the parameters for a sustainably operating economy. The economic system is thereby restricted by two general limitations or boundaries that are defined by the aforementioned 9 ecological aspects on one hand and the 11 socio-political aspects on the other. Only an economy positioned within those two boundaries – which the author calls “environmental ceiling” and “social foundation” respectively – ensures actual sustainability. Thus, the framework owes its name to these two limits, which - in the form of two concentric circles - lay out a “safe and just” economic operating space displaying the characteristic shape of the famous Anglo-American sweet. The systemic interdependencies and interactions of the 20 aspects are regarded as a given and are not outlined explicitly. Nevertheless, they have to be taken into consideration as soon as the concept is applied practically.

IV. Green Manufacturing

As the term “Green Manufacturing” already implies, the concept comprises a set of options tending to preserve environmental quality (as being recyclable, biodegradable or nonpolluting).

In order to facilitate the general discussion of current production concepts, it is necessary to define important but inconsistently used terms in the professional literature and to clarify their use in the context of this paper.

A. Lean vs. Green vs. Sustainable

The concept of Lean Manufacturing already exists since the 1980s and it initially staked no claims in an ecological sense - they were a convenient by-product, so to speak. Lean Manufacturing is commonly understood as a production and management system comprising various separate measures that intend to increase customer satisfaction in a profitable way. The concept has its origins in the Japanese automotive industry, strictly speaking in the so-called Toyota Production System (TPS). TPS was developed in the 1950s and 60s by the engineer Taiichi Ohno with the dedicated goal to identify and eliminate capacity overloads and inconsistencies in the manufacturing processes, thereby reducing waste. Waste not only comprises the unnecessary usage of material and machine capacities but also of time and manpower, resulting in processes that are inefficient and deliver poor quality. This focus on the minimization of resource consumption with concurrent optimization of customer satisfaction made Lean Manufacturing the accepted international gold standard and the predecessor of green and sustainable manufacturing.

It is only a small step from resource preservation to an actual “green” production. Industrial production mainly affects the environment due to its high raw material and energy consumption along the whole supply chain. The production processes themselves generate by-products with high negative environmental impact like toxic chemicals and waste or greenhouse gases, which potentially pollute air water and soil. The main goal of Green Manufacturing is therefore the optimization of industrial production in such a way that the processes and systems only have minimal or non-existent effects on the environment [20].

Dornfeld identified various reasons for the implementation of the Green Manufacturing concept: increasing legal pressure by regulations, laws, fines, taxes or tax-exemptions on one hand and a pull from the market or consumer side on the other. Companies can have economic advantages when applying the Green Manufacturing guidelines like an increase in efficiency, the minimization of risks due to resource shortages or of risks within the supply chain. Factors impeding the implementation have also been identified: the resulting costs, technology barriers and a lack of suitable measurement, control and management tools. Even though Green Manufacturing already respects economic and ecological interests, it lacks the social aspect of sustainability. An accepted definition of Sustainable Manufacturing is provided by the US Department of Commerce as “ […] the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound.” [21].

B. Green approaches

As manufacturing processes are rather complex, any approach towards the reduction of negative impact on the ecosystem first requires a comprehensive, holistic and systemic analysis [22]. The system (e.g. a manufacturing plant) has to be revised in both, horizontal and vertical direction respectively. In this context “vertical” describes the analysis on all levels starting from the company level (global) down to a single process level (specific). “Horizontal” means the observation of systemic interdependencies on one single level.

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Furthermore, interactions of the system with the exterior world have to be considered, like negative influences on people and environment that were either imposed on the system from the outside or vice versa cause effects by the system on the exterior. In order to decrease the net resource consumption, flows of goods and energy have to be analyzed as well as the cumulated long-term effects of the production processes or the product itself (product life cycle assessment).

In a recent review article Dornfeld identifies seven general parameters for ecologically improving manufacturing processes [23]:

- Avoid the usage of a resource in the first place.
- Reduce weight.
- Increase the yield.
- Decrease the environmental footprint of a resource.
- Increase the yield and reduce the costs of recycling.
- Leverage the resource usage (meaning: when the negative impact of a product is higher in the utilization phase than in the production phase (e.g. automobiles) future impact needs to be minimized by respective product development or reasonable resource usage).
- Increase the product lifespan.

Also other authors have dealt with the optimization of environmental compatibility of production processes and they achieve similar results, like the extension of product life cycles as discussed in [24], saving of resources during manufacturing itself [25] or respective considerations in the course of product development [26], [27]. An additional innovative approach is the software supported planning of sustainable production processes [28]. Even OECD experts dealt with sustainable manufacturing and presented a practical toolbox regarding this topic [29].

V. Literature Discussion

This section critically reviews the two subjects outlined above and reflects the conclusions that can be drawn from the current state of knowledge.

A. Operationability of Sustainability Models

The older of the presented sustainability models are quite theoretical and rather philosophical in their layout. Due to a rising awareness for global threats regarding environmental disasters and due to the fact that dramatic social disparities within an ever-growing world population were still existing in the 1970s and 80s, these models intended to anchor the socio-political and ecological aspects that were regrettably neglected in the course of the rapid economic development of the 20th century. Scientists and experts with the necessary foresight already realized at that time that large parts of the economy cannot to be allowed - without imposing any consequences - to continue pursuing a strategy focused exclusively on short-term goals, expansion and profit at the expense of the ecosystem and without any obligation towards society, if future generations should still be able to live in an ecologically and socially sound environment. Therefore, these models had to define fundamentally new goals on how the sometimes dramatically conflicting interests of economy, environment and society have to be balanced as equal dimensions of a sustainable development. The resulting frameworks were intended to provide a guideline for legal regulations by politics. This may also explain why these models are very simple and allow considerable room for interpretation.

The newer models, which were all developed in the past 10 years, are based on over 30 years of experience with the basic models and can be considered evolutionary in the sense of continuous improvement. Many of the introduced amendments emerged by observing the results of past applications. Additionally, new and much more detailed scientific information on global systemic contexts was included. Despite a significantly improved practical relevance - and this is probably the character of such concepts - suggestions regarding their actual implementation and applicability outside a scientific and philosophical context always remain a bit vague. The same applies to the Doughnut model described in this paper. It considers global interdependences and interactions, breaks down the areas “ecological” and “social” into smaller units that can be grasped more easily, thus defining the limits of a sustainable economic system in the form of various individual parameters. The concrete action steps that can be derived from this concept remain still at the discretion of the single company, which has to decide whether to meet the minimum standards defined by the legal framework or to implement additional voluntary measures.

B. Limitations of the Green Manufacturing Concept

Generally speaking, the Green Manufacturing concept is limited to improving the environmental performance of production processes by considering cost and resource efficiency. Financial benefits resulting from the “greening” of production are also taken into account.

The Green Manufacturing approach is considered a precursor of sustainable production and can be distinguished from this concept by explicitly omitting the social pillar. Indeed, this pillar is mentioned and its importance for the future is argued (for example regarding exploitation and poor working conditions in low-wage countries or child labor), but its actual implementation is rather perceived as an idealized vision of the future than a concrete strategy. The main reason for this limitation is assigned to the lack of measurability of so-called “soft facts” and the lack of internationally recognized and comparable indicators, which would enable benchmarking this dimension.

VI. Sustainability Model for Manufacturing SMEs

In the Doughnut model two limits are restricting the room for maneuver of business activities. The outer, ecological boundary comprises 9 subsystems. As the Green Manufacturing concept is mainly restricted to the ecological aspects of production, it seems to be feasible to relate each single parameter to the respective suitable ideas and approaches of this concept. As the 11 sociopolitical aspects were defined based on the Rio+20 criteria, they relate to social standards that are far below those of the European social welfare state. Therefore, these aspects have to be adapted to the actual European conditions. As already mentioned earlier, the legal framework provided by the government outlines the given minimum standards, thereby

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defining the basis from which companies have to voluntarily close the gap in the direction of true sustainability.

The original Doughnut model is outlined too comprehensively for a direct practical application. Thus, it needs to be adapted especially for countries with higher social standards. Once it is matched with the prevailing conditions as well as the specific requirements and limitations of manufacturing SMEs, the gained insights have direct practical relevance. By relating the approaches of the Green Manufacturing concept to the 9 parameters of the outer ecological ring and adapting the 11 aspects of the inner social ring to the conditions prevalent in a European welfare state, the resulting "Manufacturing SME Doughnut" model provides a new concept for sustainable corporate governance in manufacturing SMEs.

The following two sections show these relations in detail. Section A describes the influencing factors dominant in the nine ecological subsystems of the Doughnut framework and relates each of them to respective potential interventions. Section B presents excerpts of the EU legal standards for each of the 11 social parameters and links them to the respective complementary corporate initiatives.

A. Ecological Parameters (EP)

EP-1 – Climate Change

Due to an increase of CO_2 and greenhouse gas concentration in the atmosphere caused by fossil fuels, the production of fertilizers and cement, deforestation as well as agriculture and livestock farming.

Ecological Sustainability Approaches:

- *Supply Chain Management*: usage of locally available materials; reduction of transportation distances
- *Product Development*: reduction of CO_2 emissions in the product utilization phase (e.g. automobiles); usage of locally available materials; reduction of materials requiring high energy consumption during production or disposal; design of more lightweight products and packaging
- *Production*: reduction of energy consumption and increase of energy efficiency of production lines
- *Facility Management*: reduction of energy consumption and increase of energy efficiency of facilities and heating systems; installation of photovoltaic or wind energy power supply; energy saving lighting; application of systems for exhaust aftertreatment
- *Energy Management*: increasing rate of renewable energy; measures for direct energy savings (by effective usage of e.g. light, engines, computers or heating); replacement of business travel by video conferencing
- *Transportation and Logistics*: usage of vehicle fleets with Euro 6 engines; utilization of biofuel; employment of intermodal transport; utilization of E-mobility

EP-2 – Stratospheric ozone depletion

Due to an increase of chlorofluorocarbons in the atmosphere caused by usage in cooling agents and aerosol cans.

Ecological Sustainability Approaches:

- *Product Development and Production*: application of non-halogen or at least hydrofluorocarbon containing cooling agents
- *Life Cycle Management*: professional disposal and recycling of products containing chlorofluorocarbon cooling agents

EP-3 – Atmospheric aerosol loading

Air pollution and smog due to solid and liquid microparticles caused by burning fossil fuels and biomass.

Ecological Sustainability Approaches:

- *Product Development*: decreasing the emission of soot particles in the product utilization phase (e.g. automobiles)
- *Facility Management*: usage of filter systems
- *Energy Management*: increasing rate of renewable energy; reduction of energy consumption and increase of energy efficiency

EP-4 – Ocean acidification

Due to an increase of CO_2 concentration in the atmosphere caused by fossil fuels and change in land use.

Ecological Sustainability Approaches:

- *See section on Climate change*
- *See section on Change in land use*

EP-5 – Nitrogen and Phosphorus cycle

Due to a change in the natural Nitrogen distribution between soil and air caused by the production of fertilizers, animal and human excrements and fossil fuels.

Due to an increasing concentration of phosphorus compounds in the ocean caused by usage of fertilizers, detergents and pesticides.

Ecological Sustainability Approaches:

- *Supply Chain Management (e.g.in food or furniture industry)*: usage of raw materials produced by organic farming and sustainable forestry
- *Product Design, Production and Facility Management*: application of phosphate-free and biodegradable detergents

EP-6 – Chemical pollution

Due to the distribution of toxic chemicals in soil, water and air caused by chemical compounds and heavy metals, plastics and plasticizers as well as radioactive waste.

Ecological Sustainability Approaches:

- *Product Development*: application of solvent-reduced paint and varnish; eschewal of PVC; application of biodegradable plastics; reduction of plastic waste
- *Production*: reduction of solvent loss (e.g. in chemical cleaning or surface treatment processes, or during handling of fuels); application of alternative plasticizers with better biodegradability or less biochemical interactions; life cycle optimization of machines and equipment

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- *Facility Management*: application of filter systems and systems for exhaust aftertreatment; installation of sewage and water treatment plants
- *Life Cycle Management:* professional disposal and recycling of products; clearance and recycling of neglected deposits and contaminated sites; eschewal of plastic packaging for raw materials and end-products

EP-7 – Change in land use

Due to the conversion of natural ecosystems caused by deforestation, agriculture and construction.

Ecological Sustainability Approaches:

- *Supply Chain Management* (e.g. in food or furniture industry): use of raw materials produced by organic farming and sustainable forestry
- *Facility Management*: avoidance of further soil sealing by more efficient use of existing industrial sites; laying out green space; replacement planting

EP-8 – Biodiversity loss

Due to the extinction of animal and plant species caused by destruction of natural habitats, soil sealing, introduction of invasive species, mining and dam construction.

Ecological Sustainability Approaches:

- *Supply Chain Management (e.g. in food industry)*: use und conservation of traditional autochthonous and regional species and avoidance of genetically modified organisms (GMO)
- *Facility Management*: avoidance of further soil sealing by more efficient use of existing industrial sites; laying out green space; replacement planting

EP-9 – Global fresh water use

Increase of consumption due to farming, household use and industry by agricultural irrigation, dams and interference with groundwater systems.

Ecological Sustainability Approaches:

- *Production*: reduction of water consumption in the production processes by optimization of process control and modernization of production lines; improvement of measurement and control systems and of rinsing techniques;
  reduction of water consumption in cleaning and cooling processes; water processing by cycling water flows
- *Facility Management*: reduction of water consumption throughout the corporate infrastructure; greywater recycling; installation of a separate pipe system for service water

B. Social Parameters (SP)

SP-1 – Food security

Legally regulated and governed by consumer protection and food safety acts (legal framework for production, safety, labeling, GMO etc.), national action plans for healthy nutrition and national nutritional advisory panels.

Social Sustainability Approaches:

- Healthy nutrition for employees (e.g. canteen, catering etc.)
- Organic or Fair Trade food products
- Compliance with animal protection
- Cooperation with local farmers and local suppliers
- Lay out of a company garden
- Support of “Social Supermarkets“

SP-2 – Water and Sanitation

National drinking water regulations and national infrastructure legislation.

Social Sustainability Approaches:

- Employee training regarding water saving measures
- Dispenser for drinking water
- Resource management initiatives (e.g. reduction of water consumption in showers and toilet flushes (two-level-flush), rain water use, greywater recycling and installation of a separate pipe system for service water)

SP-3 – Energy

National infrastructure legislation and EU Strategy for formation of a “European Energy Union“ and a joint climate policy.

Social Sustainability Approaches:

- Employee training regarding energy consumption and energy saving measures
- Energy management initiatives (e.g. corporate power supply by photovoltaic plant, hot water generation by solar thermal systems, increasing rate of renewable energy)

SP-4 – Health Care System

EU constitutional rights regarding access to health care, social and housing assistance, EU Social Rights Charta regarding social security, national health care legislation and European Guidelines on workplace safety.

Social Sustainability Approaches:

- Introduction of a workplace health management system
- Facilitation of a health promoting work/life balance
- Strategies for occupational re-integration
- Supportive design for public space

SP-5 – Education

EU constitutional rights regarding education, free choice of employment and vocational training, EU constitutional rights regarding freedom of science and teaching as well as national education regulations.

Social Sustainability Approaches:

- Advanced vocational training for employees (individual and on industrial sector level)
- Active human resource development
- Educational cooperations with local communities, schools and social services providers

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SP-6 – Income

EU wide coverage of pension claims, national regulations on unemployment insurance schemes and national regulations on social security.

Social Sustainability Approaches:

- Just and transparent income distribution between management and employees
- Incentive and benefit schemes for all employees
- Corporate pension funds
- Employee participation models

SP-7 – Gender Equality

EU constitutional rights regarding equal pay for equal work and National General Equal Treatment Acts.

Social Sustainability Approaches:

- Transparency regarding financial equality (equal pay for equal work)
- Optional part time or home office work
- Company kindergarten (potentially in cooperation with other organizations)
- Deliberate increase of the percentage of women in management positions

SP-8 – Social equity

EU constitutional rights regarding disability, age and sexual orientation, cultural, religious and linguistic diversity and National General Equal Treatment Acts.

Social Sustainability Approaches:

- Consideration of requirements of aging employees
- Equal treatment of educationally disadvantaged employees, employees from ethnic minorities and with migration background
- Support and active encouragement of voluntary charity work
- Social cooperation with non-profit organizations
- Implementation of corporate social standards

SP-9 – Freedom of speech (Voice)

EU constitutional rights regarding freedom of expression and assembly and EU constitutional rights regarding political participation.

Social Sustainability Approaches:

- Opportunity for active employee participation
- Cooperative management style

SP-10 – Safe jobs

European Guidelines on workplace safety, EU constitutional rights regarding workers' rights (including the right to fair working conditions) and protection against unjustified dismissal, international labor standards regarding reasonable limitation of working hours and periodic holidays with pay.

Social Sustainability Approaches:

- No "vulnerable employment"
- Implementation of an occupational health and safety management system

SP-11 – Resilience

Resilience - when reduced due to simultaneous strain by multiple risk factors).

Social Sustainability Approaches:

- Implementation of a social corporate culture
- Social and ecologically responsible supply chains
- Trainings and active measures against corruption

VII. Conclusion and Outlook

The purpose of this paper is to provide a new sustainability model for manufacturing SMEs by combining the innovative "Doughnut Economics" framework with solutions provided by the Green Manufacturing concept and some Corporate Social Responsibility (CSR) ideas that seem easily applicable for smaller companies. It needs to be emphasized that small to medium-sized enterprises - due to their structure and long-term orientation - are especially suited for implementing these concepts. As Push-factors (like pressure by laws and media) and Pull-factors (like market demands by customers or competition) are getting more and more important, many companies decide for the implementation of a strategic sustainability management. And the owners or the management expect to get something in return: the most prevalent sustainability measures currently applied in German companies are directly related to the respective business activity. Therefore, energy consumption, employee education and training, emissions, waste and waste water treatment are the most important topics due to their direct economic impact. They focus their sustainability strategy mainly on the design of their product portfolio, their supply chain management and their production processes [30]. This very pragmatic orientation towards processes relevant for the daily operation shows the practical importance of the "Manufacturing SME Doughnut" model presented in this paper.

As global environmental issues are getting direr by the day, it can be expected that the legal pressure on the international manufacturing industry will increase dramatically in the future. Therefore, future scientific research into applicable environmental and social strategies and respective tools like a Sustainability Performance Measurement System (SPMS) specifically dedicated to the owners and the management of these enterprises is required.

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