Research Repository UCD

Title	The role of science, technology and innovation in the UN 2030 agenda
Authors(s)	Walsh, Patrick P., Murphy, Enda, Horan, David
Publication date	2020-05
Publication information	Walsh, Patrick P., Enda Murphy, and David Horan. “The Role of Science, Technology and Innovation in the UN 2030 Agenda.” Elsevier, May 2020. https://doi.org/10.1016/j.techfore.2020.119957.
Publisher	Elsevier
Item record/more information	http://hdl.handle.net/10197/11710
Publisher's statement	This is the author’s version of a work that was accepted for publication in Technological Forecasting and Social Change. Changes resulting from the publishing process, such as peer review, editing, corrections, structural formatting, and other quality control mechanisms may not be reflected in this document. Changes may have been made to this work since it was submitted for publication. A definitive version was subsequently published in Technological Forecasting and Social Change (154, (2020)) https://doi.org/10.1016/j.techfore.2020.119957
Publisher's version (DOI)	10.1016/j.techfore.2020.119957

Downloaded 2026-05-01 23:35:29

The UCD community has made this article openly available. Please share how this access benefits you. Your story matters! (@ucd_oa)

© Some rights reserved. For more information

The Role of Science, Technology and Innovation in the UN 2030 Agenda

Abstract

The transition path to inclusive and environmental sustainable economic development must be Science, Technology and Innovation (STI) intensive. As such, we outline an economic framework that demonstrates the need to transform the nature of STI and reorient it towards the Sustainable Development Goals (SDGs) together with the various public policy options that can reorient investment patterns in STIs towards achieving the SDGs. The Means of Implementation (MoIs) of the UN 2030 agenda will need to be blended to create new modalities of finance, governance and public policy at all levels if STI is to be reoriented and transformative changes in economic, social, environmental and political systems are to be achieved for the SDGs. After laying out a framework, the paper also addresses the implications of our analysis for the UN global Technology Facilitation Mechanism (TFM) which aims to promote STI access, transfer and capacities across nations to achieve the SDGs.

Keywords: Sustainable Development Goals (SDGs), Science Technology and Innovation (STI), UN Global Technology Facilitation Mechanism (TFM) and the UN 2030 Agenda.

1. Introduction

The UN 2030 Agenda for Sustainable Development, *Transforming our World: the 2030 Agenda for Sustainable Development* (resolution A/RES/70/1 adopted by the General Assembly on 25 September 2015 by 193 Nation States) provides a comprehensive policy blueprint in which all nations can be economically prosperous, socially inclusive, environmentally sustainable and well-governed by 2030. Alongside a vision, means of implementation (MoIs) and a follow up and review mechanism, the UN 2030 Agenda has 17 Sustainable Development Goals (SDGs) and 169 targets at its core. While all goals are linked across the economic, social, environmental and governance pillars of sustainable development, Goals 1 to 7 fall under the social pillar of sustainable development. These refer to household targets, no poverty, nutrition, health, education, gender, clean water and sanitation and access to sustainable energy, respectively. Goals 8 to 12 fall under the economic pillar and provide targets for the economy in terms of decent work, economic growth, innovation, infrastructure, income inequalities, sustainable cities, and responsible consumption and production, respectively. Goals 13, 14, and 15 form the environmental pillar and provide targets for the care of our planet in terms of climate, life under water and land, respectively. Goals 16 and 17 refer to important governance goals for the Agenda: peace, strong institutions and partnerships for the SDGs, respectively.

The UN 2030 Agenda document specifies MoIs to achieve the SDGs. These include Finance, Technology, Capacity Building, Trade, Policy and Institutional Coherence, Multi-Stakeholder Partnerships and Data, Monitoring and Accountability. Among these, Science, Technology and Innovation (STI) is identified as a central tool for SDG implementation. The Agenda mentions STI fourteen times and each term individually another sixty times. It also calls for a global Technology Facilitation Mechanism (TFM) to enable international cooperation on access to science, technology and innovation and enhanced knowledge sharing to achieve the SDGs. There is also a call to promote the development, transfer and dissemination of STI to developing countries to help them achieve the SDGs. Finally, there is a call to enhance the STI capacity of developing countries and to enhance the use of enabling technologies, such as ICT to achieve the SDGs across the four pillars (UN, 2015a).

A consensus is emerging that all countries must undertake major transformations to implement all of the SDGs (Sachs et al., 2019). While the work of Sachs et al. (2019) focusses on six key transformations required to achieve the SDGs by 2030, other related scholarship has focused on understanding interactions to determine barriers and opportunities to SDG implementation (Nilsson et al, 2018) as well as highlighting the use of evidence and science-based approaches to SDG implementation across nations (Allen et al, 2018). At the institutional level, the World in 2050 (TWI2050) global research initiative was established by UN SDSN, the International Institute for Applied Systems Analysis (IIASA), Stockholm Resilience Center (SRC) and the Earth Institute, Columbia University to develop pathways for achieving all the SDGs. The TWI2050 Report identifies six transformations for achieving the SDGs and long-term sustainability to 2050. These include a call for a digital revolution; smart cities; de-carbonization and renewable energy; sustainable consumption and production; sustainable food, biosphere and water, and human capacity and demography. Central to these transformations are technology intensive transitions and the need for open and effective governance at all levels (IIASA, 2015).

Bearing this context in mind, this paper focuses on STI in the UN 2030 Agenda. STI change is well-established as a key driver of economic growth. However, less attention has been given to the impact of STI on sustainable development. The UN 2030 Agenda, highlighted in the UN *Global Sustainable Development Report* (UN, 2015a), clearly understands the potential for science, technological change and innovation to deliver inclusive societies, sustainable environments, open and good governance, and sustainable livelihoods. Within this broad context, this paper argues three related points. First, using a modern Industrial Organization (IO) approach, we contend that the current nature of 'technology' in economic growth accounting is largely unsustainable for inclusive societies, good governance and the environment. Second, we argue that the desired 'technology' for sustainable development accounting within the UN 2030 Agenda needs large scale global public policy co-ordination across nations. This has the implication that relying on global behavioral change in companies and households is unlikely to be sufficient to achieve sustainable development. Third, having outlined an economic framework for our argument, we then examine the UN global TFM (UN, 2018) and highlight limitations in the current framework for STI to induce the transformative changes required in economic, social, environmental and political pillars of sustainable development that will allow us to achieve the SDGs in developed and developing nations. We highlight the need for a questioning of the nature of existing technology and the possibility that new technologies are required for the SDGs. The TFM aims to induce access, transfer, and a capacity to absorb and adapt existing technologies. This may not be enough to achieve the SDGs. Government policies, in partnership with all stakeholders, will be needed to induce finance and markets for a new generation of STI for the SDGs. Their creation and diffusion across all pillars of sustainable development will require a comprehensive integration of all UN 2030 Agenda MoIs around STI Policy.

2. The Nature of Technology in Economic Growth Accounting

The nature of contemporary global value chains is such that it is dominated by the role of total factor productivity (TFP) in increasing value added without a corresponding increase in the traditional factors of production. Total factor productivity can be thought of as the ratio of aggregate output (e.g. GDP) to aggregate inputs in the economy, a company, or a sector. Put another way, growth in TFP can be considered the portion of growth in output not explained by growth in traditionally measured inputs of land, labor and capital used in production. We argue that there is an urgent need for a theory that explains why TFP accounts for 80 per cent of value added in global value chains. In particular, do companies control this TFP? What is the nature of their instruments, such as STI, that can do this? What does this imply for the return to traditional factors of production worldwide? What are the implications for tax bases worldwide? What are the implications for sustainable development worldwide? These are important questions not only for sustainable development but, by extension, for the future of the planet.

Since Solow (1959), technical change has been central to economic explanations of economic growth accounting. The Solow residual, a proxy for technical change, is defined as the unobservable, or residual, in economic growth accounting. More formally, the growth in output, Y, under assumptions of a Cobb-Douglas technology and constant returns to scale, can be decomposed into contributions from physical capital, K, and labor, L. The unexplained growth, over and above the observable factors of production (which can also include factors such as raw materials and land) is called the contribution of technical change, A:

$$\frac{dY}{Y} = \alpha\frac{dK}{K} + (1-\alpha)\frac{dL}{L} + \frac{dA}{A} \qquad (1)$$

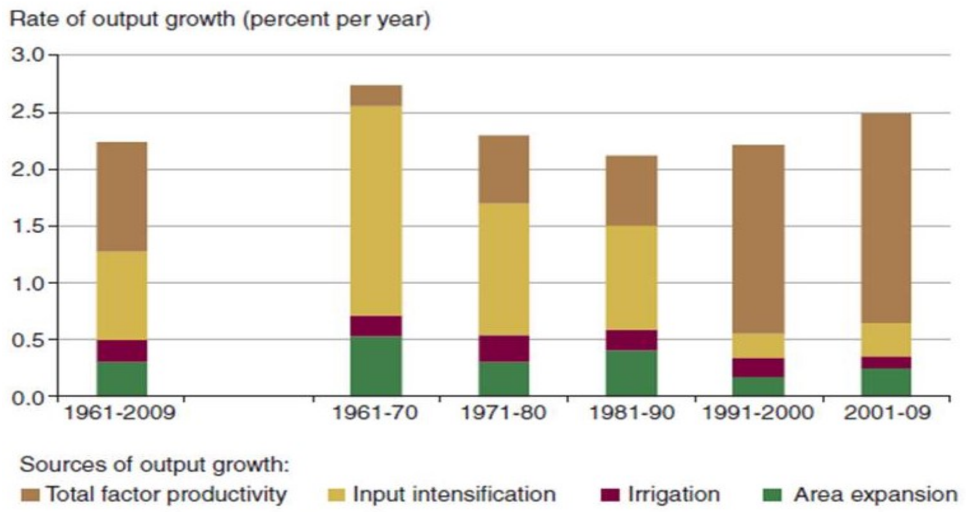
where $\frac{dY}{Y}$ is growth in output, $\alpha\frac{dK}{K}$ and $(1-\alpha)\frac{dL}{L}$ refer to the contributions of capital and labour respectively, and $\frac{dA}{A}$ is growth in Total Factor Productivity (TFP).

In (1), economic growth can be accounted for either on the extensive or intensive margin. Growth on the extensive margin occurs if observable factors of production lead to an increase in production holding the level of technology fixed. Important sources of input growth include investment in physical capital and labor force expansion, through for example, the lower cost of financing capital or increased participation of women. On the other hand, growth on the intensive margin arises when the production process becomes more efficient at transforming a given amount of inputs into output. The main source of intensive growth is often seen as ‘technological change’, i.e. the process of science, invention and innovation commercialization, and diffusion of such technologies throughout the economy.

While this unobservable in value added is referred to as ‘technological change’, in reality, it is anything that can increase the dollar value of value added for the same expenditures on traditional factors of production, such as labor, physical capital, land and raw materials. This can reflect many factors inside companies such as good human resource management, good business systems and embodied technologies in factor inputs. It can also reflect many factors outside of companies, such as good government institutions, good investment climates, good social capital and large R&D tax credits and grants (North and Thomas, 1973; Acemoglu et al., 2015). Empirically, the Solow residual should be interpreted as ‘technological change’ in the broadest sense. The residual can embody STI, but also captures many other related factors.

Initially, the Solow residual was modelled as exogenous or outside the control of companies. Hence, one could explain inequality across nations, both in terms of income and living standards, often as a result of poor governance and deficits in social and economic development. Yet the field of modern economic growth has introduced theories of endogenous change, where companies, or governments, can in a deterministic way use instruments to control the evolution of the Solow residual, with STI being central to that capability. One set of theories are based on horizontal endogenous growth where companies and nation states can enhance the productivity of factors of production (Romerm 1986, 1990; Grossman and Helpman, 1994).

For our proposed framework, we highlight a vertical theory of endogenous market structure, (Sutton, 1991, 1998, 2012) where sunk cost expenditures can lead to an increase in value added without increasing the contributions of traditional factors of production. One of the main motivations for our focus on this theory is the growing dominance of TFP in global value chains. Take global world agriculture as an example. In Figure 1 the changing role of TFP as the primary source of growth in world agriculture is documented. Here, it is evident that total factor productivity growth over time has replaced resource expansion and input intensification as the primary source of growth in world agriculture (Owen et al., 2012).



The height of the bar is the average annual growth rate in gross agricultural output over the period. The color components decompose the source of the growth into parts due to (i) agricultural land expansions; (ii) extension of irrigation to cropland; (iii) greater use of fertilizer, machinery, labor, and other inputs per acre of cropland; and (iv) total factor productivity.
Source: Fuglie, Wang and Ball (2012).

We argue that there is an urgent need for a theory that explains why TFP accounts for 80 per cent of value added in global value chains. In particular, do companies control this TFP? What is the nature of their instruments, such as STI, that can do this? What does this imply for the return to traditional factors of production worldwide? What are the implications for tax bases worldwide? What are the implications for sustainable development worldwide? These are important questions not only for sustainable development but, by extension, for the future of the planet.

To demonstrate our arguments around technology in global value chains, we apply a theoretical framework of vertical product differentiation and market dominance provided by Shaked and Sutton (1983). This is a framework from the microeconomic field of industrial economics that can help explain both the dominance of 'technology' in growth and the dominance of a few companies in production in a single global market. Shaked and Sutton (1983) explained the potential for the emergence of natural oligopolistic structures in markets where households vary in their incomes and have explicit tastes for 'quality' aspects of products. However, we apply their analysis to the global market and, in particular, OECD countries who house the top billion people in terms of incomes. In addition, they demand a higher quality of product even within narrowly defined product sectors compared to the low-income households of the mainly southern hemisphere.

Quality in Shaked and Sutton (2016) is created by investment (sunk cost) sequences in R&D that makes a product more desirable. Clearly, investment will tend towards making products more in demand by high income groups. We can interpret ‘quality’ as anything that makes consumers willing to pay for the product for any given price. We can think of ‘quality’ as R&D characteristics. In addition, a product can have more ‘quality’ because of branding and advertising. A product can also be of higher ‘quality’ due to availability created by exclusive dealing with wholesalers and retailers using digital and physical highways. Price competition can increase due to STI applied to the cost efficiency of securing factors of production across nations.

Shaked and Sutton (1983) in a three-stage game, allow price competition in the final stage, quality competition (linked to sunk cost expenditures) in stage II, and firm entry (with exogenous sunk costs) in stage I. The outcomes in a sub-game perfect equilibrium suggest that when we observe such demand primitives in taste and income, products will become sunk cost intensive and only a few firms will survive in equilibrium. In addition, the model predicts that as exogenous entry costs in markets decline (i.e. as costs relating to transportation and market access fall) these outcomes will dominate in all sectors that display these demand primitives. In other words, the process of globalization will drive production to become more technology intensive and only a few firms will survive in the global market. The companies will invest heavily in STI to capture the market share of the consumers with high incomes who want the high quality aspects of goods as standards of living increase. In equilibrium we observe an escalation in quality and price competition for high income groups. The products produced will clearly not be socially inclusive, desirable or necessary, in that the tastes of high-income groups/nations will tend to direct the path of technological change.

With globalization, global value chains and the international innovation system are now dominated by a small number of large companies that typically direct their global sourcing of inputs and STI efforts towards getting final products into the OCED markets. This has impacted the nature of STI created in terms of nature of product characteristics, the creation of digital and physical highways to navigate global commodity, wholesale and retail global markets, to by-pass tax and regulation by governments, and to outsource manufacturing goods and services to preferred countries. Such STI creates value added and protects market share in the OECD but adds nothing to the contributions of the traditional factors of production. Stiglitz (2016) refers to this phenomenon as unearned income. The owners of such STI get a supernormal high return whether, in the traditional sense, earned or not. Furthermore, there is an important trade literature that controls for the growing presence of product quality/markups in the residual of the production functions to avoid bias estimates on the return of the standard factors of production (de Loecker and Warzynsti, 2012).

We make an argument that the nature of STI investment is to orient global production to cater for preferences of the top billion people. This has disastrous consequences for global society, environment and governance. Tax bases are eroded alongside an inability of populations to earn a decent rate of return for its factor inputs, such as labor earnings. Variants of the model can be observed in many world markets with high investment in STI. For example, in drug sales, Africa accounts for only 1% of global drug sales; and because the people of Africa and the developing world do not purchase large amounts of medications, common diseases that devastate the continent are disregarded in R&D decisions undertaken mainly by managers of large pharma-companies who find it more profitable to focus on more lucrative technology-intensive treatments to illnesses that affect Europe and North America, particularly in older cohorts of the population (Combe et al., 2003; Stevens, 2004). The case is further compounded in pharmaceuticals where the majority of funding for basic medical research comes from the state and is undertaken predominantly in universities in the OECD. When advances in science pave the way for technological opportunities and the development of new technologies is highly risky, as is the case with pharmaceuticals where only a small fraction of drugs actually make it to market, we have a technological system that more or less "socializes the risk but privatizes the return" from investments in new technology (Mazzucato 2014, 2015; Mazzucato and Ray, 2017). In view of the bias in the direction of technical change, the system creates a drive to technology that creates value added that is not oriented to the global public good.

The result is that STI for inclusive society, sustainable environment and good governance suffers. On the governance side, the tendency in the current direction of technical change is to undermine the possibility of achieving both effective (the problem-solving capacity of government) and equitable (ability of government to achieve distributional outcome and equitable treatment) governance within nations. It has been noted in the literature that good, effective and equitable governance all represent different dimensions of governance to achieve the SDGs (Bernstein, 2015). On the inclusive society and sustainable side, the current situation means that value chains do not pay a 'fair' return to the traditional factors of production (such as labor) and tax avoidance behaviors by large international companies erode tax bases all around the world and undermine the goal of achieving inclusive and just societies. Similarly, countries find it difficult to invest in education, health, infrastructures and social protection, energy transitions and open governance arrangements that could help to implement sustainable development and further promote the core SDG principle of leaving no one behind. On the environment side, value chains by producing across many nations can exploit international differences in environmental legislation to maintain unsustainable technologies of production and induce large scale environmental footprints.

There is an urgent need to incentivize the production and dissemination of new technologies that are inclusive, sustainable and promote good governance at all levels. In principle, households, especially in developed countries, could pull technological change in the direction of sustainable development by changing their patterns of demand and show a preference to only consume products that are free of negative social, environmental and political spillovers. Increased public awareness of the SDGs and a mobilization of the general public behind SDG goals and targets could help to change the basic taste primitives of demand, which in turn would lead to a change in the basic technology primitives of supply which has the potential to lead us to global sustainable development.

On the other hand, companies could push technological change in a more sustainable direction. Many companies may want to internalize any negative spillover in the value chain, as part of a good business plan and risk management, in the economic, social, environment and governance spheres in any part of the world. Private finance, manufacturing, agricultural and service companies are signing up to the UN Principles for Responsible Investment and the UN Compact. The principles for responsible investment (PRI) recognise that institutional investors have a duty to act in the best long-term interests of their beneficiaries in terms of environmental, social, and corporate governance (ESG) issues. The UN Global Compact's Ten Principles are derived from: the Universal Declaration of Human Rights, the International Labor Organization's Declaration on Fundamental Principles and Rights at Work, the Rio Declaration on Environment and Development, and the United Nations Convention against Corruption.

In the academic literature on STI and growth, there have indeed been debates on related issues. In particular the work of Perez (2003) has outlined historically the relationship between growth and major technological transformations in society. Indeed, the later work of Perez (2019) argues convincingly that future growth will need to be sustainable growth which can only be facilitated by technology. In addition to this, the recent work of Sachs et al (2019 has outlined the need for six core transformations to achieve the SDGs. Therein, the role of STI is important for achieving the transformations as well as the dislocations in institutions and management systems that are required to engage in new directions. Moreover, there is also a large literature on sustainable transitions and STI (Miedzinski et al, 2018) suggesting that SDG type-transitions need to be constructed on new principles, such as the circular economy, which also imply new ways of understanding STI.

It is clear that markets under the current institutions of governments, have failed to induce the needed changes and consequently, we propose that large scale global public policy coordination is needed to change the primitives in global production and consumption patterns with a range of policies for sustainable development. The market driven processes of innovation and diffusion tends to be targeted at economic value added, and are not designed to orient technology towards more socially inclusive and greener pathways and ensure effective technology transfer to poorer or lagging countries. The challenge for public policy, coordinated across nations, is to focus the direction of technological change towards economic, social, and environmental characteristics of products, and not just value added.

3. STI and SDGs

The foregoing theoretical context outlines the need for a greater recognition within public policy circles of the dominant role that technology plays in both economic growth and in the orientation of production towards the global north. For the former, it is quite clear that technology is a crucial factor in enabling the contemporary dominance of total factor productivity as the source of intensive margin economic growth. For the latter, research and development that produces new technology has done so in a manner that orients production towards markets with value added. Specifically, the majority of research and development for the global production process has focused on the stylized consumption patterns of the wealthiest cohort of global population rather than on global social need. This is particularly true for research and development in global agriculture, but is also true for the global pharmaceutical industry, energy, transport infrastructure, among other sectors. Indeed, there is also the issue of the capture of technology ownership; technologies that may be socially valuable are now frequently held in private while others are not yet designed because financing them is difficult given that the pursuit is not typically for profit. Indeed, the strengthening of global intellectual property rights over the past thirty years has meant that mobilizing privately held technology for social benefit is not a straightforward task.

It is important to note that the UN system has recognized the vital role of not just technology, but the combination of science, technology and innovation (STI) for achieving the SDGs. Indeed, there is recognition that technology (developed through science and innovation) can influence many of the important components of the global system that needs to be addressed for achieving the UN 2030 Agenda including global production, consumption, and the use and inclusiveness of technology enabled-solutions for SDG implementation. In addition, the resourcing of SDG implementation has been recognized as crucial to achieving the SDGs and technology plays an important role in this regard particularly due to the uneven distribution in the level of technology across the globe. In fact, it has been argued that this is one of the key reasons for the persistence in inequality between nations (Naudé and Naudé, 2015).

In the UN 2030 Agenda, MOIs for all the SDGs are addressed in SDG 17 (partnerships for the goals), SDG targets on MoI under each SDG, and the Addis Ababa Action Agenda (AAAA) UN, 2015c) on financing for development (FfD). Together, these agreements provide the normative framework, targets to guide policy directions, and indicators to quantitatively assess the mobilisation of resources for SDG implementation. In response to the important role of technology, Paragraph 123 of the Addis Ababa Action Agenda and Paragraph 70 of the Post-2015 Development Agenda Outcome Document called for the establishment of a Technology Facilitation Mechanism (TFM). The TFM was established in 2015 and aims to facilitate multi-stakeholder collaboration and partnerships through the sharing of information, experiences, best practices and policy advice among Member States, civil society, the private sector, the scientific community, United Nations entities and other stakeholders. It is a global partnership and the mechanism has three components:

Component 1: A United Nations Interagency Task Team on Science, Technology and Innovation for the SDGs (IATT) currently consisting of 35 entities. It also includes a the 10-Member Group of representatives from civil society, the private sector and the scientific community;

Component 2: A collaborative Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum). The Forum convenes once a year to discuss science, technology and innovation cooperation around thematic areas for the implementation of the SDGs. The STI forums held its third annual Forum in June 2018.

Component 3: An online platform as a gateway for information on existing STI initiatives, mechanisms and programs. Work to develop the online platform has been slow and is still to be implemented. However, preliminary collection of existing technology applications and initiatives for addressing sustainable development challenges is already underway for inclusion on the platform. The online platform has three core functions. First, it will establish a comprehensive mapping of, and serve as a gateway for, information on existing science, technology and innovation initiatives, mechanisms and programmes, within and beyond the United Nations. Second, it aims to facilitate access to information, knowledge and experience, as well as best practices and lessons learned, on science, technology and innovation facilitation initiatives and policies for SDG implementation. Third, it will facilitate the dissemination of relevant open access scientific publications generated worldwide to facilitate knowledge sharing on SDGs. However, the UN TFM online platform, potentially the most publicly pervasive and beneficial component, has not been implemented. We wish to put forward two challenges that the TFM approach should consider if it is to address the issues raised in the previous sections including the reorienting of technology for sustainable development.

First is the question of whether existing (typically commercial) technologies are suitable for transfer across the globe (north to south) especially given the starkly different contexts of their development (capacities) while the question as to whether they are suitable for implementing the SDGs is real and pressing. Co-ordinated government policies are needed to create a demand pull for the creation of such technologies and for their successful transfer and absorption across the globe. In the Addis Ababa Action Agenda, Member States committed to 'adopt science, technology and innovation strategies as integral elements of our national sustainable development strategies' ([24] paragraph 119). Unfortunately, no commitment or methodology was laid down to track such a commitment. However, the IATT (2018) recently completed a meta-review of the 64 Voluntary National Reviews (VNRs) submitted from 2016 and 2017 and concluded that, despite stated commitments, countries are still at the very early stages of making STI strategies integral elements of national sustainable development strategies. Furthermore, they also concluded that no VNRs present strategic coherence from STI efforts to progress toward achievement of the SDGs. Common country challenges identified in the report included: trust in STI systems; inequity within and across countries including through brain drain; investing in human capital for continuous re-skilling; risk of stranded asset and legacy capital stock; and links to longer-term and global roadmaps especially on environmental goals.

Despite this, there are examples of how STI could be better integrated into policy to achieve the SDGS. Consider national industrial and innovation policy as an example. Many nations have national industrial agencies charged with attracting foreign direct investment that meets pre-established social, economic and governance criteria. It is entirely possible to reorient industrial policies and government funding of technology, research and innovation towards achieving the SDGs (Walsh, 2015). For example, foreign direct investment (FDI) funding could be reoriented to ensure that key criteria for receiving funding is to adhere to UN principles of Responsible Investment. In addition, companies being funded could be conditional on them adhering to the ten principles of the UN Global Compact. Indeed, such principles must also be applied to national investment abroad and through Overseas Development Assistance (ODA) commitments.

National governments can also be enablers of SDG STI in many other ways. They can create markets for sustainable development technologies by embedding SDG requirements into a range of government functions including public procurement projects, government consumption of goods and services, national research funding programs, funded non-profits and quasi-government agencies. Indeed, it is entirely within the remit of elected government to impose regulations that would alter consumption patterns along more sustainable lines including around packaging, recycling, carbon and water footprints, energy efficiency, and emissions. In addition, social enterprise funding could be established to provide product development support especially for the development of technologies that would support SDG implementation in a range of areas that may be very beneficial socially and environmentally but may not be in traditional commercial terms. Such social enterprise will likely need government underwriting if it is to be successful.

Second, we argue that all seven SDG MoIs need to work together to harness knowledge transfer into meaningful facilitation of SDG implementation across the globe. While key transformations have been identified for achieving the SDGs (Sachs et al, 2019), it is the MOIs that need to be cultivated in such a way that targets SDG transformation rather than goals. In this regard, STI as an MOI must be focused on targeting STI that targets and facilitates SDG transformations; this will provide the capacities required for enabling transformations. STI solutions cut across the entire range of SDGs and there is wide recognition that technology solutions will require significant financial resources and investment in capacities to adapt and absorb technologies into the local context. While technology can, at least in part, assist as a solution for resources, financial investment will be required to develop technologies that will assist with SDG solutions and transformations. Financing the SDGs will require involvement of the private sector, NGOs, civil society and other stakeholders. However, it is becoming quite clear that financing the SDGs will need to be government-enabled at national, supra-national and global levels. Indeed, the need for finance to be part of the solution for SDGs has been recognized by the United Nations. A Global Alliance for SDG finance has been established within the UN system to provide a more comprehensive set of solutions to mobilize private capital in achieving the Global Goals. The Alliance includes the:

- UN Global Compact Financial Innovation for the SDGs
- UNEP-FI Principles for Positive Impact
- PRI Blueprint & Advisory Group on the SDGs

Together, the UN Global Compact, the UN Environment Finance Initiative (UNEP-FI) and the Principles for Responsible Investment (PRI) constitute the largest networks of private and financial sector constituencies — corporates, investors, banks and insurers — dedicated to promoting the SDGs. In addition, The UN Economic and Social Council (ECOSOC) Forum on Financing for Development (FfD Forum) was established by the Addis Ababa Action Agenda (AAAA) to support the follow-up and review of FfD outcomes and the means of implementation of the 2030 Agenda for Sustainable Development. The Forum's conclusions and recommendations feed into the annual UN High-level Political Forum on Sustainable Development (HLPF).

There are also early innovations in SDG finance. In March 2017, the World Bank launched the first bonds that directly link private investors to the SDGs raising $173 million from institutional investors in France and Italy. Returns are linked directly to the performance of companies advancing global development priorities set out in the SDGs, including gender equality, health, and sustainable infrastructure. The return on investment in the bonds is directly linked to the stock performance of companies included in the Selective Sustainable Development Goals World MV Index. The index includes 30 companies that dedicate at least one fifth of their activities to sustainable products or are recognized leaders in their industries on socially and environmentally sustainable issues. However, to date the amount of finance raised by SDG bonds is very minor.

Yet, other areas of finance have provided insight into the potential for such innovations – green bonds being a case in point. As Obenland (2018) notes: 'The first green bonds were issued already in 2007 by the European Investment Bank in order to finance the climate goals of the European Union (EU). In the following years, notable development banks like the World Bank or the German Kreditanstalt für Wiederaufbau (KfW) issued green bonds, which have since raised more the 380 billion US-Dollars (by the end of 2017)'. The key task for SDG bonds though is to allow social, community and SME enterprise to leverage the potential of institutional investment finance. For this to occur, it will be important to find a technological solution to verify and package small to medium scale finance requirements to larger scale institutional investment requirements.

In summary, the objectives of UN global TFM can be met if government policies, in partnership with all stakeholders, induce finance and markets for a new generation of STI for the SDGs, particularly in the global north. Access, transfer and dimension to the least developed countries can happen but it will require a comprehensive integration of all UN 2030 Agenda MoIs, around a local STI Policy and underwritten by global partnerships providing finance and technical supports.

5. Conclusion

The publication of the 2018 SDG Index and Dashboard Report provided not only a wake-up call, but also a stark warning for global policymakers. It noted that no country is on a pathway to achieving all SDGs by 2030. What is also interesting from the viewpoint of the argument presented in the current paper, is that the report highlights that progress towards sustainable production and consumption patterns is too slow, that high-income countries generate significant environmental, economic, and security spillover effects that undermine other countries' efforts to achieve the SDGs (Sachs et al., 2018). STI are central to achieving more rapid progress in these areas because STI solutions have the potential to contribute to transformative actions that can reorient production, promote equality and inclusion, and have positive environmental benefits. However, for this to occur STI solutions must be re-imagined in ways that cater to the whole of society including promoting solutions that are respectful of planetary boundaries.

In this respect, our argument is a call to rethink the role and importance of technology for achieving the 2030 agenda. In our view, a much broader debate needs to occur around the nature of technology, its role in production, consumption, value chains and the wider economy, where technology ownership and control lies, its existing orientation and focus, and particularly, how it might be reoriented in a manner that can more meaningfully contribute to the implementation of the SDGs in a transformative way. In relation to the latter point, the scholarship of Köhler et al (2019), Sachs et al (2019) and others has pointed out the need for systematic change and transformations focused firmly on the need for a sustainable future.

While the UN global TFM is an admirable staring point to think about technology and the SDGs, it is designed to promote STI access, transfer and capacities across nations to achieve the SDGs. Our first question is whether the current stock of STI and knowledge is good enough when accessed and transferred across nations to achieve the SDGs? The evidence from the SDG Index and Dashboard would suggest this is not the case and that OECD countries have a considerable way to go in terms of having STI for sustainable development. While there is progress in some areas (e.g. sustainability transitions), it nevertheless remains the case that we are still far short of the systematic shift needed in the orientation of technology towards addressing the core transformations needed for achieving the SDGs.

A further key message of this paper is that technology is not benign in the production process; rather, in contemporary capitalism it has become a crucial means of capturing value in the production process. In this regard, we note that technology has been crucial in the emergence of total factor productivity as the dominant driving engine for economic growth but also, how the concentration of technology in the hands of a select number of companies has oriented economic growth in fateful directions (often consumption-led) which are not typically in the interests of the goals of the UN 2030 agenda or of sustainable development more generally.

In our view, the framework we have outlined for understanding the role of technology in production and value capture is not widely understood in policy circles. The UN global TFM takes as a given that the existing stock of technology is something that is naturally benign and can be accessed, transferred and applied to the SDGs across nations. No doubt there are opportunities to adapt and apply existing technologies as outlined in the recent *Global Sustainable Development Report* (UN, 2015b) but existing technologies are being adapted to fit the requirement of SDG implementation rather than being designed and oriented specifically for the SDGs. The problem with utilizing existing technology is that it may likely be leading us down and incorrect pathway and creating unintended ‘lock-in’ consequences which is less likely to be transformative in scope. For this SDG technology to emerge and allow the TFM to be more effective in its mission, technology creation needs a wider ecosystem with public policy supports targeting all seven SDG MoIs in a more holistic approach. These MoIs include creating a market space for SDG oriented production, finance, public and private partnerships, data and lots of other capacities to ensure STI is more pervasive in its diffusion and assist more effectively with the implementation of SDGs across nations.

Acknowledgments

This research received funding from the following funding agencies: the Irish Environmental Protection Agency under the project ‘Framework for Achieving Environmental Sustainable Development Goals (SDGs)’ and the European Commission and Irish Research Council under the Marie Curie Scholarship programme.

References

Acemoglu D, Johnson S, Robinson J. Institutions as a Fundamental Cause of Long-Run Growth. In Handbook of Economic Growth. Volume 1A. Chapter 6. Edited by Phillippe Aghion and Stephen Durlauf. 2015. DOI: lO.l016/Sl574-W84(05)OloW.

Bernstein, S. (2015) 'Good, Effective and Equitable Governance and the Sustainable Development Goals', in, Friends of Governance for Sustainable Development, Governance for Sustainable Development: Ideas for the Post 2015 Agenda, Chapter 8. New York: New Frontiers.

Combe E, Pfister E, Zuniga, Pl. Pharmaceutical patents, developing countries and HIV/AIDS research. In: Moatti u.a. 2003, S151-168.

GM Grossman, G, Helpman, E. Endogenous innovation in the theory of growth. Journal of Economic Perspectives. 1994;8(1):23-44. DOI: 10.1257/jep.8.1.23.

http://www.un.org/esa/ffd/ffd3/wp-content/uploads/sites/2/2015/07/Addis-Ababa-Action-Agenda-Draft-Outcome-Document-7-July-2015.pdf [accessed 2018-08-07]
http://www.who.int/intellectualproperty/submissions/InternationalPolicyNetwork.pdf [accessed 2018-08-07]

Köhler, J. et al. (2019) An agenda for sustainability transitions research: State of the art and future directions, Environmental Innovation and Societal Transitions, 31, 1-32.

J De Loecker J, Warzynski F. Markups and firm-level export status. American economic review. 2012;102(6):2437-2471. DOI: 10.1257/aer.102.6.2437.

Mazzucato, M, Roy, V. Rethinking value in health innovation: from mystifications towards prescriptions. IIPP Working Paper Series. 2017-04.

Mazzucato, M. A mission-oriented approach to building the entrepreneurial state [report]. 2014. Science Policy Research Unit, University of Sussex. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/417991/T15091_Mazzucato_report_summary_-_final.pdf [accessed 2018-08-07]

Mazzucato, M. The Entrepreneurial State: Debunking Public vs. Private Sector Myths. Revised ed. Anthem Press; 2015. Ch. 9. ISBN 9780857282521.

Miedzinski et al, 2018 Paving the pathways towards sustainable future? A critical review of STI policy roadmaps as policy instruments enabling sustainability transitions

North D, Thomas R. The Rise of the Western World: A New Economic History. Cambridge University Press; 1973. 2p.

Obenland, W. Case 1, SDG Bonds: Private finance to the rescue. 2018. Available from: https://www.forumue.de/wp-content/uploads/2018/07/SDG-und-Privatwirtschaft-Studie.pdf [accessed 2018-08-07].

Perez, C. (2019) Transitioning to smart green growth: lessons from history. In Handbook on Green Growth. London: Edward Elgar Publishing.

Perez, C (2003) Technological revolutions and financial capital. Edward London: Elgar Publishing.

Productivity Growth in Agriculture: An International Perspective", edited by Keith Owen Fuglie, Sun Ling Wang, V. Eldon Ball (2012), Oxfordshire UK CAB International DOI: 10.1079/9781845939212.0000.

Romer, P. 1990. Endogenous technological change. Journal of Political Economy. 1990;98(5):71-102. DOI: 10.1086/261725.

Romer, P. Increasing returns and long-run growth. Journal of Political Economy. 1986;94:1002-1037. DOI: 10.1086/261420.

Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G. (2018) SDG Index and Dashboards Report 2018. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN).

Sachs, J., Schmidt-Traub, G (2019)

Solow, R. Technical change and the aggregate production function. Review of Economics and Statistics. 1957;39(3):312–320. DOI: 10.2307/1926047.

Stevens, P. Diseases of Poverty and the 10/90 [report]. 2004. International Policy Network. Available from:

Stiglitz, Joseph E. (2016). "Joseph Stiglitz Says Standard Economics Is Wrong. Inequality and Unearned Income Kills the Economy," adapted (with permission) from: Jacobs, Michael, and Mariana Mazzucato, eds.

Rethinking capitalism: economics and policy for sustainable and inclusive growth. John Wiley & Sons, 2016. ISBN: 978-1-119-12095-7

Sutton, J, Shaked, A. Natural oligopolies. Econometrica. 1983;51:1469-1483. DOI: 10.2307/1912285.

Sutton, J. Competing in Capabilities: The Globalization Process. Clarendon Lectures in Oxford University Press; 2012. ISBN: 9780199274536.

Sutton, J. Sunk Costs and Market Structure: Price Competition, Advertising and the Evolution of Concentration. MIT Press; 1991. ISBN: 9780262193054.

Sutton, J. Technology and Market Structure: Theory and History. MIT Press; 1998. ISBN: 9780262193993.

The Addis Ababa Action Agenda of the Third International Conference on Financing for Development. 2015. Available from:

TWI205 - The World in 2050. Transformations to Achieve the Sustainable Development Goals [report]. 2018. Prepared by the World in 2050 initiative. International Institute for Applied Systems Analysis (IIASA), Laxenburg. Available from: http://pure.iiasa.ac.at/15347 [accessed 2018-08-07]

United Nations (2018) Technology and the UN 2030 Agenda: United Nations "Technology Facilitation Mechanism" (TFM). Available from: https://sustainabledevelopment.un.org/tfm [accessed 2018-08-07]

United Nations Interagency Task Team on STI for the SDGs (IATT) Science, Technology and Innovation for SDGs Roadmaps. 2018. Available from: https://sustainabledevelopment.un.org/content/documents/19009STI_Roadmap_Background_Paper_pre_STI_Forum_Final_Draft.pdf [accessed 2018-08-07].

United Nations. Global Sustainable Development Report. 2015. Chapter 5: Economic Growth, Inclusive and Sustainable Development and Sustainable Consumption and Production, available from: https://sustainabledevelopment.un.org/globalsdreport . [accessed 2018-08-07]

United Nations. Global Sustainable Development Report. 2016. Available from: https://sustainabledevelopment.un.org/content/documents/2328Global%20Sustainable%20development%20report%202016%20(final).pdf [accessed 2018-08-07].

United Nations. Transforming our World: The 2030 Agenda for Sustainable Development [report] .2015. Available from: https://sustainabledevelopment.un.org/post2015/transformingourworld [accessed 2018-08-07]

Walsh, Patrick Paul (2015) “Industrial Policy and Sustainable Development“, United Nations Global Sustainable Development Report Policy Brief, 9 Mar 2015.

Naudé, Wim and Naude, Paula Nagler (2015). “Industrialisation, Innovation, Inclusion” No 43, MERIT Working Papers from United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).