Technology transfer for social benefit: Ten principles to guide the process

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Abstract: The transfer of knowledge and inventions from universities to society has a twofold objective: the business community should be advanced by innovations, and society should benefit. Economic success is relatively easy to measure (e.g., increased sales), but social benefits are not. Thus, we presented a matrix of 10 principles for the assessment of the social value of technologies. With this understanding, technology transfer processes can be designed to lead to products and services that are more valuable in a holistic sense. The application of these 10 principles is explained by considering the examples of three distinct technologies and markets: smartphones, genetically modified agricultural crops, and artificial intelligence.

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PUBLIC INTEREST STATEMENT

The purpose of technology transfer is to generate economic and social added value. Although economic value creation has been widely studied and can be measured relatively well, this is not true for social value creation. However, social benefit does not arise automatically through the ongoing technologicalization of the world; it must be targeted and evaluated according to specific criteria, as technology can be used for good or for bad. Are there criteria that can be used to judge how new technologies will impact the individual user, society, and nature? This paper presents 10 principles by which new technologies can be assessed and designed to have the most positive effect. An explanation of how to apply these 10 principles is provided by three examples of distinct technologies and markets: smartphones, genetically modified agricultural crops, and artificial intelligence. The understanding gained from this research demonstrates that the design of technology transfer processes can lead to a holistic increase in the value of products and services.
1. Purpose of technology transfer

Research and education have been the core tasks of universities since their founding; however, a third task has been added. This so-called “third mission” is translating the value of academic institutions into benefits for society (Zommer et al., 2011). Hence, the “third mission” refers to the social, entrepreneurial, and innovative activities that universities conduct besides their educational and research activities, and the aim is to transfer knowledge and technology from academic institutions to society to solve real-world problems. In practical terms, this concept usually means out-licensing research results to industrial partners or establishing spin-out companies. Although such commercialization process may generate income for the university involved, it is not for the purpose of technology transfer. Instead, the purpose of pursuing the “third mission” is to make a valuable contribution to society (Mars & Burd, 2012).

This view was confirmed by Dr. Mary Sue Coleman, President of the University of Michigan, in her speech at the Annual Meeting of Technology Transfer Managers:

I think many people are often confused about why we are interested in technology commercialization, in nurturing start-up companies, and in facilitating more patents and license agreements. It is not about the promise of future revenues that might be generated from this activity. You heard me correctly. It is not about the money. Of course, revenue generation serves as an incentive. But first and foremost, technology transfer must serve our core mission: sharing ideas and innovations in the service of society’s well-being […] (Abrams, Leung and Stevens 2009).

The idea that society should be the (primary) beneficiary is anchored in most mission statements of technology transfer offices. For example, the Mission Statement of MIT (the Massachusetts Institute of Technology) states: “Our mission is to move innovations and discoveries from the lab to the marketplace for the benefit of the public […] (Massachusetts Institute of Technology, 2019).” A similar statement is in the Mission Statement of Stanford University Office of Technology Licensing: “Our mission is to promote the transfer of Stanford technology for society’s use and benefit […] (StanfordUniversity, 2020).” A similar statement is from Cambridge Enterprise, the Tech Transfer Company of Cambridge University: “We facilitate knowledge transfer by helping innovators, experts and entrepreneurs to use commercial avenues to develop their ideas and expertise for the benefit of society, the economy, themselves and the University.” (University of Cambridge Enterprise, 2020).

Therefore, the consensus is that added value for society is the main purpose of technology transfer. This understanding raises basic questions: What are the definition and concrete terms of “social benefit”? Without elucidation, statements on the well-being of society easily degenerate into empty phrases. Considering the vast literature on technology transfer (and innovation in general), the scant amount of attention to the central question of what constitutes a good society, and based on that, what constitutes social benefit is surprising. In our view, this analysis requires a holistic model that considers a) individuals’ well-being, b) the common good of society, and c) the planet. In this paper, we propose 10 criteria (principles) to measure whether technology transfer leads to social benefit.

2. Definition of social benefit: 10 criteria (Principles)

2.1. Well-Being of the individuum

What constitutes a good, fulfilled life is a question as old as mankind. Over the centuries, there have been several attempts to adequately characterize the multi-faceted nature of humans. However, since humans are complex beings, this task was challenging. We used a three-layer model on the basis of Aristotle’s views since it serves our purpose—understanding the interaction between technology and humans—particularly well.¹
We call these three layers—which are explained in Table 1—the basic, emotional, and rational levels.²

On all three levels, humans need a continuous supply of healthy “food” to survive, grow, and develop. Humans need air, water, food, sanitation, and protection (basic level); diverse and simulating sensory impressions and feelings for healthy emotional development (emotional level); and mental nutrition for mental development (rational level). These levels are not separate; they are interrelated, interdependent, and interpenetrating and form an integrative whole. Thus, all three levels must be appropriately cared for and cultivated to obtain a holistic sense of well-being. Metaphorically, well-being can be compared with a banquet at which all three levels are nurtured. Eating and drinking supply the essential functions of life, and although the smell of wine and the band’s music appeals to the emotional level, a satisfactory conversation with the neighboring table stimulates the mind.

Since the Stone Age, humans have attempted to satisfy their needs by inventing techniques and tools. Notably, each invention can be assigned to one (or more) level(s). Technologies that address the basic level range from the invention of agriculture to the most modern medicine, inventions that address the emotional level range from the invention of musical instruments to augmented reality glasses, and the rational level range from the invention of writing to webinar trainings.

Therefore, the positive application of technology is similar to that of healthy food: it promotes health and a flourishing life. However, metaphorically, sometimes an individual can consume too much of both good and even toxic food. The same concept applies to technology, which may be destructive when unwisely used; hence, it necessary to design technologies in such a way that they provide lasting benefits for their users.
Table 1. Three-layer model of humans

| Level  | Functions |
|--------|-----------|
| Basic  | Enables and controls the core functions of life (e.g., nutrition, breath, metabolism, growth, and reproduction). All living beings depend on this level. |
| Emotional | Enables sensory impressions (e.g., smell, sound, and color) and internal feelings (e.g., fear, anger, and joy). This is the level of animality. |
| Rational | Comprises the capacities of mind and will and the ability to think, argue, and draw conclusions. In its distinct form, the rational level is only available to humans. |

2.2. A good society
The search for well-being and happiness requires a balance of responsibility to live such that other humans are also enabled to develop their potential. Thus, the human quest for progress, can only be realized through shared values and principles widely accepted in societies and cultures. Only when clarity is provided on what constitutes a “good society” in this sense can it be assessed whether a (technical) innovation results in social progress. Therefore, we defined five criteria (principles) anchored in many cultures to comprehensively characterize a good society.

2.2.1. Trusting relationships
From their first to their last breath, humans are social beings, and relationships are an existential part of their lives. These interactions occur on all three levels (basic, emotional, and rational). Individuals need others to satisfy their basic needs and experience emotional closeness, security, and joy. Others are also necessary for intellectual growth. Close relationships are required for the ability to learn from each other, help each other, correct each other, and flourish. Therefore, relationships based on trust are the leaven for a good society.

2.2.2. Meaningful business
A well-functioning economy must produce and distribute goods and services that a society needs for a flourishing life; beyond that, work has an additional meaning. Through meaningful work, human potential is raised and realized. By using and applying their skills in their work, people find self-development, identity, and happiness. Therefore, participating in business is a means to create products or provide services, and meaningful work is essential for well-being.

2.2.3. Freedom
Freedom is a prerequisite for a good society. Similar to work, freedom has an external and an internal dimension. In its external dimension, freedom means that a person is not forced by external constraints to exhibit a behavior. In a free society, all citizens have protected rights to ensure their free pursuit of happiness using basic rights such as freedom of thought, expression, assembly, and religion. People are not manipulated, exploited, or oppressed. The inner dimension of freedom, by contrast, means that individuals do not act because of an inner, blind urge but can freely choose which goals to pursue. The desire for freedom and the responsibility for others and nature must be balanced such that freedom is not abused at the expense of fellow human beings or natural resources.

2.2.4. Justice
A good society is measured by its sense of justice, for example, how it treats its weakest members. Can the poor satisfy their three levels of needs, or does society only promote the interests of the powerful? In this sense, a good society ensures its citizens at least equal access to food, heat, health care, information, and education, promoting equal life opportunities (Bughin et al., 2019, p. 18–19; Schutt, 2001, p. 3; Brey, 2017, pp. 4,7).
Table 2. Possible positive and negative effects of smartphones on all 10 levels. (This paper does not examine and argue the listed individual effects in detail but does illustrate the importance of using a holistic model to realistically assess the interaction of technology with society.)

| Individual |
|------------|
| **Rational** | |**Positive impact** |
| | Access to knowledge: Smartphones, when combined with the internet, allow for easy and fast access to a universe of information. With an appropriate attitude, smartphone users can expand their knowledge quickly. | |
| | **Negative impact** |
| | Mental laziness: An increase in the number of cognitive tasks being transferred to smartphones has been observed. There is a threat that excessive use of mobile devices may lead to mental laziness (Barr et al., 2015). | |
| **Emotional** | |**Positive impact** |
| | Promoting creativity: Smartphones can be used to cultivate curiosity, nourish the imagination, snap photos of mundane objects, or document ideas. In that manner, smartphones can be used as creativity-enhancing tools. | |
| | **Negative impact** |
| | Distraction: Smartphones cause massive distraction from the real world if constantly used (Duke et al., 2017; Stothart et al., 2015). Distancing from reality in this manner can promote unhealthy emotions such as fear and narcissism (Hussain et al., 2017; Lee et al., 2014). | |
| **Basic** | |**Positive impact** |
| | Health monitoring: Smartphone use can promote a healthier lifestyle, for example, by tracking the user’s amount of movement, nutrition, or blood pressure. | |
| | **Negative impact** |
| | Health hazard: Excessive smartphone use can negatively affect health because of, for example, exposure to electromagnetic radiation and blue light, and cause poor posture, its resulting neck stiffness, or damage to vision. | |

| Society |
|-----------------------------|
| **Trusting Relationships** | |**Positive impact** |
| | Strengthen bonds: Smartphones help users stay in touch with family and friends worldwide, facilitate continuous communication, and thus strengthen and support social relationships. | |
| | **Negative impact** |
| | Emotional neglect: Excessive smartphone use can impair and endanger interpersonal relationships (Elbahi et al., 2017) and has a particularly critical effect on small children. When parents are absorbed by their smartphones, children may experience emotional problems. | |
| **Meaningful Business** | |**Positive impact** |
| | New business: Smartphones create many new opportunities for companies, for example, smartphone manufacturers, app development companies, and internet service providers. | |
| | **Negative impact** |
| | Increased stress: The constant accessibility made possible by smartphones can also easily lead to increased stress. Research has confirmed that the intrusion of smartphones into daily life can significantly endanger a healthy work-life balance (Harris, 2014). | |
| **Freedom** | |**Positive impact** |
| | Freedom: Smartphones offer new freedoms to do what an individual thinks is important, for example, phone booths are obsolete, and research can be conducted online from home, instead of at the library. | |
| | **Negative impact** |
| | Addiction: Smartphone addiction is a substantial problem. A meta-analysis demonstrated that approximately 25% of children and teenagers demonstrate signs of smartphone addiction (Sohn et al., 2019). | |
| **Justice** | |**Positive impact** |
| | Exposing injustices: Smartphones have capabilities, such as video, that can help victims and expose injustices. For example, bystanders recorded the police killing of George Floyd in the United States, and the videos were broadcast on the news and used as evidence in court (Rowley, 2015). | |
| | **Negative impact** |
| | Sweatshop labor: The production of smartphones can be problematic, for example, child or enslaved labor and toxic factories without safety equipment (Cooper, 2018; Bloomberg News, 2018; Lee, 2016). | |

(Continued)
Table 2. (Continued)

| Individual |
|------------|
| **Peace** |
| **Positive and negative impact** |
| Smartphones can be used, for example, to build a peaceful world and to endanger it, or communicate affection and goodwill or glorify hatred and violence. The availability of smartphones makes it easier to organize collective activities, peaceful and violent (Pierskalla & Florian Hollenbach, 2013). |
| **Planet** |
| **Biosphere** |
| **Positive impact** |
| Wildlife preservation: Smartphones can be used to monitor and protect wildlife such as the poaching of African elephants (Wall, 2014). |
| **Negative impact** |
| Electropollution: Ecosystems are under the constant influence of high-frequency radiation from smartphone antennas. Behavioral changes in and damage to insects, birds, and other animals have been reported (Rafiqi et al., 2016). |
| **Resources** |
| **Positive impact** |
| Raising awareness: Smartphones enable real-time documentation and communication. This effect can be used to protect the environment, for example, in 2013, when the Pegasus pipeline in Arkansas burst and the residents documented the resulting damage (Sheppard, 2013). |
| **Negative impact** |
| Wasted resources: Smartphones are one of the most resource-intensive products on the market, containing precious metals and rare earths. The production of smartphones causes an enormous consumption of these valuable elements, and an estimation is that approximately 10 million smartphones are discarded or replaced each month in the European Union (Gabbatiss, 2019). |

2.2.5. Peace

Peace is a prerequisite for a fruitful, happy life. To achieve peace, the following are mandatory: institutions, fair legal systems, just moral attitudes, and the reasonable behavior of all citizens. Peace requires that enterprises practice corporate responsibility and cooperate with communities.

We applied the five social principles to comprehensively characterize a good society. Notably, other values (e.g., democracy, privacy, or innovation capacity) are essential for a good society but have only an instrumental character (i.e., they support the achievement of one of the five principles). For example, democracy supports the values of freedom and justice. Similarly, respecting privacy is necessary to ensure that the value of individual freedom is not violated and that innovation is considered a prerequisite for a functioning economy.

The five principles are connected and should thus be considered holistically in their evaluation. If one principle is isolated and absolutized, a bad society can result. Freedom without justice leads to abuse of power by the strongest members of society, and justice without freedom then easily leads to state control and paternalism of the individual.

Furthermore, the five principles are linked to the aforementioned three principles of human life. All individuals act within society and are thus influenced by society. During the novel coronavirus pandemic, for example, freedom of movement has been restricted by official measures to reduce the risk of infection and that of vulnerable individuals (safety: basic level). Technological options can affect outcomes in this case, for example, tracing apps can reduce infections, but notably, they also restrict freedom and autonomy. Thus, a balanced analysis requires a holistic view.

Therefore, a good society makes possible, strengthens, promotes, and safeguards the five principles, whereas a bad society weakens, endangers, or makes these principles impossible.

2.3. A healthy planet

Manmade artifacts (technologies) substantially influence nature. Human influence on biological, geological, and atmospheric processes is so profound that today's era is sometimes called
Anthropocene. Because individuals have reason and will (rational level), they are responsible for their environment, described in terms of sustainability in its three dimensions: economic, social, and ecological (Giddings et al., 2002, p. 1).

2.3.1. Biosphere
The WWF’s Living Planet Index states that the diversity of species decreased by 27% between 1970 and 2005. The populations of breeding bird species native to Europe’s agricultural landscapes decreased by almost 50% between 1980 and 2009 (Avifaunisten & für Naturschutz, 2012). The most significant difference between earlier mass extinctions and today is that today’s species extinction is due to one species: homo sapiens, namely, their activities, demand for space, and consumption of resources. Hence, being good also means protecting the environment to preserve biodiversity.

2.3.2. Inanimate nature (Resources)
Today, half a billion tons of material are extracted from the earth annually. Turning this material into products requires an enormous amount of energy, which seems wasted when many of these products are discarded and dumped in landfills. Of all the products elaborately manufactured, less than 1% remains in use after 6 months (Shedroff, 2009). Thus, this phenomenon must stop to achieve sustainability targets.

Technologies that add value on a planetary scale must therefore be sustainable technologies, namely, technologies that use biodegradable or recyclable materials that are energy efficient, use renewable energy, are embedded in sustainable life cycles, and are linked to product designs and business models that promote sustainable behavior and limit unsustainable behavior (Brey, 2017, p. 13).

On a planetary level, “good” therefore means that technologies, products, and economic systems are sustainable, that is, designed not to cause structural damage to ecosystems, deplete natural resources, pollute the environment, and harm biodiversity. Unsustainable economic activity is also unfair because future generations are unjustifiably deprived of goods available to the present generation or because of the immediate direct (through air, water, hazardous substances, or noise) or indirect (through climate change, biodiversity loss, or natural disasters) impact on the quality of people’s lives (Brey, 2017, p. 7). Thus, society must recognize its grave duty to preserve and ameliorate the damage inflicted on the earth.

3. How to evaluate technologies with the 10 principles
In this section, we explain how to use the 10 principles (see Figure 1) to evaluate the social value of innovations and technologies. Using three technology examples—smartphones, agricultural genetic engineering, and artificial intelligence (AI)—we demonstrated that the principles help various technology and market sectors.

3.1. Example: Evaluating smartphones
Smartphones are an ideal example of technology assessment because they are ubiquitous, with a penetration rate of 45.4% (Oberlo, 2020). The impact of smartphones on daily life is diverse and strong. Almost everyone knows the positive and negative effects of smartphone use. Based on the 10 principles, these effects can be considered systematically and holistically. For each principle, we provided in Table 2 examples of positive and negative effects to demonstrate how to apply the 10 principles.

3.2. Conclusions: Evaluating smartphones
Today, smartphones affect almost all areas of life. The interaction of this technology with the individual user and society is diverse and can be confusing. With the 10 principles, the complex effects of smartphones can be logically structured and thus more easily analyzed. We have demonstrated that the impact of technology on humans depends on two basic dimensions: a)
how the technology is designed and b) how the user uses the technology. Dimension a) is the responsibility of inventors, developers, innovators, and entrepreneurs; they decide a smartphone’s functions, the materials used in its production, and the conditions of manufacturing. Dimension b) is the responsibility of customers and users; they decide how smartphones are used in daily life. Both dimensions determine how technology affects society. Both the individuals who develop a technology and bring it to market and those who use it share the responsibility for the impact of the technology. For example, the consumer decides whether smartphone use leads to addiction, but this also depends on the design of the technology (in combination with internet platforms, e.g., social media).

In this paper, because we investigate how the design of technology (in the sense of technology transfer) can be oriented toward societal benefits, the primary focus is on the responsibility of technology developers. Thus, the topic of the second section of this paper is how can technology be designed to have more positive and less negative impacts. We answer this question by applying the 10 principles.

3.3. Example: Evaluating Golden Rice

Golden Rice is our second technology example because of the debate on whether it benefits society. What is the background of this debate? In poor countries, rice often is the only staple food, leading to nutrient deficiency that causes serious health problems. For example, insufficient vitamin A can negatively affect skin, growth, and eyesight and cause blindness and death.

In the early 1990s, two German biologists, Ingo Potrykos and Peter Beyer, attempted to ameliorate vitamin A deficiency by means of modern technology by developing a variety of rice that contained beta-carotene (which is converted into vitamin A in the human body). Notably, after many attempts, they succeeded by using genetic modification. Because the color of these rice grains is orange, the plant was named Golden Rice.

A diet that uses Golden Rice instead of conventional rice should, therefore, drastically reduce the number of cases of diseases associated with vitamin A deficiency. The Golden Rice Project was therefore considered an exciting achievement in ameliorating malnutrition. To transfer their invention from the laboratory to agriculture, the two inventors entered partnered with the agritech company Syngenta, which should enable the distribution of seed to farmers in third world countries.

However, resistance to the cultivation of Golden Rice plants arose worldwide. Many environmental organizations—especially Greenpeace—attempted to prevent the cultivation of Golden Rice. They argued that Golden Rice would solve the problem of vitamin A deficiency and exacerbate the problem because the consumption of Golden Rice leads to an even more unbalanced diet. According to Greenpeace, when considered in a medium and long-term perspective, only the supply of a variety of foods can eliminate malnutrition. Furthermore, the motives for the Golden Rice Project are being questioned. Was the goal to improve the health of the poor or to increase the profits of the participating companies?

When confronted with these accusations, the inventors and Syngenta claimed that they had no commercial interest in growing Golden Rice in third world countries and that it should be freely available, to avoid creating dependencies (Beyer et al., 2002, pp. 506–510). Notably, the Golden Rice opponents considered this explanation to be a falsehood. In the 1960s, similar measures were implemented in many Asian countries during the “Green Revolution,” when seeds, herbicides, and fertilizers were free. However, subsequently, farmers had to buy these resources from corporations and incurred massive debt to do so.

The debate between proponents and opponents of Golden Rice has become increasingly serious. In 2016, 110 Nobel laureates signed an open letter to Greenpeace. The letter sharply criticized
Table 3. Presents arguments for and against the deployment of Golden Rice. Because of the opposing views, the table does not present positive or negative effects

| Individual | Rational | The mind is the essential tool with which the effects—and the possible side effects—of a technology can be assessed. Reason asks for facts and draws logical conclusions. However, both sides—proponents and opponents—present data to support their views. |
| --- | --- | --- |
| Emotional | The debate on Golden Rice is very emotional. Prominent proponents write that millions of children are unnecessarily blinded because Golden Rice is not being introduced to their diet (Potrykus, 2013). The delay in the introduction of Golden Rice was even called a ‘silent holocaust’ (Chassy, 2010). Opponents are destroying field trials because they believe this method is the only way to maintain food sovereignty (Kupferschmidt, 2013). |
| Basic | The aim of Golden Rice is to remedy basic nutritional deficiencies that lead to serious diseases. It is therefore on the basic level. Proponents argue that Golden Rice is an effective aid to alleviate the problem (Tang et al., 2009) and that no risks are associated with this technology (Golden Rice Project kein Datum). Opponents argue that the yield of carotenoids in Golden Rice is far too low (they base their argument on field studies) (Grain, Masipag and Stop Golden Rice! Network, 2018). Therefore, Golden Rice will not be a solution to vitamin A deficiency (Grain, Masipag and Stop Golden Rice! Network, 2018). Furthermore, whether the rice is safe is in doubt (Stone & Glover, 2016). |
| Society | Opponents argue that social and cultural barriers to Golden Rice must also be considered. For example, white rice (as opposed to yellow rice) has high cultural value. Technological projects have often failed because a gap between science and local communities has not been bridged (Kettenburg et al., 2018). |
| Trusting Relationships | Proponents argue that Golden Rice is an efficient solution to a major problem (Mayer et al., 2006). The critics, however, posit that planting gardens with fruit and vegetables would be a far more cost-effective method. |
| Freedom | Is the freedom of local farms restricted by Golden Rice? Opponents fear that small farmers will become dependent on agrotech companies and lose their freedom to grow and promote their rice varieties. Proponents argue that this case will not occur and that cultivation will only be approved by regional authorities and independent rice research institutes (Mayer et al., 2006). |
| Justice | Proponents argue that refusing to allow the poor to benefit from modern agrotechnology is irresponsible. Opponents consider Golden Rice a fake quick fix because the urgency to ameliorate the underlying poverty would be veiled and a quest for social justice would be prevented (Kettenburg et al., 2018). |
| Peace | The intensity of the conflict over Golden Rice (and GMOs in agriculture in general) is so serious that it has been compared with war (Lang & Heasman, 2004). |
| Planet | Would growing Golden Rice endanger traditional rice varieties? Opponents fear genetic contamination, leading to losing native and regionally adapted varieties and reducing biodiversity (Kettenburg et al., 2018). Proponents argue that a possible gene flow from Golden Rice to wild varieties would be very low. However, even then, they would be quickly thinned out because the carotenoid genes would not have a selective advantage (Golden Rice Project kein Datum). |
| Biosphere | Opponents ask how Golden Rice will influence the abiotic components of ecosystems. Will more fertilizers, pesticides, and irrigation be required than for wild plants? Notably, irrigated rice cultivation is responsible for a considerable amount of methane emissions (Kettenburg et al., 2018). |

Greenpeace’s anti-Gold Rice campaign. The accusations included that Greenpeace was denying scientific facts and distorting the chance to risk ratio of Golden Rice. More than 1 million deaths per year might be avoided if vitamin A deficiency is ameliorated by Golden Rice. The letter provocatively asked how many more people would have to die before Greenpeace stops their anti-Golden Rice campaign.
As expected, this letter provoked counter-reactions. However, after decades of confrontations between supporters and opponents of Golden Rice, there is no solution. What are the reasons for this conflict? What is the real problem? What level are the mutual accusations on? To provide a more in-depth overview, we structure the key arguments of the proponents and opponents according to the 10 principles in Table 3.

3.4. Conclusions: Evaluating golden rice
The debate on Golden Rice occurs on all 10 levels; thus, it is often confusing and people frequently talk past each other. What is important and relevant for one person may not be perceived by others. Therefore, a model such as the 10 principles should be used to open the space of opportunities and risks, and hopes and fears, and make them visible; only then can the arguments of all sides be reasonably assessed.

3.5. Example: Evaluating AI
AI is a rapidly developing technology whose application in key areas of society is spreading rapidly. AI is the third technology example because it is the source of great hopes and deep fears. Notably, the definition of AI remains unclear but is usually understood as a combination of machine learning (for the analysis of large amounts of data), programmable machines, and decision-making systems capable of making autonomous decisions. To obtain a holistic picture of the opportunities and risks of AI, we have again applied the 10 principles in Table 4. The opportunities and risks of AI are not fully (if at all possible) presented; instead, the table presents by way of example how the 10 principles can be used as a matrix to create holistic opportunity and risk profiles.

3.6. Conclusions: Evaluating AI
AI presents a broad spectrum of possible advantages and dangers of modern technologies. The effects of AI can strongly affect individuals’ self-image and if not considered, can substantially affect human values. Thus, need a holistic view and evaluation of the various aspects of AI is necessary to guide its development and application such that the well-being of society is served.

Figure 2. To achieve social value through technology, the two classic drivers of innovation, namely, technology push and market pull, are now insufficient. A third dimension is necessary—we call it good world design—which helps align technical progress with social welfare.
Table 4. A selection of possible effects of AI on society. Because the technology has been used for a short time, but is developing rapidly, this table refers to opportunities and risks.

| Individual | Chances                                                                 | Risks                                                                 |
|------------|------------------------------------------------------------------------|-----------------------------------------------------------------------|
| Rational   | Improving learning: AI could potentially improve individual learning through personalization. A pilot study demonstrated how AI-based training programs can improve cognitive performance (Kee et al., 2019). | Loss of rational overview: In many cases, AI algorithms cannot be explained, because the results are obtained remains unknown. Thus, it is difficult—or impossible—for human reasoning to determine whether the decisions made by AI are justified (Herweijer & Waughray, 2018). |
| Emotional  | Helping the blind: AI could potentially make life easier for the visually impaired through navigation aids, providing a richer and deeper understanding of their surroundings, including the recognition of other people (Chui et al., 2018). | Distrust in reality: With AI technologies such as Deepfake (a portmanteau of ‘deep learning’ and ‘fake’), individuals might have increasingly less trust in their senses. For example, when they view video content that depicts an event (e.g., a political speech) that did not occur (Howard, 2019). |
| Basic      | Improved health: AI technologies can be valuable support in maintaining or achieving health, for example, fitness training, personalized medical treatments, or improved diagnosis (e.g., cancer) (Crawford et al., 2019; Bughin et al., 2019, p. 26). | Compromised safety: AI can be hacked to harm people, or autonomously decisive AI algorithms can lead to dangerous results (e.g., in autonomous vehicles) (Herweijer & Waughray, 2018) (Crawford et al., 2019). |
| Society    | Trusting Relationships | Chances                                                                 | Risks                                                                 |
|           | Understanding fellow humans: With AI tools, attempts have been made to overcome the emotional difficulties of understanding autism. The aim is to help children with autism to better understand how other people feel (Marwan, 2018; McManus, 2017). | Pseudo relationships: Machines are becoming increasingly human-like and can seemingly replace human interactions, for example, Akihiko Kando, in Japan, took a virtual hologram, a comic figure, as his wife (Paulo, 2019; Hegarty, 2019). |
|           | Meaningful Business | Chances                                                                 | Risks                                                                 |
|           | Undoubtedly, AI will improve the efficiency of businesses, for example, predictive maintenance, where service parts and machines are repaired or replaced at the optimum time, namely, before they fail (Barnard, 2019). | Abusing power over employees: AI systems can be used to comprehensively monitor employees. Today, such systems are used to automatically assess employees’ performances, set performance targets, and initiate dismissals (Crawford et al., 2019). |
| Freedom    | Chances                                                                 | Risks                                                                 |
|           | More freedom: The old question of whether machines lead to more freedom or more coercion of humans is condensed in the judgment about the effect of AI. Proponents of the AI technologies see this as a positive development liberating people from routine work, allowing them to pursue their own interests. There is no reason that standard work week cannot be halved in the future as productivity increases due to AI (Spyros, 2017). | Endangered freedom: When algorithms are increasingly making the most important decisions, and when governments and companies monitor an increasing amount of citizens and customers with AI systems, human freedom is at high risk (Crawford et al., 2019). |

(Continued)
Table 4. (Continued)

| Individual | Chances | Risks |
|------------|---------|-------|
| Justice    | Justice will be more affordable: AI has the potential to improve the quality and efficiency of the judicial system because substantial amounts of information could be analyzed more efficiently, possibly making the public civil justice system more affordable (Wu, 2019). | Mindless law: The critical question is whether only humans (and not AI) can distinguish between what is morally good and bad, and thus able to interpret the law correctly (Davis, 2018). |
| Peace      | Nations are vying to become the leading power in autonomous weapons, for example, military drones, automated combat aircraft, and robotic soldiers are already in use. The increase in destructive power that technology provides is far beyond the imagination. | |
| Planet     | |
| Biosphere  | Chances | Risks |
|            | Habitat conservation: The use of AI opens new possibilities for monitoring and conservation of habitats, which should prevent, for example, trade of wild animals (Herweijer & Waughray, 2018). | Loss of biodiversity: If agriculture is only geared toward short-term production efficiency—and AI-driven agriculture could take this to the extreme—agricultural landscapes will be exposed to even more pesticides and fertilizers, leading to leached soil and soil erosion and a further loss of biodiversity. |
| Resources  | Chances | Risks |
|            | Improving recycling: The modern era is creating too much waste. To increase the recycling of dumped products, AI-assisted robots are being developed that are better than humans at sorting waste in processing plants (Ioannou & Petrava, 2019). | Massive carbon footprint: AI models require massive computing resources to process large training datasets. Thus, technology is a major factor in the further increase of greenhouse gas emissions (Strubell et al., 2019). |

The possible benefits must not be allowed to endanger other elementary values. For example, if AI is used to strengthen the security of the state and its citizens, their freedom and autonomy must not be undermined, or when AI is used in combination with robots to care for people in need, it must not be forgotten that people primarily need other people for their well-being, not machines and algorithms alone. For a technology to have a positive impact on society, all 10 principles must be holistically considered.

4. How to shape the technology transfer process to provide social benefits

We have illustrated by using the 10 principles that technologies have various effects, for example, helpful or destructive impacts on individuals and the common good. The challenge, therefore, is to design technologies (and related business models) that have more positive and less negative effects. The traditional key performance indicators of technology transfer (number of patents, license revenues, spin-offs) are insufficient tools to design the innovation process in such a manner. Society needs the courage to expand the two classical dimensions of technology transfer, namely, technology push and market pull, by means of a third dimension. Namely, adding an orientation that focuses on the well-being of individuals, society, and the planet. We call this third dimension the “Good World Design” (see Figure 2).

4.1. Example: Shaping smartphones

In this example, the development of a new smartphone is assessed. Smartphones are complex systems comprising hardware, an operating system, and applications. At every level, a new generation can be developed such that the net social value is higher than those of smartphones currently on the market. To illustrate this example, we present an aspect of “Good World Design” efforts at the individual, social, and planetary levels (see Table 5).
Table 5. Exemplary targets for better designed smartphones (derived from the 10 principles)

| Individual          | Goal: Reduction of addictive behavior |
|---------------------|---------------------------------------|
| Emotional           | Social media and news feeds are designed to attract and retain users. Digital over-consumption is therefore encouraged but not prevented. This problem must be addressed on the hardware and software sides (and connected with business models). The ‘Lightphone,’ for example, is designed to be used as little as possible (The Light Phone, 2019). It should serve the user, not the other way round. At the software level, many apps have been developed for ‘digital detoxification,’ which should help reduce individuals’ continuous connection to their smartphones (Van Harald, 2015; Menthal, 2019; Hold, 2019; FamilyTime, 2019). |

Society

| Freedom             | Goal: Ensuring privacy |
|---------------------|------------------------|
| For an increasing number of activities, society is depending on smartphone apps. The further processing of personal data by these tools often leads to an invasion of the user’s privacy. With the appropriate attitude, however, apps can be designed to reduce access to sensors (location, motion, camera, microphone) and locally stored data (pictures, contacts) to an absolute minimum (European Union Agency For Network and Information Security, 2017). |

Planet

| Resources           | Goal: Reducing e-waste |
|---------------------|------------------------|
| On average, consumers replace their smartphones every two years. Discarded smartphones worldwide are dumped into landfills in Africa and Asia, demonstrating the dirty side of digitization. Smartphones must therefore be designed to last longer and be repairable when necessary, requiring new design methods that support easy disassembly and a secondhand market for smartphones (Michel, 2018). |

In the example of smartphones, business interests and social goods can diverge if no explicit effort is made to integrate them. With a one-sided, purely profit-oriented view, the dirty sides of technologies are easily overlooked. For example, if a user is addicted to digital content, online advertising will be more successful. Business can be advanced by using a user’s personal data, regardless of the user’s preference. Shortening the lifespan of smartphones can increase sales, but has a negative effect on consumers and the environment.

Innovation is not a “magic word” that automatically improves the world and is not synonymous with social progress. Therefore, the core of technology transfer is not creating innovative products and services but those with an improved holistic value. In other words, the aim of technology transfer should be to develop goods that are good for the consumer and to develop services that serve society—and only then do business with them. Business interests can be well linked to social benefits if they are part of the initial strategy.

4.2. Example: Shaping the golden rice dispute
Golden Rice—in contrast to smartphones with their multitude of applications—has exactly one socio-political goal: reduce diseases caused by vitamin A deficiency. This aim is ethically high-ranking and therefore not the subject of heated debate. By contrast, the controversy is whether Golden Rice is a suitable means for achieving that goal.

The Golden Rice debate is a satisfactory example to demonstrate that the assessment of the impact of a technology depends not only on empirical facts but also on the underlying world view that sets the framework for research and interprets the results. Answers to what is the core problem of malnutrition and how it could be solved depend mainly on the underlying worldview. These questions cannot be solved in individual studies. By contrast, they are value-laden interpretations of how the connections between poverty, nutrition, economy, agriculture, and biotechnology are assessed. The framework of interpretation also depends to a large extent on education, namely, whether, for example, plant biologists, economists, or social scientists attempt to answer the questions (as meta-studies have also demonstrated) (Kettenburg et al., 2018).
Table 6. Key requirements for AI design, as a basis for enabling social value creation

| Individual   | Requirement: AI must be controlled by humans
|              | AI can fulfil many functions of humans. As a result, citizens will increasingly be subject to decisions made by AI systems. It is therefore essential that AI systems are designed to support and enhance human cognitive abilities, not to advance beyond them. AI should complement cognitive abilities, but not replace them. Thus, AI must never have final and complete control because it can always be overridden by humans.
|              | EU requirement 1: human agency and oversight
|              | EU requirement 7: accountability
| Emotional    | Requirement: AI must be recognizable
|              | AI is becoming increasingly capable of imitating reality; thus, it must be ensured that the individuals who perceive reality through their senses can assign it as such. For example, it must be possible to recognize whether a video documents a real process or whether it was produced synthetically (cf. “Deepfake”), or whether a voice on the telephone belongs to a person or a chatbot.
| Basic        | Requirement: AI must not cause harm
|              | AI technologies can pose new security risks to users when embedded in products and services. For example, a stand-alone car can incorrectly identify an object on the road, because of a flaw in object recognition technology, causing an accident with injuries and property damage (European Commission, 2020). AI systems must be designed to be safe, reliable, and robust so that they can safely manage errors and inconsistencies. If a system is compromised, it must be possible for human control to take over and abort the system.
|              | EU requirement 2: robustness and safety
| Society      | **Trust Relationships**
|              | Requirement: AI must support healthy human–human relationships
|              | AI enables the increasingly complete observation of individuals; social scoring systems evaluate how “good” citizens are. AI-activated surveillance systems that infiltrate the lives of individuals and thus affect human relationships are extremely dangerous and would massively undermine a healthy, trusting relationship between individuals in society.
|            | **Meaningful business**
|              | Requirement: AI must enhance meaningful work
|              | AI systems will fundamentally change the world of work. They should support workers in their working environment and aim to create meaningful work. However, a real danger is that technology will deprive people of their uniqueness and treat them like objects. The development of AI technologies requires a greater awareness of how technology can complement rather than reduce meaningful work (Commission & High- Level Expert Group on Artificial Intelligence, 2019).
|            | **Freedom**
|              | Requirement: AI must respect human autonomy
|              | AI increases the possibilities to follow and analyses daily habits. For example, AI could be used by employers to monitor employees’ behavior (European Commission, 2020). However, AI systems must respect the freedom and autonomy of the individual, and this includes that citizens should have full control over their data. AI systems must be designed to ensure privacy and freedom.
|              | EU requirement 3: privacy and data governance
|            | **Justice**
|              | Requirement: AI must be fair
|              | The overall goal of the development, introduction, and use of AI systems must be fairness. Special attention must therefore be paid to AI applications that would exacerbate power or information asymmetries, such as those between businesses and consumers or between governments and citizens (Commission & High- Level Expert Group on Artificial Intelligence, 2019). The advantages and disadvantages of AI systems must be evenly distributed among the various population groups, and the weak and vulnerable must receive special protection.
|              | EU requirement 5: diversity, non-discrimination, and fairness

(Continued)
Individual

| Peace          | Requirement: Autonomous weapons should be banned within their spheres of influence. This is to ensure the defense industry is a strong driver of innovation, for example, autonomous lethal weapons. Such systems could be inefficiently deployed, thereby increasing the risk of human intervention and fully automating lethal damage. Notably, in the most diverse national and corporate guidelines for the development of ethical AI, the enormous importance of peace is clearly seen. However, what must be ensured is that AI must be used for the benefit of human beings. |

Planet

| Biosphere     | Requirement: AI must not endanger (habitats of) other species. With the help of AI, humans can realize their demands on space and resources more efficiently. Thus, of central importance in the design of AI is to consider and protect the right to life of fellow beings. |

Resources

| Requirement: Enhance sustainability. AI-controlled precision agriculture could enable the early detection of plant diseases and thus reduce the consumption of pesticides (Herweijer & Waughray, 2018); however, it can also be used to further exploit the soil by further eliminating accompanying plants and organisms if the soil is only considered as a production factor and not as a living ecosystem with inherent value. AI systems must therefore be designed to enhance sustainability. The EU requirement 6: societal (relates to all social principals) and environmental well-being (relates to both planet principles). |

To advance the debate, we suggest that both the questions and the methodology should be holistic and prioritize human well-being, the involvement of communities, and ecological integrity. Valuable solutions to the problem of vitamin A deficiency could well come from a combination of companies, nongovernmental organizations, and public authorities. The best option is for all three structures to cooperate, but this requires trust. The 10 principles are a valuable tool to ensure that this holistic view is considered in research and goal setting in due time, avoiding an irreconcilable polarization of opposing camps.

4.3. Example: Shaping AI

AI systems are powerful tools that can potentially cause substantial damage if not well designed and controlled. For AI use to provide social benefit, it must be designed, developed, and implemented in a value-oriented manner. In 2019, the European Parliament published guidelines on ethics in AI, defining seven key requirements for trustworthy AI: 1) human authority and oversight; 2) robustness and security; 3) privacy and data management; 4) transparency; 5) diversity, non-discrimination, and fairness; 6) social and environmental well-being; and 7) accountability. These seven criteria are also reflected in the model of the 10 principles. For each principle, we define (see Table 6) a requirement for AI development—which could be extended—so that the effect is positive for individuals, society, and the planet.

The development of AI is a prominent example of the importance of implementing ethical criteria in the initial development process. Metaphorically, AI can be compared to a child, who quickly increases in strength, dexterity, and ability (technology push). However, left alone or in bad company, a child will soon grow up to be a selfish person who only pursues her own interests (market pull). Responsible educators will teach with patience and love that it is also important to respect others and their needs (good world design).

Value criteria—such as the 10 Principles—are therefore needed to be able to orient the development of technologies toward social benefit. This is all the more true when technologies increasingly replace human decisions, as is the case with AI. Just as the value of justice is a fundamental criterion for successful human coexistence, justice must also become the basis for the behavior of AI algorithms.
5. Good world design: Advancing technology transfer
The purpose of technology transfer is to generate economic and social added value. Although economic value creation has been widely studied and can be measured relatively well, this is not true for social value creation. However, social benefit does not arise automatically through the ongoing technologization of the world; it must be targeted and evaluated according to specific criteria. We propose applying the 10 principles to complete this task. Based on these principles, goals can be defined, and a strategy can be developed to deliberately generate social added value through technology transfer processes.

What does this mean in concrete terms? “Good World Design” means the strategic alignment to invent, develop, and bring to market technologies that are better than the state of the art in at least one of the 10 criteria (and in no other criteria worse than the state of the art). This concept is not about aiming for technologies that have no undesirable side effects, no impact on the environment, and cannot be misused under any circumstances, which would be good but is unrealistic. By contrast, the good world concept is about developing such technologies that are better in one aspect or another—following the 10 principles—than the alternatives already on the market, benefiting individuals, society, and the planet.

Technology transfer can create both economic and social value if the responsibility to society is perceived and anchored as a core dimension of corporate strategy. In this manner, knowledge and inventions from academic institutes can be transferred into solutions for social problems and major business opportunities. However, if social responsibility is only understood as a means for improving the reputation of companies and not anchored in the core mission, this dimension becomes unnecessary. By integrating social and environmental objectives into the corporate mission, technology transfer organizations will build long-term corporate value and help achieve the core objective of the third mission of universities.

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Notes
1. Explained in the book De anima from Aristotle.
2. These three levels are called the nutrition, the sensible, and the rational soul by Aristotle.
3. See the definition provided by the High-Level Expert Group on Artificial Intelligence (glossary section of the Ethics Guidelines for Trustworthy AI). A definitive definition of AI is unavailable. For an overview of the notion of AI and the difficulty of defining it, see Philip Baucher’s 2019 EPIS briefings on How Artificial Intelligence Works and on Why Artificial Intelligence Matters.
4. EU guidelines.

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