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Competitive Sustainable Globalization General Considerations and Perspectives

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Abstract

Globalization has essentially empowered both newly industrialized and early industrialized countries but also caused considerable global challenges on economic, environmental, and social stability. Trends and risks of globalization and sustainability are specified by reports of global stakeholders as IMF, OECD, UN and its related organizations, WEF, WTO, and WWF. Competitive Sustainable Globalization (CSG) is introduced as a new paradigm and as a means to cope with the respective challenges. Competitive Sustainable Manufacturing (CSM) can be a fundamental enabler for CSG, proposing a global as well as a local approach for manufacturing. Potentials of value creation by manufacturing with reference to business models, education, and innovation are presented.

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1. Introduction

Globalization is a highly complex process in progress, conceived and implemented by multilevel stakeholders, driven and constrained by forces concerning economy, society, environment, politics, and technology. It is a worldwide movement leading to economic, financial, trade, and communications integration. Globalization is bringing different levels of useful and harmful impacts to the early and newly industrialized countries. It is a change

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unavoidable for the time being: it is and will be affecting the life and activities of all multilevel stakeholders ranging from individuals to communities, companies, to universities and research institutions, governmental and civil institutions, to regional, national and to international organizations.

Globalization hosts the conflicting role of two different dynamic, but somehow interconnected, development paradigms, i.e. mere economic development and sustainable development including economic development both adopted, to different degrees, by early and newly industrialized countries. Mere economic development is based upon competitiveness and on an economic growth-oriented philosophy. Sustainable development is a development that aims at meeting the needs of the present while ensuring the ability of future generations to meet their own needs [1]. Sustainable development supports progress in economic, environmental, social, and technological domains. The sustainable development paradigm is slowly emerging, due to the growing support of global institutions as well as national and regional public administrations throughout the world. Within the International Academy for Production Engineering CIRP (www.cirp.net), Jovane has introduced the Competitive Sustainable Globalization CSG paradigm [2]. The following considerations set up a framework of challenges as described by international stakeholders i.e. IMF, OECD, UN, UNACTAD, UNESCO, UNIDO, WEF, WTO, and WWF to identify potentials of manufacturing to cope with them.

2. Framework

Stiglitz defines globalization as the “closer integration of the countries and peoples of the world brought about by the enormous reduction of costs of transportation and communication, and the breaking down of artificial barriers to the flows of goods, services, capital, knowledge, and people across borders” [3]. Globalization involves economic integration by transferring policies and transmitting knowledge across borders [4]. It is a phenomenon of increasing global interdependences of markets and value creation through the growing volume and variety of trade in tangible and intangible products in different countries, of increasing cross-border flow of capital, and of the rapid and widespread exchange and diffusion of technology [4,5,6]. The flow of capital, also called financial globalization, is characterized by the reduction of controls for the cross-border flow of capital combined with a simultaneous deregulation of the domestic financial sectors [4]. The process of economic integration has essentially deepened during the last decades through the increasing application of new information and communications technology (ICT), and by the rapid technological progress in general [4]. Interconnected economies benefit from global value chains [7]. According to the WTO, the global value creation can be currently characterized by [8]:

- Trade in goods, manufactured parts and components
- Emergence of new services throughout the value creation networks and the linkage of services with manufacturing (“Servicification”)
- Global investment in production facilities, education, technology, and business relationships
- The use of infrastructure services to coordinate the value creation networks such as the internet or air cargo
- Cross-border flow of know-how such as intellectual property

A further global integration is currently being pursued by the negotiations concerning new trade agreements such as TPP, TTIP, RCEP, the Pacific Alliance in Latin America and the Tripartite Free Trade Agreement in Africa [9]. All existing countries are affected, to a different degree, by globalization, as shown by ETH KOF Globalization Index [10].

Globalization is considerably based on mere economic development, driven by competitiveness. Nature has been and is supplying the necessary resources for men and technology’s life cycles as well as absorbing and metabolizing related waste. Natural as well as technological resources, not available locally, have been acquired through commercial exchanges, leading to early forms of globalization.

World population has been and may be growing through time thus inducing, along with technology, a continuous, fast increase in resource consumption and related waste generation. Globalization is contributing to making use of more resources than earth can renew [11], leading to the estimated use of the biocapacity of one and a half earths to support humanities current lifestyle [12]. This development had been predicted in the 1970s by the Club of Rome document: the limits to growth [13]. Further degradation of the earth’s capacity to generate resources, continuous

accumulation of greenhouse gases and other wastes, make the decline, or even collapse, of critical ecosystems likely. However, this path is not unavoidable. Local solutions to these challenges do not need to wait for a global consensus.

Referring to the social domain of sustainability, globalization has dramatically widened the inequality. Trade, employment and social policies need to be pursued together [14]. There is a need to foster and support a sustainable development, based on economic, environmental, social, and technological domains to achieve a balanced interaction of these domains, as fostered by the new paradigm proposed: Competitive Sustainable Globalization [2] including the mandatory involvement of all multilevel stakeholders.

2.1. Impacts on Early and Newly Industrialized Countries

Enabled and supported by new technologies, ranging from communication and information technologies to new production and manufacturing technologies, as well as by new disruptive business models, globalization has addressed mere economic development, predominantly based on economic competitiveness. Globalization has stimulated the global economic growth as well as the rise of global value creation driven by technological advances in ICT and transportation systems. Due to new technological innovations, the global value creation networks are evolving rapidly [8]. This has led to great transformations in early and newly industrialized countries [8] resulting in some essential impacts concerning economy, environment, and society. These impacts are listed hereafter in Table 1. In conclusion, globalization has created a variety of impacts in early and newly industrialized countries addressing many different levels such as growth, job quality, job quantity, wealth, standard of living and life expectancy, as well as politics, civil rights, and pollutions, resource depletion and species extinction.

2.2. Future Perspective

The previous survey shows that beside benefits, there are relevant challenges, concerning not only economy but also society and environment. Two striking problems, concerning respectively the anthropic and technological ecosystems, are reported here after.

Anthropic ecosystems. A basic challenge is the value creation and its fair distribution among people. It is necessary to increase the standard of living of billions of people living in or close to poverty. The prevailing common approach that only an expanding GDP can eliminate poverty and provide the wealth needed to address ecological concerns [15] might lead to a resource consumption exceeding all accountable economic, ecological, and social bounds, as e.g. also feared by the Club of Rome foresight study [13].

Technological ecosystems. For the first time since the beginning of the industrial revolution, the world economy is also facing shortages of access to essential non-renewable resources. By 2008, 63 of the 89 depletable mineral resources that sustain modern industrial economies had become globally scarce as revealed by diminishing returns to exploration and dramatically rising prices [15].

Thus, the globalization paradigm must move from a mere economic development mostly competitiveness driven, to a new Competitive Sustainable Globalization paradigm, combining competitiveness and sustainability, caring for economy, society, and environment.

Table 1. Summary of impacts of globalization mainly according to the OECD [16]

Specific Economic Impacts on Early Industrialized Countries	Growth	There has been the opportunity for national economic growth [17]. However, the economic growth continues to remain rather weak after the 2008-2009 financial crises [9]. Companies of the early industrialized countries could expand their market into other early and newly industrialized countries [17].
	Job Quantity	The increasing competition going hand in hand with the globalization leads to the continuous necessity of cost reduction for the involved companies. Thus, companies in early industrialized countries have used offshoring of jobs to newly industrialized countries as instruments to reduce their costs [16]. The jobs lost in this connection in early industrialized countries are mostly related to labor-intensive and low-skill areas such as assembly lines [16]. The resulting savings in productivity allows companies to make new investments e.g. hiring new workers [16]. In early industrialized countries despite from offshoring additional factors related to productivity gains, such as new technologies or companies' strategic re-orientation, have also led to job losses [16]. On the other hand, there has been job creation in the high-tech and service industries [16]. It has been predicted by the OECD that the increase in the quantity of service-related job has been greater than the number of industrial jobs lost related to off shoring [16].
	Job Quality	The wages in industries for high-educated and experienced workers have improved as well as in industries where countries are holding a major competitive advantage [16]. The wages of jobs in the less-competitive low value-added sectors have decreased [16].
Specific Economic Impacts on Newly Industrialized Countries	Growth	The shift of labor-intensive value creation to newly industrialized countries and the global mobility of technology have initiated a new era of growth for the markets of newly industrialized countries fostered by rapid industrialization [9,18,19]. Brazil, Russia, India, and China ("BRICs") in general experienced a rapid growth [9]. Moreover, new countries such as Bangladesh, Egypt, Indonesia, Iran, Nigeria, Vietnam, Pakistan and the Philippines are experiencing a comparable rapid growth and become increasingly important for the world economy due to the rise of labor costs and thus of production costs in the other early and newly industrialized countries [16]. The so called Asian "tigers", Hong Kong, South Korea, Taiwan, and Singapore developed as leaders in consumer goods [16].
	Job Quantity	Jobs have been created due to entrepreneurial activities or companies off-shoring from early industrialized countries [16].
	Job quality	The job quality in newly industrialized countries has generally improved since international companies imported high quality standards and practices paying employees' higher wages than local companies. However, child labor, modern slavery as well as sub-contracting by so called sweatshops with long working hours and very low wages are still relevant [16].
Global Social-Economic Impacts		Globalization can contribute to the instability of countries, which are essentially dependent from raw materials, or by the exposure of countries to speculative finance bubbles, as well as through the weakness of local companies faced with global competition [16]. There has been a global increase in the middle class [16] but globalization also contributes to increasing inequalities among social groups [16]. The share of people living in extreme poverty has increased in southern Asia and Sub-Sahara Africa [16]. In 2011, the poorest countries were poorer than the poorest countries in 1980 [16]. However, some improvements in living standards have been realized. The global infant mortality has essentially decreased [16]. Life expectancy has raised in early industrialized countries to around 65% but which is still ten years less than in early industrialized countries [16]. In addition, the literacy rates have risen by 10% since 1970 [16]. Politically, the share of the world population living in countries run by elected governments and in freedom has increased [16]. Moreover, more and more countries have adopted civil and political rights [16].
Global Environmental Impacts		Globalization has occurred alongside with rising pollutions, resource depletion and species extinction [16]. However, the impact of globalization on the environment is partly difficult to evaluate [16].

3. Challenges

There is growing concern about globalization and its growth pattern. Evans views it as liberalism failure and urges that more equitable development of human capabilities and environmental stewardship is needed [20]. A report prepared by the United Nations [21] proposes that the pattern of finance-driven globalization, currently dominating international relations, should be replaced with a model of development-led globalization. A Task Force of the World Economic Forum conducted a major study on the future of manufacturing in a global world. This study addressed mainly the economic developments related to global manufacturing and the impact of government policies on the future of global manufacturing in general [22]. Some Authors are stating that an orderly contraction is the only viable means to a “just” sustainability and this, in turn, implies nothing less than a deliberate rewrite of contemporary society’s grand cultural narrative [15]. In particular, the world would have to abandon its core myths of perpetual progress and material growth and focus instead on “degrowth” toward a sustainable steady state with greater equity [15]. The new proposed paradigm, Competitive Sustainable Globalization (CSG), should progressively integrate both economic and sustainable development while globalization is progressing by acting at the appropriate different stakeholder levels. CSG promotes a sustainable development in early as well as in newly industrialized countries simultaneously retaining competitiveness.

In the two following sections competitiveness and sustainability, referring to globalization, are analyzed as to identify where and how to act.

3.1. Competitiveness

Globalization and competitiveness are strictly related. Competitiveness is of paramount importance for implementing CSG. Competitiveness is a relevant driver of globalization. Its architecture must be known to find out where, when and how to act to reduce problems induced by globalization, and generate a move towards sustainability, as suggested by WEF [22]. This introduces sustainable competitiveness as the set of institutions, policies, and factors that make a nation productive over the longer term while ensuring social and environmental sustainability, following [23]. Competitiveness is defined as “the ability of a firm or a nation to offer products and services that meet the quality standards of the local and world markets at prices that are competitive and provide adequate returns on the resources employed or consumed in producing them” [24]. In broad terms, competitiveness may be considered as market success at country, industry, and company level.

Competitiveness at country level. Competitiveness at country level was introduced by Porter in his basic work on the competitive advantage of nations. Porter identified Nations’ competitiveness as based on the productivity with which they produce goods and services [25]. The Global Competitiveness Report of the World Economic Forum defines competitiveness as “the set of institutions, policies, and factors that determine the level of productivity of a country” [23]. Competitiveness focuses on the productivity and determines the rate on investment, which in turn fundamentally empowers global growth [9]. The WEF states that openness to the world through trade, investment or finance flow, and the mobility of people is substantial for competitiveness [9]. The annual Global Competitiveness Report [23] assesses the competitiveness landscape of 140 economies, providing insight into the drivers of their productivity and prosperity. The report series may be one of the most comprehensive assessments of national competitiveness worldwide.

Competitiveness at field level. Competitiveness at field level may be defined as a comparative concept: i.e. the ability and performance of an actor (firms, universities, institutes and research centers etc.) to respond to a “customer demand” better than anyone else. Networks such as “value chains,” “industrial districts”, are going to play a rising role [26]. Globalization, together with rapid technological changes, is increasing competitive pressures on all firms and altering the environment in which they operate. Thus, in a more open and globalized world, increasing firm competitiveness is enhancing a firm's market opportunities and is offering expanding opportunities for a firm's success but also has become a major challenge to the SMEs. As a result of the current global development, the competition has intensified in global markets in terms of the increasing number of market participants and the growing difficulty for generating market opportunities and economic links [9].

3.2. Trends and Risks

The term “Sustainable Development” in its current meaning was first mentioned by the report “Our Common Future in” 1987 as the ability to ensure “the needs of the present without compromising the ability of future generations to meet their own needs” [1]. Another essential milestone towards shaping the term of sustainable development was the United Nations Conference on Environment and Development in 1992. The passed Rio Declaration and Agenda 21 [27] introduced the three pillars model of sustainability with its three equally weighted pillars: economic, environmental, social.

Sustainability here is meant as sustainable development and can be interpreted in economic, ecological, social, and technological domains. For each of these domains, the global risks report 2015 and 2016 published by the World Economic Forum details some major trends. Figure 1 presents a selection of these global trends in 2015 and 2016 and their impacts on the different domains [28,29].

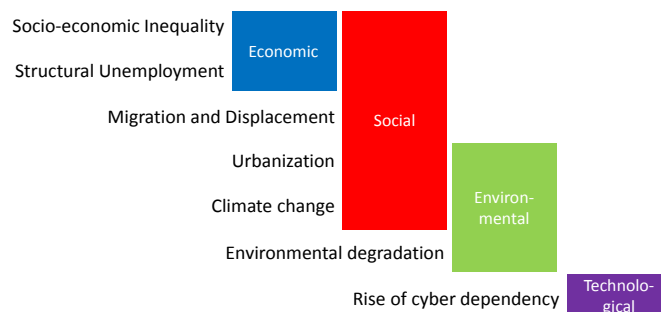


Fig. 1. Selection of relevant global trends 2015 and 2016 [28,29].

The following paragraphs summarize some characteristics for each of the relevant global trends.

Socio-economic Inequality. The average income of the richest 10% among the countries of the OECD has grown to about nine times to that of the poorest 10%, which corresponds to an all-time peak [30]. A recent Oxfam study shows that 62 people own the same as half of the world [28, 31]. The inequality is not only present between social groups but also between genders. In average, women earn 16% less than men [30].

Structural Unemployment. Rising structural unemployment in connection with the spread of connectivity is increasing the risk for violence, which can spread from local to global level and could thus negatively affect the global economy as well as the social stability [28]. E.g. the average unemployment rate in the EU for the youth, addressing people with an age of less than 25 years, is almost at 20% [32].

Migration and Displacement. Globally, migration and displacement have reached an unprecedented extent in recent history [33]. Worldwide, 40.8 million people were internally displaced (IDPs) in 2015 as a result of conflict and violence [33]. The total number of IDPs has doubled over the past 15 years [33]. Around three quarters of these IDPs were located in just ten countries and mostly in newly industrialized countries in Africa, Middle East, and South America [33].

Urbanization. The increasing urbanization and global urban population growth is another global challenge which especially affects Africa and Asia. India, China, and Nigeria are estimated to contribute by more than 1/3 to the increase in urban population until 2050 [34].

Climate Change. The average annual global temperature has increased from -0.2 °C in 1950 to 0.75 °C in 2015 [35]. Climate Change also has an impact on agricultural capabilities and the access to fresh water in certain regions on our globe [28]. Thus, it can also lead to an uncontrolled migration from these regions to regions, which are not affected by the climate change to the same extent [28].

Environmental degradation. The consumption of regenerative resources can be measured through the Ecological Footprint, i.e. an estimate of the biologically active area needed to support humanity's current lifestyle. The actual consumption of natural resources exceeds the regenerative capacity of the planet by 50% [12]. Global water requirements are projected to be exceeding a sustainable degree of water use by 40% in 2030 [36]. This will be

the result of a growing water use for the food production, induced by population grows, of changes in dietary habits, as well as of an increase in use of water for energy generation and production [36]. Water Security itself serves as the cornerstone for energy security, climate security and food security [36]. Another important issue of the environmental degradation is the depletion of the biodiversity due the extinction of species. According to the WWF Living Planet Index, a decline of 52 per cent between 1970 and 2010 occurred: on average, vertebrate species populations are about half the size they were 40 years ago [12].

Rise of cyber dependency. The increasing hyperconnectivity in context of the Internet of Things or Industry 4.0 leads to a rising “cyber dependency” and the risk of large-scale cyber-attacks [28], e.g. the detection of ransomware has increased worldwide by 600% between October 2015 and February 2016 [37].

All the before mentioned relevant trends lead to some likely global risks, which are pointed out in Figure 2 addressing a regional perspective and the four domains, following the WEF.

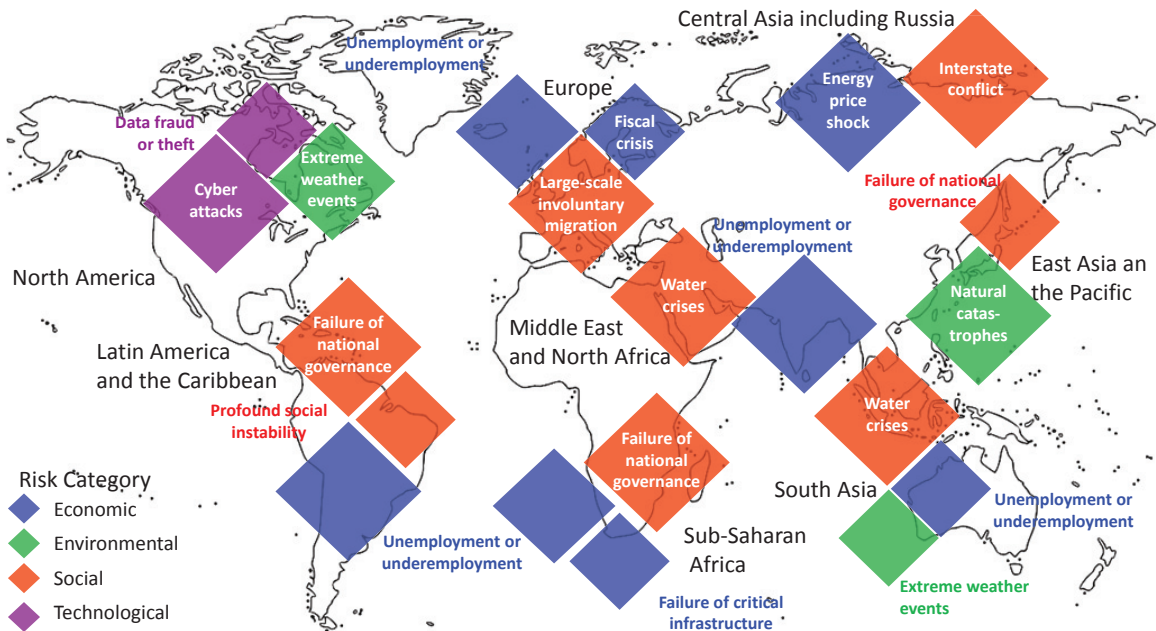


Fig. 2. The Most Likely Global Risks 2016: A Regional Perspective [29]

3.3. Interim Conclusion

If future lifestyles of early and newly industrialized countries will be shaped by the existing, actually predominantly applied technologies, then the global development will exceed reasonable economic, environmental and social boundaries. The dynamics of global competition and cooperation shall be exploited for innovating and mediating manufacturing technologies towards the reasonable demanded sustainability on earth. Hence, establishing, sustainable development globally has become a growing and dramatic requirement and a challenge for mankind's survival on earth and his future development, considering the limits of resources and growth and the unequal distribution of wealth. Thus, the sustainable development must simultaneously ensure the economic, environmental, social as well as the technological domains of human existence.

The above-stated is fundamental for moving towards the new paradigm: i.e. Competitive Sustainable Globalization. To this end, action should take place, prevalingly, at “local” level where political power and availability of resources can initiate strategic sustainable innovation ecosystems, capable of responding to the global crisis as well as addressing the future. Reiterating this process, at local level, across the world, would “globalize” sustainable development: i.e. sustainable globalization. This process has already started [38].

4. Activities

The previous analysis has shown, that globalization activities

- refer mainly to a well-established paradigm: i.e. an mere economic development, based on competitiveness and leading to benefits and challenges in the economic, environmental, and social domains;
- whereas globalization should more and more refer to a sustainable development paradigm, which sustains and creates benefits for society, environment and economy.

The two paradigms, economic development and sustainable development inspire globalization processes acting within our living metaspace and our global value creation. Competitive Sustainable Globalization can help balancing activities in their economic, environmental, and social domains. Relevant initiatives including from global institutions, to national, local public administrations, within early and newly industrialized countries are reported hereafter.

4.1. World organizations

In September 2000, the United Nations General Assembly adopted the Millennium Declaration [39]. It has eight chapters and key objectives (MDGs), adopted by 189 world leaders during the summit. The declaration stressed the observance of international human rights law and international humanitarian law as well as the treaties on sustainable development. Then a 2030 Agenda for Sustainable Development, including 17 Sustainable Development Goals (SDGs) was developed and adopted by world leaders in January 2015, officially coming into force on September 2015 [40]. Over the next fifteen years, with these new goals, which universally apply to all countries, early as well as newly industrialized countries, will mobilize efforts to end poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind. The SDGs shall be integrated into national planning priorities and documents for developing measures, which support an implementation of the goals at regional and local level [41]. Many early and newly industrialized countries have already started integration activities for implementing the SDGs into their existing national strategies and plans [41]. Various global organizations will support the Initiative:

The OECD will support “[...] the United Nations in ensuring the success of the 2030 Agenda for Sustainable Development by bringing together its existing knowledge, and its unique tools and experience, including: a strong track record in policy work with developed and developing countries and measures and systems for monitoring performance” [42]. UNESCO will promote the implementation of the SDGs by focusing its working activities on six fields: education, natural sciences, social and human sciences, culture, communication and information, as well as on ocean science [43]. The UNIDO “[...] strongly promotes paths of economic growth and industrialization that reconcile all relevant dimensions of sustainability” [44]. This shall be achieved “[...] through strong, inclusive, sustainable and resilient economic and industrial growth, and the effective integration of the economic, social and environmental dimensions of sustainable development” [45]. According to the UNIDO, a sustainable industrial development can be achieved “[...] provided that policymakers resolutely facilitate and steer the industrialization process, which requires sound policies” [44]. The United Nations, referring to the above sustainable development goals (SDGs), has produced the Global Sustainable Development Report 2016 [46], designed as an assessment of assessments. The report “[...] endeavors to present a range of scientific perspectives and to be policy-relevant but not policy-prescriptive” [46]. The role of technology for SDGs is considered critical “[...] because technology has greatly shaped society, economy and environment and vice versa. In fact, technology, society and institutions co-evolve. Hence, technology progress requires institutional adaptations and may be constrained by social issues.” [46].

According to UNIDO, the manufacturing sector is the cradle of innovation and technical change and thus has a relevant place in the activities of economic policy-makers [47]. Most innovations are being developed and commercialized in the manufacturing sector [47]. Consequently, is the “main engine of technical change and economic growth” [47]. To ease and help the design and implementation of policies, by policymakers, UNIDO is providing “[...] insights into current and future global trends that will influence manufacturing production in developing and developed countries in the years to come” [48].

4.2. Countries

The recent Global Competitiveness Report [23], by the World Economic Forum lists countries scores concerning, singularly and combined, competitiveness, social and environmental sustainability. The report shows that a consistent number of countries is gradually moving towards sustainability.

In India, the 12th Five Year Plan and Beyond [49], proposes a manufacturing plan, i.e. strategies for accelerating growth of manufacturing in India and a move towards sustainable manufacturing. Studies are being carried out in Africa concerning governance practices and vertical alignment at the national and subnational levels [50].

4.3. Regions

Studies and initiatives, concerning the move of regions towards sustainable development, are being carried out in many early and newly industrialized countries, including USA, China, and Europe. Here, in particular, the European Commission has paid great attention to a Sustainable Development Strategy (SDS) [51]. The recent initiative: “Research and Innovation Strategies for Smart Specializations” (RIS3) [52] that involves more than 200 EU Regions and refers to sustainable development, may be seen as an initial contribution to sustainable globalization.

Midtkandal and Sörvik state that RIS3 “[...] is a strategic approach to development through targeted support for research and innovation. It involves a process of developing a vision, identifying the place-based areas of greatest strategic potential, developing multi-stakeholder governance mechanisms, setting strategic priorities and using smart policies to maximize the knowledge-based development potential of a region, regardless of whether it is strong or weak, high-tech or low-tech.” [53].

Hence, even if innovation has globalized, the role of regions as the critical nexus for innovation-based economic growth has increased. Regional economies are keys to innovation and growth. Evidence and practical examples confirm that regions and cities play an important role in developing innovation by being the home of industrial clusters, competence centers, incubators, technology parks and many other types of formal and informal innovation spaces. Regions are well positioned to tackle both innovation and sustainability as:

- on the one hand, regions have an insight into their own innovation systems, as well as the capacities to mobilize regional innovation stakeholders through specific policy instruments;
- on the other hand, regional stakeholders have a good understanding of regional environmental performances, as well as the capacities and competences to take local action to promote environmental sustainability.

4.4. Stakeholder Involvement

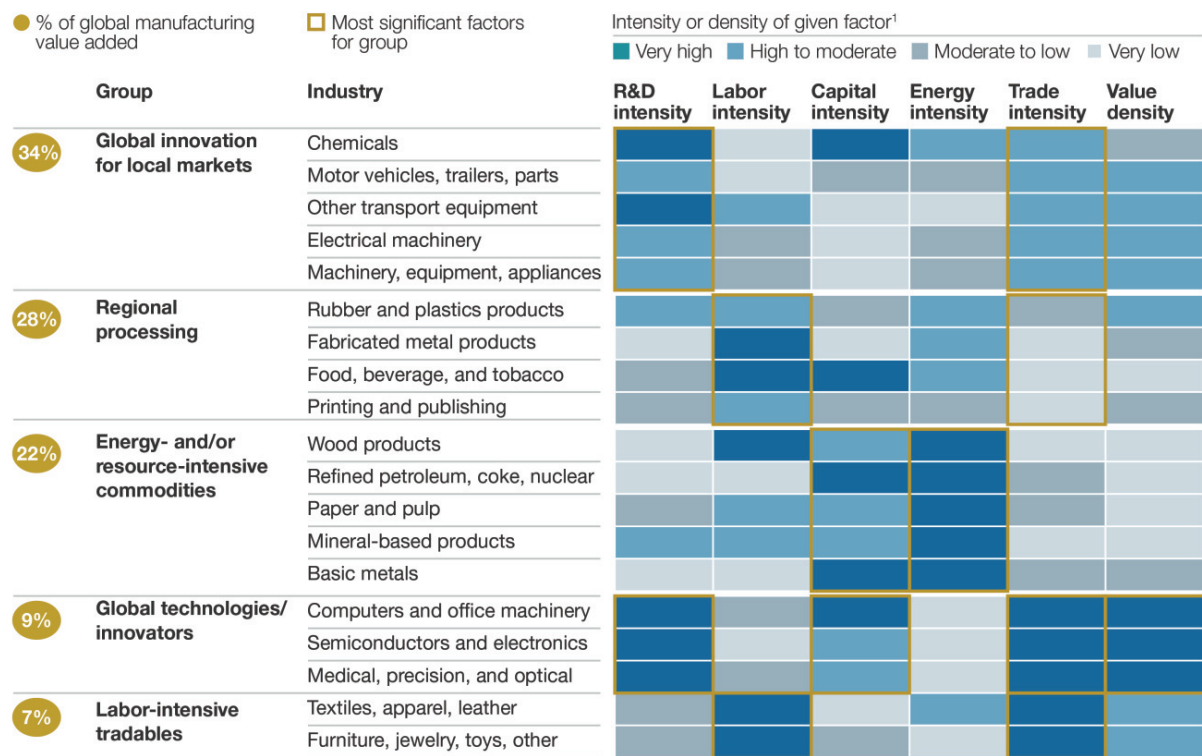
A sustainable future of our planet depends on appropriate political as well individual decisions by the multilevel stakeholders. Globalization is a paradigm, involving these stakeholders, singularly or aggregated as ecosystems and networks, these being groups of interconnected elements, formed by the interaction of a community of organisms with their environment. People as consuming stakeholders are passively affected and as producing stakeholders are actively involved in shaping nature and life world. There are different levels of harmful and useful impacts resulting e.g. from individual daily live decisions via management decisions on company investment to geopolitical negotiations on climate change. Stakeholders on each level are both affected by nature and life world as well as principally able to contribute on shaping nature and life world with respective levels of harmful and useful impacts by influencing e.g. the material wealth, community life, religion or the technological development. As the globalization paradigm is giving great concern to most of the stakeholders, it is mandatory to address fundamental political features such as competitiveness and sustainability, and define where and how to act. In particular, two levels should be considered:

- globally, mostly concerned with competitiveness, global companies and newly industrialized countries;
- locally, where sustainable development could progressively be “installed” through appropriate ecosystems, within early and newly industrialized countries.

5. Manufacturing as Enabler

Globalization has been made possible by several hard and soft technologies. They include from manufacturing, to transportation, telecommunication and above all education. This chapter concentrates on the relevance of manufacturing in the light of CSG.

Interdisciplinary research on the links between manufacturing, innovation and the world economy as well as actions at national and local level have led to the conclusion, shared by US, EU, Japan as well as other countries, that a strong manufacturing base should be retained for reasons spanning from defense capacities to job creation, to manufacturing large potential for innovation-based economic growth. This is critically important to both early and newly industrialized countries [29]. The important role of manufacturing in solving global problems was recognized by a report published by the McKinsey Global Institute (MGI) in 2012 [54]. The MGI report identified five broad manufacturing segments and analyzed how different production factors influence the location of new factories, and the penetration of new markets as shown in Figure 3. It is interesting that one of these segments is entitled “Regional Processing” and is estimated to be 28% of the future manufacturing market. The MGI report characterizes the regional processing segment by (a) low tradability (5–20%), and (b) local tastes drive proximity need.



¹For methodology, see *Manufacturing the Future: The next era of global growth and innovation* available on mckinsey.com.

Source: 2010 Annual Survey of Manufactures (ASM); 2007 Commodity Flow Survey, US Census; IHS Global Insight; Organisation for Economic Co-operation and Development (OECD); McKinsey Global Institute analysis

Fig. 3. Global manufacturing sectors vs relevant factors [54]

5.1. Paradigm Competitive Sustainable Manufacturing (CSM)

Proposed as a new paradigm, Competitive Sustainable Globalization can contribute to a “desirable and acceptable future” which calls for a development that is sustainable and within which competition can play an important role.

According to Jovane, Competitive Sustainable Manufacturing (CSM) can be a fundamental enabler in this context, “[...] as it generates wealth, sustains jobs (directly and through related services) and manages human and physical resources, from materials to energy.” [26].

CSM consists of two complementary paradigms: a local paradigm and a global paradigm. The global paradigm will constitute of global value chains with factories located in newly industrialized countries exploiting respective competitive advantages such as tax and labor cost. This is a key driver for job creation and elevating living standards. The local paradigm emphasizes CSM and innovation at the local level by pursuing the creation of local jobs in product design, manufacturing and related services, as well as enhancing the comfort and the wealth of people in the local communities. This complies with recent efforts to make segments of the innovation process regional in their scope, where the regional ecosystem is made up of a constellation of key industries, suppliers, and supporting institutions including private firms, public-private partnerships, government and educational institutions. Such initiatives are fast developing in countries such as US, EU, Japan, China, UK and others. CSM would generate high added value and would be knowledge-based. CSM would concern:

- manufacturing industry, i.e. products and services, processes, and business models;
- as well as the related Education, Research and Technological Development and Innovation (E&RTD&I) system.

CSM should comply with conflicting expectations of early and newly industrialized countries. CSM should be developed and implemented in each country and its regions. Cooperation among countries and regions, particularly on sustainability, should take place.

The industry is on the verge of the fourth industrial revolution or Industry 4.0 [55]. Industry 4.0 is fundamentally different from the previous three industrial revolutions, as it is characterized by a range of new technologies that are integrating the physical, virtual and biological worlds, involving all disciplines, having relevant impacts on all economies and industries. The digital transformation of manufacturing systems towards Industry 4.0 has a substantial impact on CSM by establishing Cyber-Physical Systems and leading to cross-linked technical systems in real time [54]. New and disruptive business models will be evolving around Industry 4.0 [55,56]. Thus, Industry 4.0 will concern early as well as newly industrialized countries.

It is important to underline, that nations on our globe show different levels of development [11], e.g. rapid economic growth or a slow economic development. This implies a progressive and articulated action towards

- newly industrialized countries, for them to consider sustainability at the earliest stage of their process of growth and development;
- early industrialized countries, for a rapid move towards CSM.

5.2. *The global and local approach of CSM*

Jovane differentiates between the global and the local paradigm for CSM [26]:

The global paradigm of Competitive Sustainable Manufacturing will constitute of global manufacturing industries with factories located in newly industrialized countries holding a competitive advantage in terms of e.g. tax, labor cost, etc. This is a key driver for job creation and elevating the living standards in these countries. Corporate decision-makers are driven by the need to provide best shareholder value in their manufacturing and business strategies. Wherever parts and final goods can be produced and distributed in the most cost effective ways, manufacturing plants are likely to be established. Governments and policy-makers are increasingly challenged to foster the creation of high-paying jobs and the generation of economic growth. Beyond traditional policy and institutional levers, governments around the world are being compelled to use stimulus packages, job creation programs, financial incentives and regulatory regimes to promote economic growth. However, it would be very difficult to combine these different interests to achieve sustainability [57].

The goal of this paradigm is to create local jobs in product design, manufacturing and service, the products as well as to enhance the comfort and pleasure of people in the local communities supported by a local periphery. By local we mean a state or a region within a large state, or a large metropolitan area. In particular, it is possible to

envision the creation of a new sustainable local manufacturing industry in early industrialized countries and their regions. This new industry will be based on manufacturing new products that are characterized by (1) their need to be tailored to individual buyers and (2) be modified during their lifetime to readapt to changing needs of customers. This new paradigm will also require new manufacturing technologies, and a new generation of manufacturing professionals. Local manufacturers are more likely to innovate because of their close proximity to their customers. Note, however, that the local manufacturer is using in the tailored product general commodities supplied by global manufacturers that by utilizing economies of scale can supply low cost parts. Therefore, the local industries will be sustainable, namely will keep their local production operations forever. Note that both the global and the local industries are part of a global value chain that seamlessly connect the global and the local industries. Recent developments in manufacturing policies in advanced industrialized countries include the shift towards comprehensive regional strategies to support advanced manufacturing, as local plans that will generate sustainable sources of income by establishing new local startup companies that will create new jobs. This is a very important goal of globalization. Public policy at the local and regional scale improves manufacturing resilience, encourages the adoption of new models of production and consumption, and enables the ongoing viability of older industrial cities and regions. The economic domain of sustainability and the competitiveness should still be the foundation of a companies' activities, but there should be a growing attention to balance this foundation with the social and environmental domain of sustainability. This is a spreading process that supports the proposed CSG paradigm.

6. Value Creation

Values can essentially influence our decision-making making process for shaping the technological reality towards a more sustainable development (Figure 4) [58].

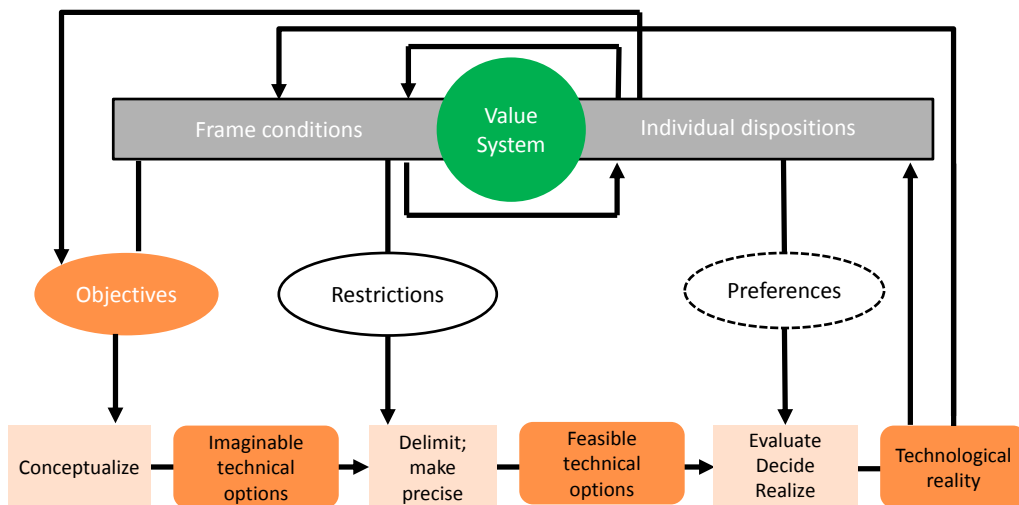


Fig. 4. Value System in Engineering [58]

The value system of a decision maker is based on individual needs, interests, and norms. Thus, the value system is being coined by the general frame conditions as well as the individual dispositions. General frame conditions can be distinguished into natural frame conditions and societal-cultural frame conditions. The natural frame conditions are centered on the laws of nature in general such as availability of natural resources. The results of human actions and structures of human cohabitation determine the societal-cultural frame conditions. Individual dispositions represent the individual needs of life support and for necessities of life. Additionally, they include individual points of view shaped by religion, cultural area, social environment, as well as individual life experience and ways of living and thinking of the decision maker. The frame conditions and individual dispositions influence each other and both lead to objectives for developing a new technology. The objectives are the starting point for the

conceptualization of a new technology within the search field of imaginable technical options. These options are delimited and made precise by restrictions set by the frame conditions. The outcomes are feasible technical options. This search field is then the basis for an evaluation, decision, and realization formed by individual preferences, which are the manifestation of the individual dispositions. The developed technology is finally becoming a part of the technological reality, which closes the cycle by affecting the frame conditions and individual dispositions. [58]

In conclusion, the engineering values as part of the individual value system have an essential impact on the development of sustainable manufacturing technologies. These sustainable manufacturing technologies subsequently shape the general frame conditions as well as the individual dispositions of individuals in the sense of a sustainable development. New sustainable manufacturing technologies as main building block of many national economies consequently play an important role for realizing a global sustainable development. In this sense, new manufacturing technologies are contributing to a sustainable development by shaping the technological reality in the economic, environmental, and social domains.

The next section (6.1) describes the breadth of the systemic reference for enabling sustainable value creation. The subsequent section (6.2) describes the depth of manufacturing technology exemplarily covering the leverage of education followed by a section (6.3) pointing out how new sustainable and technological innovations can be developed.

6.1. Breadth and Depth

The approach to cope with the challenges of sustainability is combining the breadth of systemic reference with the depth of manufacturing technology to enable for sustainable value creation.

Trade-offs between different values. Sustainable manufacturing is the manufacturing engineering's approach to cope with the addressed challenge. Manufacturing technology is developed in the direction of economic competitiveness, of environmental compatibility with natural global frame conditions of resource availability and of social welfare with different societal frame conditions in different human communities on globe. This multidimensional goal system can be balanced by developing adequate economic, environmental and social values, analyzing their interdependencies and applying the analysis for guiding technology innovation in respective economic, environmental and societal frameworks. The standard VDI 3780 [58] provides an overview of a value system in engineering for application in the process of developing and assessing technological systems.

Factors which can be influenced and factors which are considered as frame conditions. The manufacturing engineering's approach can be spelled in terms of manufacturing modules. These modules can be modelled by the value creation factors of product, process, equipment, organization and humans, each of which can be directed in respective approaches of technology innovation. A thorough differentiation between what could and should be influenced and what has to be considered as frame conditions for respective value creation is required for each development process. Sustainability criteria gain a radar function in guide lining manufacturing innovation.

Functional unit concept and Implementation in Areas of Human Living. Manufacturing modules consisting of value creation factors represent functional units on different levels of aggregation i.e. an elementary cutting process on the lowest level, manufacturing department, factory, enterprise, industry, national economy in between and global value creation on the top level. On each level, the generic five factors can be instantiated and respective sustainability criteria be assigned. Moreover, by vertically or horizontally integrating modules, they can be interpreted as value creation networks, also on different levels of aggregation. Vertical integration addresses the product lifecycle from material extraction via design and manufacturing, use, remanufacturing for further usage phases and disposal. Horizontal integration addresses scale effects of manufacturing steps for higher lot sizes or different products with the extremes of one central factory for the whole world or decentralized manufacturing sites directly aside product use. Driving forces for and against vertical and horizontal integration are cooperation and competition in the respective markets.

Sustainable manufacturing innovations have to be implemented within the areas of human living in fair relations of exchange between early and newly industrialized countries. Areas of human living are interpreted not only in the sense of tangible and intangible artefacts shaping human life but also in the sense of surrounding fields of useful technology coming into existence and consequences of applications in respective fields. Figure 5 gives an overview the functional unit concept and implementation in areas of human living.

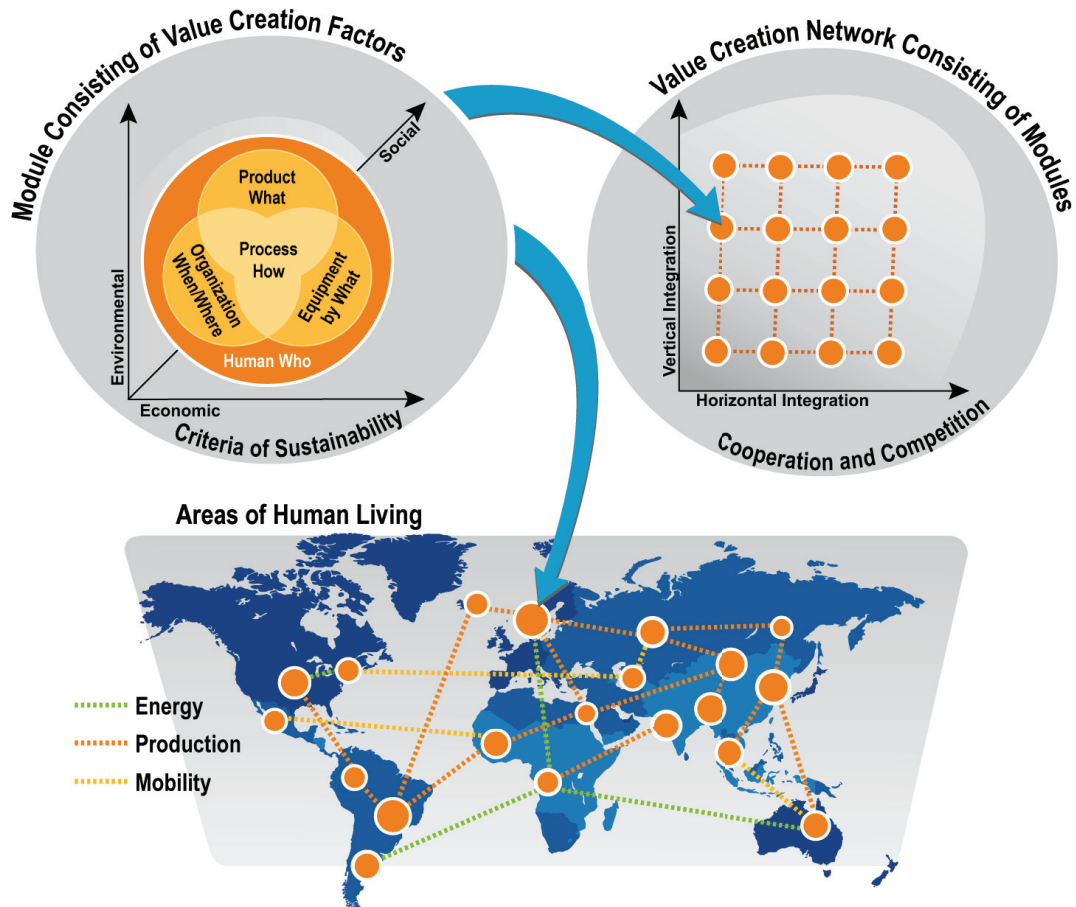


Fig. 5. Value Creation Module, Networks and Areas of Human Living [59]

Assessment of Alternatives. Different modes of life cycle assessment provide a wide variety of means to compare and measure alternatives. However, often the complexity of values to be taken into account is beyond what can be handled in practical technological development. The complex solution space of development for sustainable manufacturing as addressed above in the functional factor, module, and network concept can perhaps be divided into adequate smaller segments coined by respective frame conditions e.g. local environment, level of education, economic wealth to be improved by approaching the relevant values according to sustainability criteria. Life Cycle Assessment (LCA) addresses "[...] the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal" [60]. The Social Life Cycle Assessment (SLCA) analyzes and assesses the positive and negative social and social-economic impacts of a product throughout its life cycle phases [61]. The SLCA focusses on the impacts of products on different stakeholders [61]. In general, data acquisition and data gathering is the most critical step within the SLCA. Life Cycle Costing (LCC) addresses the holistic assessment of the costs for an investment good from the manufacturer as well as customer point of view. The method aims at analyzing the entire costs and its related activities and processes throughout the product life cycle [62].

6.2. Business Models

The solution space for sustainable manufacturing innovations can be structured according to the three sustainability domains: economic, environmental, and social. In this sense, new developments within the technological domain contribute for moving towards a sustainable development in the other three sustainability domains.

Keeping non-renewables in product and material life cycles, substituting non-renewables by renewables and consuming renewables only to the extent that they can be regained is the leading approach in the environmental domain within sustainable manufacturing. The use productivity of resources can be considerably exploited by closed loop supply chains with re-utilization, re-use, and recovery.

The awareness of humans on all levels of wealth and education about the sustainability challenge has to be increased by magnitudes. Increasing the teaching and learning productivity for empowerment towards a sustainable manufacturing is the leading activity in the social domain for achieving sustainable value creation. Learnstruments as artefacts demonstrating their functionality to the user automatically are an element of action-oriented manufacturing research to combine both physical sustainable value creation and conveying awareness by education. Innovative ideas are required to develop and evaluate products and services according to ecological, environmental and social sustainability criteria. These concepts have to be introduced to and understood by all participants, spread among the world and coming from different cultural and educational backgrounds. Potentials for new teaching and learning concepts can be exploited by means of innovative product design in combination with modern information technology implemented in professional and academic education in institutional cooperation between early and newly industrialized countries. Young pupils and students in their early phase of life can coin their professional career by coping with the challenge of sustainability.

The development of new business models for global value creation is an essential activity for future sustainable manufacturing in the economic domain. By selling functionality instead of tangible products more benefits for more people with less resource consumption can be provided. The approach of selling functionality instead of selling products proves to be competitive due to information and communications technology (ICT) enabling real time knowledge about demand and supply. Product Service Systems are tending to fulfill the needs of a customer by combining products and services. By using logistics- and information-technologies Product Service Systems are providing functionality in the specification as required, at the location where required, to the point in time when required by ICT connected with modern logistics. The logistics- and information-technologies are in this connection more cost-effective than the capacity costs of the product during idle periods. Figure 6 points out the concept of Product Service Systems addressing the principle of selling functionality instead of tangible products.

Selling functionality is profitable if idle capacity costs are higher than costs for provision of functionality

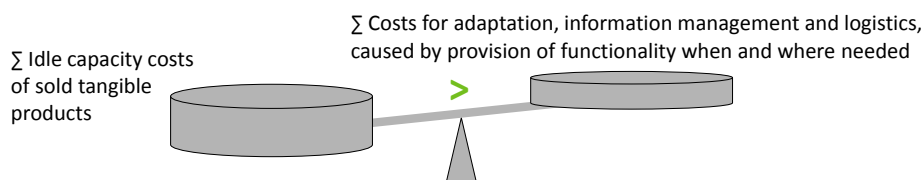


Fig. 6. Selling functionality instead of tangible products

6.3. Leverage of Education

This section aims at describing the depth of manufacturing technology exemplarily covering the leverage of education by detailing the concept of Learnstruments.

Teaching and learning for a global culture, wealth, and health become vital tasks for the global human community and should be applied considering the diversity of different cultures and human values on globe. Therefore, Manufacturing can provide comprehensive functionalities and objects for learning about sustainable value creation. In this sense, manufacturing is enabling for win-win among early industrialized and newly

industrialized communities and is enabling for responsible global citizenship by raising awareness about sustainability. So-called Learnstruments can essentially contribute to raising this awareness in early industrialized and newly industrialized communities. Learnstruments i.e. are objects which automatically demonstrate their functionality to the learner. They aim at increasing the productivity in teaching and learning as well as at expanding the competencies of the learner in the economic, environmental, and social domains of sustainability. They provide adequate learning goals and support the learner in achieving these goals by the usage of existing and new information and communication technology (ICT). Moreover, Learnstruments can be applied in work processes on the one hand to enable learners to overcome cumbersome situations and on the other hand, to make the process itself more efficient and effective.

Figure 7 points out how the awareness about the sustainability challenges can be raised using a bottom-up approach starting with the stakeholder level of educational institutions and SME's, moving to big enterprises, and governmental organizations, and finally affecting nations industries and unions.

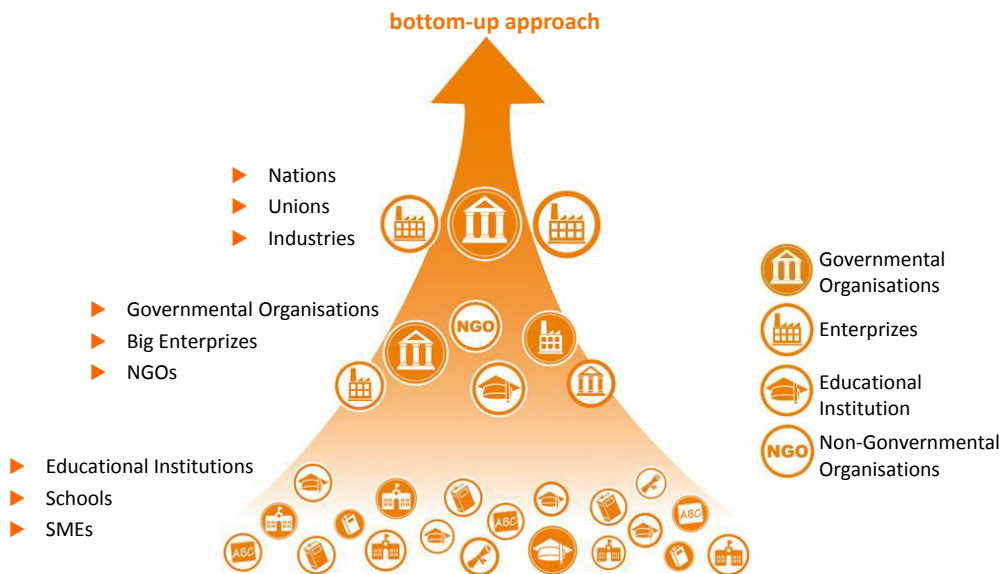


Fig. 7. Bottom-up approach for raising the awareness

6.4. Leverage of Innovation

This section is giving an insight on a methodology for developing sustainable and technological innovations. The development of innovations is an essential activity for creating new manufacturing technologies for sustainable value creation. By means of the market dynamics of cooperation and competition in global value chains and knowledge networks, sustainable innovations can contribute to a global sustainable development. In this context, a sustainable invention has to be transformed into a competitive innovation by the integrated development of a product as well as of a business model in an environment of uncertainty [63]. The Diamond Model (Figure 8) provides a methodology for these requirements [63].

The starting point for the integrated innovation development is a concrete idea for solving a specific problem. This concrete solution idea can be generated within the so-called fuzzy front end of innovation. A model for the development of sustainable innovations for this early phase of the innovation process is described in [64].

The systems design aims at establishing an overall solution concept for the product and business model. In terms of the product development, the requirements for the product are defined, the product functions are determined, and principle solutions for the functions are established. In terms of the business model development, a vision for the overall model is defined first, subsequently initial hypotheses for the value chain, customer, value proposition, and

the revenue model are determined, and finally different configuration solutions for the hypotheses are established. Principle solutions and configuration solutions are in most cases basic solutions which have already been proven within the state of the art or in entrepreneurial practice. [63]

The domain-specific design addresses the development of designs for the mechanics, electronics, and software domains of the product as well as the development of prototypes for the value chain, customer, value proposition, and revenue model domains of the business model. For the product development, this includes structuring the domains into modules, designing the modules, as well as the interfaces between them. For the business model development, different development paths for the configurations of each domain are identified and elaborated. Subsequently, specific prototypes for the development paths are created. [63]

The system integration aims at the integration of domain-specific designs for the product and of prototypes for the business model into an overall system. Moreover, incompatibilities between the domain-specific designs and prototypes are identified and eliminated. [63]

Testing and assurance of properties is continuously carried out throughout the development process in order to validate and evaluate the established results as well as to exchange data, information, and knowledge between the product development and business model development phases. [63]

The modelling and model analysis supports each phase of the development process by providing and applying suitable modelling methods for each phase. Examples of suitable methods are e.g. the morphological table or CAD methods for the product development as well as business model canvas and value proposition canvas for the business model development. [63]

The “customer solution” is the final outcome of the Diamond Model and represents a detailed and validated business models as well as a fully designed and tested product [63].

In conclusion, the Diamond Model provides a methodology for the development of innovations, which can contribute to move towards a more sustainable development in the economic, environmental, and social domains.

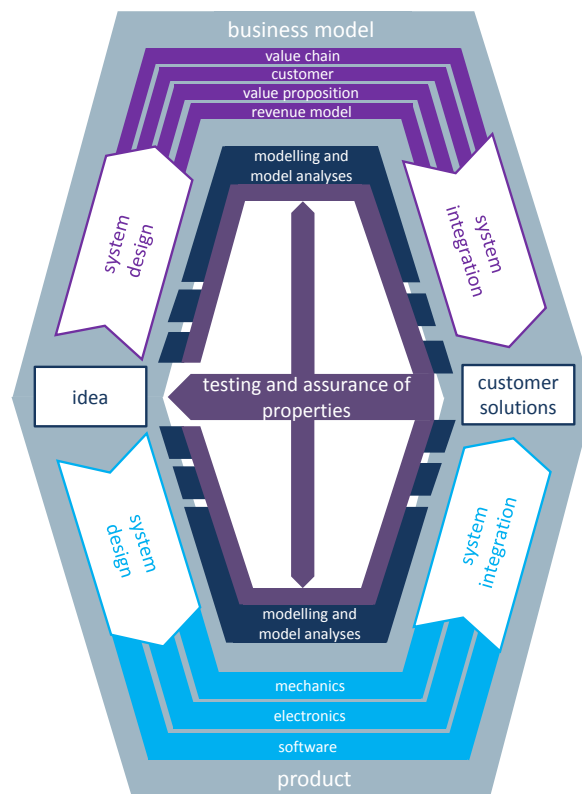


Fig. 8. Diamond Model for the integrated development of the business model as well as of the product [63]

Summary

The analysis of global stakeholders as IMF, OECD, UN and its related organizations, WEF, WTO, and WWF documents the challenges of globalization in economic, environmental, and social domains. Manufacturing is identified as means to cope with these challenges. The paradigm of Competitive Sustainable Globalization is specified. Competitive Sustainable Manufacturing as a fundamental enabler for CSG is introduced, addressing a global as well as a local approach for manufacturing. An architecture of value creation for sustainable manufacturing addressing business models and the leverage of education and innovation gives directions of future research.

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