A human-centred approach to promote Science, technology and innovation for Sustainable Development

Irmgard Nübler [1]

International Labour Organisation (ILO)

April 2023

[1] Research Department, Route des Morillons 4; 1211 Geneva, Switzerland

Email: nubler@ilo.org

Nübler, I., 2023, forthcoming, A human-centred approach to promote Science, technology and innovation for sustainable development, Working Paper, ILO, Geneva.

This paper benefited from discussions with colleagues from various UN organisations collaborating in Work Stream 10 on Analytical work on STI: Richard Alex Roehrl, Clovis Freire Junior, Fouad Mrad, Fernando, SANTIAGO RODRIGUEZ, Pierre Henri Boileau, Susan Schneegans, Naoto Kanehira, Cui, Jin, as well as from the contributions of presenters at the Expert group meeting in 13 December 2022 (Giovanni Dosi, Jaime Echavarri, Dorothea Kleine, Clapperton Mavhunga, Frank Neffke and Uma Rani) and from other participants.

1. Introduction

The 2030 Agenda framework highlights Science, technology and innovations (STI) as important means of implementation of Sustainable Development Goals (SDGs). Out of the seventeen SDGs, eleven make explicit reference to technology (SDG 1,2,3,4,5,6,7,8,9,12,14,17), three refer to innovation (SDGs 8, 9) and two mention science (SDGs 14,17). The 2030 Agenda thus recognises the potential of STI to provide solutions to many of the challenges faced by SDGs,

Despite wide efforts of governments and other stakeholders to promote SDGs, the United Nations recognises that actions to meet the Goals is not yet advancing at the speed or scale required for achieving them by 2030. One of the issues in accelerating progress in SDGs is how to best harness STI. This is a main issue addressed by the 2030 Agenda Technology Facilitation Mechanism (TFM) with the Inter-agency Task Team (IATT), its work streams and the STI Forum as its pillars. It undertakes analytical and policy-oriented word to improve our understanding of technology facilitation processes, the factors shaping these processes, provide evidence on the capacities of frontier technologies to promote specific SDGs, and explores policies and undertakes and undertakes capacity building and awareness creating work to support member states in harnessing STI. [2]

The debate on STI for SDGs within the United Nations system takes an optimistic perspective on STI to accelerate implementation of SDGs. It recognises that humanity has accumulated a huge stock of relevant technological knowledge to advance SDGs. Indeed, many studies demonstrate how cutting-edge scientific knowledge and frontier technologies such as Artificial Intelligence, digital technologies, Big Data, Blockchain, 3D printing, Robotics as well as energy production and storage technologies, biotechnology, nanotechnology and neuroscience provide opportunities for innovation in support of SDGs3. Policy analysis highlights the barriers to fully harness these technologies and the policies required to remove the constraints. Hence, policies focus on facilitating technology transfer, raising financial resources and building capacity, e.g., investment in education and technical skills, developing infrastructure, the role of patents and procurement, or on eco-innovation systems. This "techno-centric perspective" on sustainable development seems to have a long tradition in the United Nations.[4]

Another debate deals with the process of science, technological change and innovations itself, the forces shaping the dynamics and outcomes of these processes. One strand of this literature explores technological change and innovation in the tradition of neoclassical and market-based models, with a

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[2] The United Nations declared a Decade of Action (2020), calling "for accelerating sustainable solutions to all the world's biggest challenges"

[3]. UN DESA, 2016, Global Sustainable Development Report 2016
gsdr tech chapter 2016.pdf:
UNCTAD, 2021, Technology and Innovation Report 2021
https://unctad.org/webflyer/technology-and-innovation-report-2021

[4] The United Nations Conference on Sustainable Development (2012) reviews the history of the UN debate on technology and development and states that "most UN commitments of the past twenty years [1980 to 2010] follow the technology-centric perspective which aims to facilitate technology transfer from developed to developing countries for which it is considered crucial to raise financial resources and build capacity. Often these three elements have been referred to as "means of implementation. " This view is also reflected in SDG8, target 8.4.

focus on market forces, incentives, institutions, technology transfer and spill-over. These models build on the idea that economic growth is driven by innovation, and they explore explain that innovation increases the productivity of existing firms, create new firms and industries, and lead to the adoption of new technologies and products. This literature emphasize the role of market structure and competition in promoting innovation and growth, and they discuss policies and institutions such as patent laws, research and development subsidies, and competition policy to promote innovations for economic growth.

A recent literature discusses the role of choices, power and agency in the process of technological change. This literature stresses the fact that STI processes are not deterministic, human beings and societies have choices in shaping technological paths and innovations, and that those in power need to design policies and institutions to support achievement of development goals and aspirations of societies. This literature discusses the role of governments, entrepreneurs, workers and other stakeholders in this process. It discusses appropriate technologies, mission-oriented innovations or frugal innovations in achieving sustainable development goals, and that these innovations are supported and shaped by social demand and public choices, thus highlighting the responsibility of actors to reshape innovations. [5]

Also, the literature on technological paradigms discusses human choices and human agency in the STI process. The argument is that new technologies evolve along paradigms (such as steam engine, combustion engine, or the most recent of digitalisation) and that technological change is path-dependent and moves along trajectories (Dosi). There are limits to changing and influencing technological trajectories, but when there are opportunities at bifurcations, the issue is not only to choose good trajectories, but also to develop the human agency to shape the process that lead to desired outcomes (G. Dosi). It cannot be driven by markets because markets do not provide such choices and therefore, they pre-determine the direction of change. Steering technological change beyond interest (incentives) needs to be institution driven, and these institutions need to be public institutions.

Moreover, the theory of shifting techno-economic paradigm explains that each new technological paradigm creates a new wave of change which can be distinguished into different phases (C. Perez). The first phases translate new technological knowledge into process and product innovations within existing industries, leading to job destruction, jobs creation, “unlearning the old and learning the new”, and of explosive growth of new wealth, and high and rising inequalities. One these disruptive effects lead to social responses, new social demand and political choices, and new institutions

[5] Daron Acemoglu and Simon Johnson (2023) Power and Progress: Our Thousand-Year Struggle Over Technology and Prosperity, Publisher, PublicAffairs, 2023.

Acemoglu, Daron, and James A Robinson. 2012. Why Nations Fail: The Origins of Power, Prosperity and Poverty (1st). 1st ed. New York: Crown, 529.

Nübler, I. 2018, New Technologies, Innovation, and the Future of Jobs, in E. Paus, Confronting Dystopia

UNDP, 2022: Changing directions: Steering science, technology and innovation for the Sustainable Development Goal; (STRING Project)

Mazzucato, M. (2018) 'Mission Oriented Innovation Policy: Challenges and Opportunities', Industrial and Corporate Change, 27 (5), pp. 803–815.

(regulatory framework such as in finance, labour markets, product markets), the economy makes the transition into new industries, new jobs and occupations. This transition requires human beings to learn, mobilise creativity and agency, and entrepreneurship. [6]

This brief review of frameworks to analyse science, technology and innovations shows that different economic models provide different framings of the debate on how to shape STI and harness STI for SDGS. These analytical frameworks have in common that the role of human beings in this process remains widely unrecognised. While human beings play complex roles in the process of STI, the insights of disciplines studying the nature of human beings and their cognitive, intellectual, emotional, and psychological resources as the drivers of progress, did not get the attention they deserve. [7]

Mainstream economic models are unable to explain the diverse and complex roles of human beings because they view human beings in a narrow and instrumental sense as labour or human capital, and thus as input or production factor. These models ignore the true nature of human beings by assuming autonomous, rationale and maximising individuals. In models to explain the search for new technological knowledge, R&D, technological change and innovations, human beings are mainly discussed in their role of making choices (guided by rationality, preferences and incentives, and limited by external constraints, in particular income).

The evolutionary and institutional models focus on collective entities, not the level of individuals. These models explain capabilities at the level of organisations and societies which exist in the rules and procedures of routines and institutions and expressed in collective agency or collective choices.[8] The focus of evolutionary theories of technological change is on the non-equilibrium and nonlinear processes that transforms technologies and the economy. The unit of analysis is knowledge at the aggregate level, and how bodies of useful, technological knowledge and socially shared beliefs emerge and evolve, how process, product or organisational innovations diffuse and transform the economy. Knowledge emerges from experience and learning, but the learning process at the individual human level is not modelled. [9]

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[6] Carlota Perez (2009), , Technological revolutions, paradigm shifts and socio-institutional change, in Reinert, Erik (ed) Globalization, Economic Development and Inequality: An alternative Perspective, Edward Elgar, Cheltenham, UK • Northampton, MA, USA, 2004, pp. 217-242

[7] Kleine, D. (2013). Technologies of Choice? ICTs, development and the capabilities approach. MIT Press: Cambridge, MA,

https://mitpress.mit.edu/9780262018203/technologies-of-choice/

[8] Nübler, I., 2014. A theory of capabilities for productive transformation: Learning to catch up, in: Salazar-Xirininach, J.M., Nübler, I. and Kozul-Wright, R., (2014). Transforming Economies: Making Industrial Policies work for Growth, Jobs and Development, ILO, Geneva. , pp. 113–149.

Nübler (2023, forthcoming), *Dynamic capabilities for innovation, transformative change and jobs: the Case of South Africa* , Working Paper, ILO, Geneva

[9] Mokyr (2000) argues that mainstream economics has its value in explaining markets, but "I have serious doubts about the usefulness of neoclassical tools that view long-run technological growth exclusively as another outcome of rational behavior in a well-defined environment." He views technological development as the most relevant domain for evolutionary theories in economics.
Mokyr, J, 2000, Natural History and Economic History: Is Technological Change an Evolutionary Process? C:\WPDOCS\Lectures\jerusalem1.pdf.wpd (northwestern.edu)

It is important to note that most people would of course support the idea that human beings are the source of creativity and new knowledge, that humans are the ones who make choices, and that people develop the capacity to define future goals and to design and implement changes to achieve these goals, and that human beings set for themselves moral ends which guide their choices. These ideas or insights, however, are often not integrated into models and analytical frameworks. They are therefore not reflected in the models and theories taught in courses at schools and universities, and in the models used by policy advisers, policy makers, researchers, engineers and practitioners in decision making and activities.

For example, while education is highlighted as a major indicator to improve "innovation readiness" and a key policy area, policy recommendations in education would mainly focus on technical skills and "core competences", and debate the relevance of STEM subjects versus liberal arts subjects, gender-specific constraints to access these skills, or the use of digital and artificial intelligence tools to enhance efficiency of teaching. While these are all important aspects of education for STI, many of the issues raised by pedagogy, philosophy, psychology and cognitive science are not taken into account, for example the central role of working in teams at the workplace for learning and building dynamic cognitive capabilities, the role of teachers as the architect of learning environments, or the role of decent work in motivating human being to acquire capabilities for adopting new technologies.

The challenge is to build frameworks that reflect the important roles of human beings and their dynamic capabilities in STI processes. These frameworks need to take into account the insights provided by those disciplines which focus on cognitive processes, learning, non-cognitive dimensions of the human mind and behavior of human beings as the unit of analysis. This framework needs to explain how human beings to create and implement new technologies and innovations, and how these dynamic capabilities develop and evolve.

This research is undertaken as part of the work program of Work Stream 10 of the UN's Inter-agency Task Team (IATT

2. A framework for a human-centred analysis of STI

In the following, the main elements of a framework for the analysis of STI are presented. This human-centred perspective provides a vision for re-framing the analysis of STI, and to explain progress in STI endogenously, with the dynamic capabilities of human beings as the engine. This enlarged framework is most relevant in order to explain the many channels, mechanisms and functions through which human beings harness and shape STI processes. The main points are:

1. Human beings develop capabilities to bring novelties into the world. We call them dynamic or transformative capabilities, and they relate to tasks and procedures humans perform when searching for new knowledge, identify and solve problems, invent and innovate. The concept of capabilities adopted in this framework describe the ability and power of human beings to develop new technologies, new products and ways of doing things, or organise production of goods and services. Creating novelties is different from the concept of capacities which relates to performing existing and established activities.

2. We distinguish between two dimensions of dynamic capabilities. The moral dimension relates to capabilities to mobilise and apply a moral compass, ethical and normative standards and values performing the various roles human beings need to perform to generate, shape and accelerate an STI process. Philosophies, theology and anthropology are concerned with humans acting ethically. In the context of science, technological change and innovations, they discuss human dignity, the intrinsic value of a person and human responsibilities as the end goal, and how the values and dignity of human beings shape consciousness, choices and behaviour as an inner compass for moral, ethical and responsible behaviour. The moral dimension of dynamic capabilities are discussed in chapter 3 of this paper.

   The positive dimension of capabilities relates to the resources the human being has developed to perform the various tasks which lead to novelties. Disciplines such as cognitive science, neuroscience, psychology, and pedagogy are concerned with the evolution of psychological, intellectual and personality resources such as the ability to envision, imagination, curiosity, self-confidence and entrepreneurial spirit as well as tenacity and resilience (Kleine 2013). They empower human beings to drive the STI process, e.g., to mobilise creativity, exert agency to overcome resistance, and to make choices which support STI which provide solutions to progress in development goals. Capabilities to mobilise, shape and accelerate transformative processes are discussed in chapter 4.

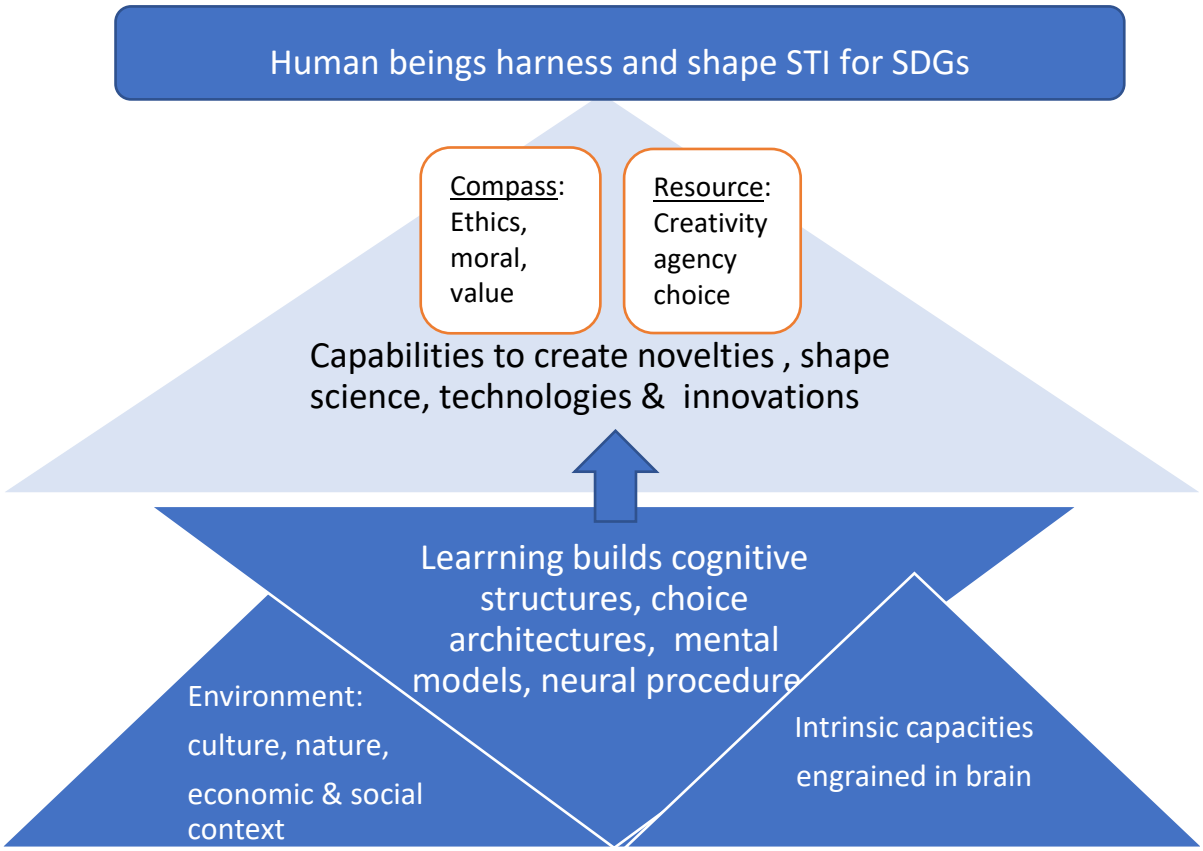
3. These capabilities reside in the human mind, and they evolve in a complex process of learning. Different disciplines explore how the human mind builds knowledge structures, choice architectures, mental models or procedural knowledge which enable humans to perform tasks related to change. This process of building cognitive and non-cognitive abilities and skills is enabled by innate human capacities to learn and to store the knowledge, experience, insights etc. While all living species have innate traits by birth, homo sapiens have specific traits which enable them to build highly complex and powerful cognitive and non-cognitive (e.g. affection, emotions, self-efficacy) resources and moral compasses. Pedagogy, psychology, cognitive and neuroscience, biology, and anthropology all make the important point that the innate capacities enable the human mind to learn, and that the learning process itself is shaped and influenced by the specific environment, culture, social and economic context in which learning takes place. While the innate capacities are given, the dynamic capabilities can be influenced and need to be nurtured.

In summary, this framework distinguishes between the innate capacities of human beings which are given by birth, and the social, economic and environmental context in explaining learning of human persons which build up cognitive and non-cognitive skills and psychological resources. Dynamic capabilities of human beings which are the result of learning and they reside in the many different forms in which knowledge, experience, practice, socialisation, observation etc. is stored and shaped. Moreover, the framework distinguishes between moral capabilities providing the compass and psychological, intellectual capabilities providing the intellectual and psychological resources to perform.

In the following, these different aspects of the framework are discussed with the aim to inform academics, policy makers and other stakeholders about the fundamental role of human beings in technological change and innovations. The framework raises many new policy issues in all those areas

which are related to the development of dynamic capabilities in human beings, and those mobilising these capabilities for progress in STI.

Graph 1: Dynamic Capabilities of human beings providing moral compass and intellectual and psychological resources for transformative change



3. Capabilities to provide moral compass and ethical frames for STI

Philosophy is the discipline which explores the ethical aspects of Science, technology and innovation. While scientists, engineers and economists discuss how to harness STI for achieving economic, social and environmental goals, philosophers raise the moral issue. They discuss value systems and principles to be followed in research, in designing new technologies and innovations and in using them. The current ethical debate on STI is rooted in different philosophical strands which all place human beings centre stage, though in different ways. The traditional debate on ethics and STI is focusing on human rights and human dignity as the end. This implies that the nature and process of STI needs to be shaped in a way that respects human rights and protects human dignity.

The more recent debates on the ethics and technology highlight are motivated by the different nature of contemporary technologies as compared to those of previous centuries and decades.

This section aims to discuss the changing ethical frameworks discussing technologies. While the new technologies and innovation in production systems of the industrial revolution had disruptive impact on the life, working conditions, decency of many human beings and thus societies (Smith, Marx, ILO), an expanded framework emerged when the negative impact of innovations damaged and destroyed nature and concerns emerged over the value of nature, and the consequences of such damages for people in distant places. The most recent debates are concerned with disrupting effects of technologies which threaten the essence of human beings such as bioengineering, artificial intelligence or nuclear technologies. While the intrinsic value of human beings and human dignity remains the constant, the various ethical frameworks take different views on the moral responsibilities of human beings.

Human dignity and human rights

The dominant ethical framework applied to analyse STI is the philosophy of the Enlightenment, a European intellectual movement of the late 17th and 18th centuries. This belief system emphasizes reason, individualism and freedom rather than tradition. This new body of beliefs was developed by 17th-century philosophers such as Descartes, John Locke, Voltaire, Jean-Jacques Rousseau, David Hume, Immanuel Kant and Denis Diderot. The new ideas emerging from this school of thoughts fundamentally changed thinking of people about science, innovation, business, exchange, and the role education and training, all which contributed to the creation and wide diffusion of new scientific and technological knowledge. Adam Smith, a Scottish moral philosopher, contributed to this debate by applying the idea of human beings as rational and autonomous person in explaining economic development. According to his theory, rational behaviour of individuals pursuing their self-interest will be coordinated by the "invisible hand" of markets and will increase exchange value as the wealth of a nation (Wealth of Nations (1776). Smith explains with this model new forms of organising production, in particular process innovations, that is, new ways of doing things - such as increasing division of labour as a main type of innovation for higher productivity and value creation.

In contrast, Immanuel Kant, a German moral philosopher, reflected on the ethics of human behaviour. He provided the new argument that the rightness of an action is determined by the principle that a person **chooses** to act upon. Here, Kant provides a ground-breaking argument that stands in stark contrast to previous moral theories that dominated moral philosophy.

Kant is showing that these principles are normative also for rational agents. He introduces the concept of human dignity (Würde) as the intrinsic value of human beings. He argues that this value is intrinsic to the human existence regardless of their circumstances, and therefore all human beings are equal in the dignity and their inner value. This intrinsic worth should be recognized and respected by others and therefore human beings should treat each other as equal and as an end in themselves and not as a means to something else. 10

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[10] Kant, I., 1785, Grundlegung zur Metaphysik der Sitten, J. F. Hartknoch.

In 1785, Immanuel Kant writes: "So act that you use humanity, whether in your own person or in the person of any other, always at the same time as an end, never merely as a means." Kant introduced the 'categorical imperative' as a

However, Kant argues that human beings are free to choose and most importantly, this implies the ability of human beings to set moral ends for themselves. Human beings differ in this capacity from the rest of nature, and it is this ability which establishes the moral value of a person. The human dignity stems precisely from this human ability to set moral ends, and to be free in choices and have choices guided by these ends. This capacity, however, can be inhibited or amplified by the socio-historical contexts in which people live.

This concept of human dignity as the intrinsic value of a person became the foundation of the Universal Declaration of Human Rights on which the United Nations' 2030 Agenda is grounded. The 2030 Agenda places people first as "… a promise to secure peace and prosperity, which is founded in the respect for people's rights and their dignity."[11]. The ethical framework for the 2030 Agenda views both, Science, technology and innovations as well as the Sustainable Development Goals instrumental in achieving progress in humanity, human dignity, human development and human well-being. STI and SDGS are promoted not as an end in themselves, but as means to increase the dignity of human beings.

While the concept of Human dignity has entered jurisdiction and laws in many countries across the world, and is applied to protect human rights, the literature stresses that the Declaration of Human Rights allows for flexibility in the meaning of dignity, and for different interpretations of human dignity across regions and cultures. For example, there are the liberty, individualistic-and-rights-oriented American constitutionalism, or the comparatively communitarian, and value-oriented European dignity jurisprudence. Also, it is not uncommon that there is a "elitist" concept when legal transplants of laws lead to a "divergence of law and society" and a gap between the legal elite culture and the culture surrounding the legal system.[12]

These different conceptions of human dignity have important influence on contemporary debates on ethics in the context of STI. [13] Empirical studies demonstrate the risk of new technologies such as AI in information and communication technologies, management algorithms and algorithms of digital platforms to violate human rights, to manipulate political elections and to influence decision-making in relation to nuclear war, climate change and other existential threats. While it is true that humankind has piled up a huge stock of scientific and technological knowledge, and they may contribute to promoting SDGs, serious ethical concerns arise when unintended effects risk new technologies to violate human rights and human dignity.

Recent initiatives at the United Nations are calling for "human-centred" approaches to ensure that emerging frontier technologies and innovations respect these ethical principles and ensure that progress in STI and harnessing STI for SDGs protects human dignity and contributes to progress in

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foundational moral principle: "Act only according to that maxim whereby you can at the same time will that it should become a universal law." Such an imperative is an absolute, unconditional requirement that must be obeyed in all circumstances and is justified as an end in itself.

[11] Human Rights 'Intrinsic' to Sustainable Development, Deputy Secretary-General Tells Human Rights Council, Stressing Need to Empower Youth | UN Press

[12] Li-ann Thio, 2022, "Human Dignity and Relational Constitutionalism in Singapore", in: Jimmy Chia-Shin Hsu Chapter 8, Ronald Inglehart and Christian Welzel, 2022, in: Jimmy Chia-Shin Hsu (2022)

[13] Christopher McCrudden, 2008, Human Dignity and Judicial Interpretation of Human Rights, in: *European Journal of International Law, Forthcoming;Oxford Legal Studies Research Paper No. 24/2008,* McCrudden :: SSRN

humanity. The Centenary Declaration of the ILO (ILC 2019) calls for a human-centred approach to the future of work "which provides decent work and puts workers' rights and the needs, aspirations and rights of all people at the heart of economic, social and environmental policies", while calling for a "human-in-command" approach to technological change.[14] The ILO therefore established a research agenda to explore the impact of digital technologies and artificial intelligence on decent work and respect for workers rights, as well as explore ways of using these technologies to promote decent work and employment, and thus, SDG8.[15] The UNESCO Recommendation on Ethics of Artificial Intelligence (2021) is calling for a human-centred approach to Artificial Intelligence, where AI must serve the greater interest of the people, not the other way around, international and national policies and regulatory frameworks must ensure that emerging AI technologies safeguard human dignity, fundamental freedom, and human autonomy and benefit humanity as a whole. Artificial Intelligence has social, technical, ethical and human rights impacts and raises moral and ethical issues regarding violation of workers and human rights. -OHCHR is developing Human Rights due diligence tools for technology adoption within the UN system.

The UNCTAD's Technology and Innovation Report 2021 discusses the risk of frontier technologies to widening existing inequalities and creating new ones, the increasing concern about the ethical principles that are shaping technological development and need to develop ethical frameworks to address these inequalities.[16].

A new Imperative of Responsibility

With the emergence of scientific and technological knowledge and the wide diffusion of frontier technologies, many disciplines recognised the need to rethink existing ethical frameworks and the moral principles applied to decision making and behaver related to STI. This need was derived from the fundamentally different nature of contemporary technologies and the consequences these technologies have on humanity. These new technologies raise issues which were unknown in all previous technological paradigms. In the following two major contributions to this debate are provided and some major elements of these new ethical frameworks are discussed.

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[14]. The decent work agenda rests on the four pillars of full and freely chosen employment, social protection, rights at work, and social dialogue. The decent work agenda became integral elements of the new 2030 Agenda for Sustainable Development. Goal 8 of the 2030 Agenda calls for the promotion of sustained, inclusive and sustainable economic growth, full and productive employment and decent work, wording which is taken up in the ILO Centenary Declaration (2019) calling for a human-centered approach to the future of work.

[15] See in particular the work on digital labour platforms, microtask workers and algorithm management.

ILO (2021), The role of digital labour platforms in transforming the world of work,World Employment and Social Outlook 2021

[16] The UNCTAD report provides a list of over 160 principles, guidelines, and frameworks which have been developed (see in Annex D). They do not endorse one single ethical principle. The report concludes "Translating these principles into policies for global governance will require cross-national harmonization while respecting cultural diversity and moral pluralism." Technology and Innovation Report 2021 | UNCTAD

Hans Jonas in' *The Imperative of Responsibility – In Search of an Ethics for the Technological Age* (1979) argues that the impact of contemporary technologies on the natural world and – most importantly, on humanity itself has been unprecedented, and therefore it is essential to discusses the relations between human knowledge, technological power, responsibility and ethics. He concludes that technology must be made into an ethical problem and that it requires a totally new contemplation on ethics. The ethical framework by Jonas adds to human dignity the obligation of human beings towards the environment and humanity.

Already during the 1970s, Jonas argues that science has progressively developed ever new and more powerful forms of technologies. While new technologies are imposed on the non-human environment and nature, and have seriously damaged nature, they also have the power to manipulate life and to threaten the essence of humanity. This calls for a new ethical framework for technologies. Traditional ethics on technology assumes human nature as a "constant" or unchangeable", while in contemporary technologies, human nature itself has become the subject of changing technologies. In addition, the new technological activities often have great reach, even a global one, affecting the nature and humans not only in the near, but also in distant places.

Huge ethical and moral problems have evolved with these new characteristics of technologies. They are extending the reach of human power beyond human ability to foresee the consequences. [17].. Given an indeterminate future for humanity, the cumulative, often irreversible and global effects of technologies, it is impossible for any human being to fully understand the consequences of new technologies. Jonas therefore argues that we therefore have the obligations toward all future generations to include them in our ethical reflections. In other words, the characteristics of the modern technological civilisation have changed the nature of our moral obligations. Jonas therefore added a new dimension to the concept of responsibility which is expressed in a reformulation of Kant's categorical imperative: «Act so that the effects of your action are compatible with the permanence of genuine human life».

This categorical imperative of responsibility also requires the preservation of nature because a person cannot be fully human without nature. Proportionate with the power of technologies to change the genuine nature of humanity, human responsibility ought to be increasing, adopting the moral principles of protecting the essence of human which has evolved in a natural process during many thousands of years. The challenging task of disciplines such as humanities and of philosophy in particular is to make this imperative work, and help the engineer, the practitioner, the manager, the entrepreneur, as well as political decision-makers to know how to abide by these moral values and norms. They should also help solve or at least mitigate conflicts among them.

There seems to be an urgent need to adjust ethical frameworks so that they are fit for these new technological paradigms which pose a threat not only to the essence of humanity, but also the integrity and cohesions of societies and stability of democracies and peace. While some governments

[17] Jonas, Hans (1984): The Imperative of Responsibility: In search of an ethics for the technological age. Chicago: Chicago University Press.
Hans Jonas's Ethic of Responsibility (sunypress.edu)

decided to ban the use of this technology (e.g., Italy), others think of putting them on hold further innovations and more advanced versions to give time to regulate this new tool.

New values and consciousness

The recent papal encyclical Laudato Si (Pope Francis, 2015) provides an important contribution to the current debate on the ethics of technological change by analysing the consequences of a "technocratic paradigm" (not technological!) which leads to a logic and science that attempt to control nature and assert power over it, assuming an infinite supply of goods and materials

The encyclical argues that throughout the past decades a technocratic paradigm has evolved which has a "tendency to warp our perception of reality and thereby lead us towards making mistakes - both moral and technical - in our interactions with the world. The technocratic paradigm tends to see all of reality as a problem awaiting an application of scientific and technological power". This technocratic thinking has led to a "modern anthropocentrism" where human beings place themselves at the centre of their life, give priority to immediate convenience, while all other relationships become irrelevant unless it serves one's own immediate interests. This anthropo-centrism and the technocratic paradigm seeking solutions for all problems in science and technology has resulted into a "cult of unlimited human power". Economic growth models, technological progress and globalisation promised sustained increase in productivity, income and human well-being. The encyclical argues that this technocratic paradigm has shaped a value system with destructive impact on nature, humanity and society.[18]

Erich Fromm has argued along similar lines in his book , *To Have or to Be*? Fromm, a psychoanalyst and philosopher,. distinguishes between two modes of existence. One can live one's life in the "mode of having" or in the "mode of being". The mode of having sees everything as a possession, while in the mode of being we perceive ourselves as the carriers of properties and abilities, rather than the consumers of things. Fromm identified a profound unhappiness of Western modern people as the result of a flawed economic system, based on capitalism, technological progress and an ideology promising "unlimited" happiness from consumption. This system forces people to emphasis material goods (the "having" of things) and to neglect the qualities of our characters (our "being" as persons).

The encyclical therefore calls for fundamental changes in values and consciousness, a new moral and new form of anthropocentrism. Laudato Si highlights the need for interconnectedness, arguing that life itself, nature and the planet are a gift for which humanity is responsible and this implies taking care of all people, animals, and nature (The subtitle of the encyclical is *On Care for our Common Home)*. Human beings need to recognise the intrinsic value of being connected with other people and with nature. He introduced the concept of integral ecology which requires "that human beings consider

[18] Pope Francis, 2015, Laudato Si: On Care for our Common Home, Vatican June 2015

Laudato si' (Praise Be to You)

duties of justice in terms of three relationships: to God; to human beings (and especially the poor); and to the earth itself.

As a common challenge, these approaches highlight the need for a shift in values which connects ethics with interconnectedness. Relationships and connectedness generates higher levels of consciousness.19 In other words, human beings need to shift in their belief paradigms, and to develop a new consciousness as the basis for redirecting scientific research, search for new solutions and innovations, changes in the economic models of production and consumption and in lifestyles, as well as changes in the established structures of power and governance. Wangari Maathai, the Peace [20] also highlights the need for humanity to "shift to a new level of consciousness, to reach a higher moral ground" as the basis for humans to take care of the environment.

Humanist educators stress the importance of instilling human values such as cooperation, dignity, self-responsibility, civism and social justice in human beings.[21]. Educators such as Paulo Freire, working in Brazil, viewed education as an emancipatory process of both building skills (such as literacy and digital literacy) and then, through critical dialogue among learners and with educators, conscientização – consciousness.

4. Intellectual and psychological resources: Capabilities to shape the process of STI

While section 2 of this paper reviewed the normative or ethical dimension of a human-centred approach to STI, this chapter explores the role of human beings in shaping the process of science, technological change and innovations. Despite the fact that human beings are critical in processes of change, their role is yet insufficiently recognized in models and theories which frame the discussions. Human beings are the source of new ideas and knowledge, and they have the ability to imagine future states, set goals and find ways to achieve them. They build up knowledge, and develop psychological resources which enable them to influence the dynamics of STI processes.

The debate on STI for SDGs often neglects these aspects of human beings. Too many framings take an instrumentalist view of humans. However, creativity and innovation frequently does not only result from narrowly goal-oriented or efficient human behaviour, but also from curiosity, playfulness, and affective states such as joy and flow – traits of humans which are not best understood from an instrumental perspective. Also, economic models assuming uncertainties, imperfect information or risks in the analysis of technological change avoid modelling the role of intrinsic human capacities and

[19] Laudato Si: p. 88;
encyclical-instructors.pdf (scu.edu)
[20] Kenyan professor and environmental activist, peace Nobel prize winner,
Maathai, W. 2012, p 8-11,
Speech held during the Nobel Prize ceremony, Stockholm,

[21] Schunk, D.H., 2014. Learning Theories: An Educational Perspective, 6th Edition, 6th ed. Pearson.

cognitive capabilities in causing "imperfections" and how human imagination and ingenuity could help to provide solutions. Human beings are assumed to be rational or bounded rational and optimising individuals or they are modelled as human capital, but not as human persons.[22] Political economy explore the role of power and institutions in explaining the dynamics and outcomes of the STI process.

The following sections provide insights from various strands of the literature on the link between the nature of human beings and progress in science, technology and innovations. Insights from cognitive science, psychology, pedagogy, neuroscience, and anthropology provide evidence for the role of cognitive, psychological, and intellectual resources of humans in shaping the dynamics of change and progress of humanity. This literature explores the specific nature of human beings and innate traits of humanity as the primary force of progress and change. These innate traits and the acquired capabilities are non-trivial as they are the power which allowed the species of homo sapiens to survive through innovations.[23]. Since these capabilities enable human begins to improve, solve problems and make progress, we call them dynamic capabilities. It is important to note that the concept of dynamic capabilities is different from the human capability approach developed by Amyarta Sen.[24]

And because these capabilities are acquired and shaped by the environment, they need to get explicit attention in the analysis of policies to promote the dynamics of STI and to harness STI for SDGs. 25 .

Human beings as the source of ideas, knowledge and innovations

The specific traits of human beings allow people to build those psychological resources which are needed to drive change, new technologies, new solutions and increasingly complex innovations. These innate traits are the sources of creativity and innovation. Philosophy began to explore the specific human nature more than 2000 years ago. It identifies cognitive capacities as innate human traits. Characteristics such as curiosity, playfulness, and inquisitiveness emerge spontaneously in children from birth, they are innate, and they enable human beings to learn, make progress and develop capabilities.

Anthropologists explore the evolution of human-specific traits by comparing the homo sapiens to other hominids. The growing size of the brain in homo sapiens allowed the evolution of increasingly complex reasoning abilities, the production of cultural and technological artefacts, assigning symbolic values to objects and innovations, and creating art for its own sake. These abilities make human beings exceptional in the sense that change became the norm.26. Anthropologists argue that human beings

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[22] COVID-19 Vaccine Refusal among Nurses Worldwide: Review of Trends and Predictors - PMC (nih.gov)
A prime example is the recent COVID 19 vaccine refusal by significant share of the population in many countries came to the surprise of most experts and politicians

[23] Yuval Noah Harari, 2015 Sapiens – A Brief History of Humankind
Sapiens - Yuval Noah Harari (ynharari.com)

[24] Sen's concept focuses on the choices human beings have to live the life they value.

[25] Peter J. Richerson and Robert Boyd, 2005 Not by Genes Alone: How Culture Transformed Human Evolution

[26] The traits that make human beings unique - BBC Future

were able to develop complex languages because they have innate capacities to build complex languages, develop different languages such as to process information, and these innate capacities are given by birth. In a similar manner, humans are unique in the level of abstractness and to reason about other people's ' mental states. This capacity enables human beings to link their minds together, to cooperate, to rely on each other, and thus to establish cognitive capabilities which are fundamental for undertaking research and development of new technologies.

Psychologists and biological anthropologists explore innate traits which enables humans to accumulate knowledge, maintain technologies and innovations over time and to increase complexity.27 Increasing complexity of technologies requires the capacities of humans to collaborate with other humans, cooperate and connect their brains. Humans have the ability to organise cooperation and to develop complex strategies to work towards goals and solutions. This is a unique form of human intelligence which supports change and innovations. Another innate capacity highly relevant for innovation capabilities is the ability to break down tasks and innovations, decomposing tasks into constituent parts, and manipulating these parts in a variety of ways. They allow humans to learn and acquire the psychological resources and the physical competences to manipulate, mix and match various component parts of tasks, and "to imaginatively, as well as physically, try out the combinations and permutations of various innovations".[28]

This literature has important implications for different learning models, education and training to nurture human capabilities to develop and mobilise creativity and to innovate. Sennett (2002), a cultural sociologist, describes a learning model to build such innovation capabilities in individuals. Sennet argues that each human beings has the intrinsic desires to perform tasks well for their own sake. Sennet calls this "craftsmanship". While the desire is intrinsic, craftsmanship, however, has to be developed. Individuals need to learn both, the skills needed to perform jobs at high level, and the mindsets to improve and innovate "even when repairing". Sennet argues that humans create new things by interacting with their environment, and through slow, concentrated and repetitive interaction with their environment they acquire manual and cognitive skills and competences.

Moreover, Sennet argues that this type of learning is profoundly stabilizing the individual, and it shapes skills, behaviors, principles and values including commitment, pride and self-respect, discipline and upholding objective standards. As a result, craftsmanship becomes a source of self-worth, imagination, creativity and innovation. It is important to note that Sennet relates the concept of craftsmanship to all occupations and activities, not only in the crafts sector. However, the crafts sector has historically applied this learning model in their apprenticeship systems.

Another field, modern neuropsychology, explores the cognitive processes underlying creative performance. Studies explore the relation between creative cognition and creative drives Mednick

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[27] Andrew Buskell, https://www.lse.ac.uk/philosophy/blog/2016/03/03/what-makes-humans-special/

[28] Richerson, P. & Boyd, R. (2005). Not By Genes Alone: How Culture Transformed Human Evolution. Chicago: University of Chicago Press.

Henrich, J. (2015). The Secret of Our Success: How Culture is Driving Human Evolution, Domesticating Our Species, and Making Us Smarter. Princeton: Princeton University Press

Tomasello, M. (1999). The Cultural Origins of Human Cognition. Cambridge, MA: Harvard University Press

(1962) identified the capacity of associative thinking which was not directed to any specific field of application such as art or science, but instead, it was viewed to define processes underlying all creative thought. Creativity is therefore not only a cultural or societal construct but is essentially a cognitive process (Bass et al. (2015). Moreover, this literature finds that creativity is influenced by the state of emotions, motivation, rewards and other factors such as mood states, regulatory focus, and social interaction. Dopamine, noradrenaline and serotonin are found to impact on the interplay between creative cognition and creative drives.29.

This research shows that creativity is not only a cognitive process based on innate capacities. It is mobilized and driven by an environment which mobilizes psychological resources and supports high motivation, provides rewards to creativity and generates a conducive environment which supports human interactions and supportive mood states. This relates to the learning process at schools, in enterprises and in communities and the important role of creating an environment where young people learn to enjoy learning, are rewarded rather than punished, and making mistakes is seen as part of the learning process. A human-centered approach to STI takes a holistic view of the learner as a human being with intrinsic dignity rather than human capital that is to be shaped. Curiosity, joy in learning new things and creativity should be fostered, and this requires relationships and affective dimension of the learning process to be nurtured and being free of fear. The humanist perspectives to education have centered the human being and have framed the learning process as a holistic process which affects behaviours, thoughts and feelings of learners.

At the workplace, the development of dynamic capabilities is about building trusted relationships and providing decent work, and respect workers' rights and dignity to motivate workers to improve and innovate, and to mobilise creative drives. It is central for young workers to work in teams with experience workers who are role models and thus shape dynamic capabilities. Schumpeter highlights the need to build social institutions that reward innovative behaviour and entrepreneurship.

Exerting human agency: being in the driver's seat

Human agency represents another capability which plays a central role in innovation and change. While the previous section focused on human beings as the source of knowledge, creativity and innovation, human agency describes the ability of a person to shape the environment and to make meaning of the environment through purposive, conscious, reflective and creative action (Houston, 2010).. The concept of human agency in the context of technology and innovations reflects the notion of human beings "in command of technological change", and being in the "driver's seat", and that human beings rather than markets, robots and algorithms are in command of technological change.30 A prevailing theme related to Artificial Intelligence (AI) regulation has been the empowerment of users to help them gain control over their lives involved in AI-enabled processes. .31

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[29] Radwa Khalil , Ben Godde and Ahmed A. Karim, 2019; Frontiers | The Link Between Creativity, Cognition, and Creative Drives and Underlying Neural Mechanisms (frontiersin.org)
Creative cognition relates to cognitive flexibility, inhibitory control, WM updating, fluency, originality, and insights.
[30] Future of Work Commission (2019). Work for a brighter future. Geneva: ILO.
[31] The European Commission High-Level Expert Group on Artificial Intelligence (AI HLEG 2018) defines 'human agency and oversight' as the first of seven key elements in their "Trustworthy AI" framework..

Psychology developed a theory of human agency to explain how agency becomes an important psychological resource to drive change and innovations32. Human beings possess the innate capacity of self-organising, self-regulating and self-reflecting. These traits enable them to construct, evaluate and modify alternative courses of actions and thus to secure aspired and valued outcomes, and to also override environmental influences and resistance. This made humans unique in their power to shape their life circumstances and the course of their lives.

Social cognitive theory explores human agency as a determinant of creative performance of individuals. It argues that humans have evolved the innate capacity for observational learning which allows humans to develop self-efficacy as the most distinct capability which determines human agency. Self-efficacy is an individual's belief in his or her capacity to execute behaviors necessary to produce specific performance attainments. Self-efficacy reflects confidence in the ability to exert control over one's own motivation, behaviour, and social environment. Unless people believe they can produce desired effects by their actions, they have little incentives to act or to persevere in the face of difficulties.

Bandura makes the distinction between the role of inherent human capacities and the role of culture in shaping the psychological resources that allow individuals to exert agency. He argues that beliefs about self-efficacy emerge in a learning process in transactions with the environment, guidance through families and teachers and private reflection on one's experience. Most importantly, he argues that his learning process takes place regardless of the culture in which humans reside. The cultural context is shaping the ways in which agency is exercised, and the purposes to which they are put, but it does not shape the evolution of agency itself.

Capabilities to exert human agency and to shape and steer innovation process cannot be "taught". Rather, it is the role of the teacher to shape the learning process so that students can develop self-efficacy and agency. Teachers become "crafters of an environment that supports learning" (Schunk 2014), where learners feel nourished and free to explore, experiment, make mistakes and problem-solve – in other words, to innovate. This experience for self-fulfilling learning grows learners' psychological resources of self-confidence, self-efficacy and motivation, which in turn strengthen their innovation capacity. For STI, it is essential that the learning process normalizes mistakes and makes failure, analysis and retry an accepted and valuable part of learning. Since learning also has important affective dimensions and learners' psychological resources need to be fostered, it is important to adopt discursive and classroom practices which frame failure in a way that does not dent learners' sense of self-confidence and self-efficacy.

Michael Polanyi, a biologist who expanded his work into anthropology and philosophy to gain a better understanding of how human beings learning to perform tasks in a "smart" manner. (Polanyi (1958) He introduced the concept of tacit knowledge to explain that humans learn to master a task by initially practicing the task consciously, but eventually developing procedures which move from the conscious to the sub-conscious level of human awareness. This innate capacity of moving procedures to the sub-conscious level relates to all types of performance, such as playing the piano, riding a bicycle,

[32] Bandura (2006) Towards a psychology of human agency (free.fr);

undertake surgery, and performing innovation activities. High performance of tasks is based on smart tacit procedural knowledge which can only be developed in a long process of practicing.33

Human agency allows individuals to shape their own destiny effectively and to be active participants in the process of change rather than being passive recipients. The recent discussion on using new technologies and innovations and data for urban development and developing Smart Cities highlights the need to develop human agency. When the concept of Smart City gained traction some years ago, cities around the world began investing in sensors, data analytics, and other technologies to monitor and manage everything from traffic flow to energy consumption. However, many early smart city initiatives were criticized for focusing too heavily on technology, without sufficient consideration for the needs and priorities of residents. It was recognized that in order to move to community-led and people led innovations, individuals need to acquire the agency to engage in the initiatives. People-led approaches seek to empower residents to participate in the design and governance of smart city initiatives, to build agency of communities to implement innovations.

Schumpeter has developed a theory of innovation which highlights the important role of entrepreneurs and entrepreneurial spirit in creating new ways doing things, and in overcome the psychological and social resistances which stand in the way of doing new things. If entrepreneurship is so important for creating a dynamic process of STI, the question is what determines entrepreneurship and how can we boost entrepreneurial spirit. According to Schumpeter, the entrepreneur demonstrates the personality traits of a leader. People differ in "entrepreneurial spirit" because social institutions which reward entrepreneurship contribute to developing these characteristics.34 This human-centered concept of entrepreneurship or knowledge-based concept of entrepreneurship shows that the wide diffusion of entrepreneurial spirit in a society is a reflection of the socially shared knowledge and beliefs, and the institutions in a society to reward and promote entrepreneurship.

Human decision making, choices and behaviour

Finally, human human beings play an important role in STI by making decisions. Choices have important implications for investment in science, the uptake of scientific findings by policy makers, the direction of technological change, the diffusion of innovations, the purpose of change and the nature of innovations and of institution to distribute benefits from new technologies. One important question in the innovation debate is why new technologies are adopted by some and rejected by others, and why innovations are resisted despite being a better alternative to existing ones?

While the neoclassical models assume choices to be rationality or bounded rational, new models are discussed which provide alternative framings of human choices which are relevant for STI. These models take into account that decisions making in the context of innovations take place under uncertainty and high complexity where future "landscapes" are unknown.35 In these situations,

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[33] 1946 Riddell Memorial Lectures at Durham University published as *Science, Faith and Society.*
1958:, based on Polanyi's 1951 and 1952 Gifford Lectures (Scott and Moleski 2005, p. 203ff.).
In *Personal Knowledge: Towards a Post-Critical Philosophy, Polanyi* challenges the philosophical model of knowledge and

[34] *Professor Schumpeter's Theory of Innovation (jstor.org)*

[35] A Behavioural Model of Rational Choice on JSTOR

decision making is much more a process than an event, and it is therefore important to recognise the complexity of decision making in an STI process, and the many factors which influences choices relevant for harnessing STI for SDGs.

Behavioural economics and game theories in economics challenge economic models which assume that all people are exclusively pursuing their material self-interest and do not care about ''social'' goals per se. 36. Experiments show that individuals make "non-rational" choices when they feel treated in an unfair manner, or when they lack trust in the reliability and quality of the innovation. The hesitation of many consumers to get the COVI 19 vaccination provides a recent example.

Neuroscience, cognitive science and psychology discuss biases in choices and decision-making process. They find that humans have "priors" - the innate capacities of human brains - which allows "human sapiens" to build mental models and choice architectures. These mental models constrain information flow and choose most essential information in each situation by inductive bias.37 Thaler and Sunstein provide empirical evidence for the bias and argue that the design of these choices architectures is not neutral. Such choices are influenced by cultural, social or institutional expectations38 ,which implies that Governments are challenged with transforming such cultural and socially shared belief systems where the urgency to achieve SDGs requires the transformation of belief and value systems for new choices, demand and adoption of technologies and innovations.

Behavioural innovation economics – an emerging field of research – is applying the insights of behavioural insights to innovation economics. This literature finds that it needs lateral approaches and combined measure – which resonate with cultures, demonstrate empathy and provide narratives which reach emotions of people in addition to measures such as incentives or legal enforcement.39 Case studies show that trying to devise effective policy purely on a technical basis, such as with a narrowly bounded economic model or with engineering science, may therefore not be successful (e.g. selecting the location for wind turbine based only on wind-efficiency criteria without taking into account the situation of people living in this location). In other words, when decision makers and those affected by the consequences of policies live in different realities, policies may fail to achieve the goals because behaviour of those affected may be different than expected or assumed by policy makers.

Simon introduced bounded rationality and satisficing as analytical constructs to substitute for the unrealistic neoclassical assumptions of unbounded rationality and maximizing/optimising.

A Behavioral Model of Rational Choice

Herbert A. Simon, 1955, The Quarterly Journal of Economics, Vol. 69, No. 1 (Feb., 1955), pp. 99-118 (20 pages)

[36] Work by Nobel Prize laurates Daniel Kahneman and Amos Tversky showed the many external and internal forces shaping people's decision making and behaviour.

[37] Denzau and North 1996 discuss mental models to be shaped by own experience and interaction of the individuals with the environment, and they are shaped by beliefs which are provided by society. This explains similarities in individual choices in social communities.

Denzau and North 1996 Shared Mental Models: Ideologies and Institutions, in:KyklosVolume 47, Issue 1 p. 3-31

[38] such as human tendency to strive for consistency and status quo rather than to continuously search for, and embrace new ideas, products and services

[39] See Jason Potts, Behavioral Innovation Economics, in Roger Franz (ed) Handbook for Behavioural Economics.

Human choices also play an important role in creating a new technology, and in developing AI tools such as algorithms that help managers to make choices. While algorithms are performed by computers, they are developed by human beings. Human beings make choice in the analysis, design and coding of these algorithms and the data used by algorithms. While humans will always make errors randomly, there may also be systematic biases, and these are the result of choices, which may enter in a subtle and unconscious way, and AI then automates and perpetuates these biases. Algorithmic bias describes systematic and repeatable errors with unfair outcomes, and the increasing complexity of algorithms (made worse with recent moves into machine learning) can undermine systematically justice and fairness, in both processes and outcomes (Henman, 2021)40

A major consequence of such experienced biases may be a loss of trust of people in digital technologies, and this will have important consequences for their willingness to use AI technologies and act upon decisions in which AI was involved. The challenge is to generate responsible approaches to develop algorithms for AI, to build trust in AI tools and its wide adoption to provide solutions for SDGs. 41

5. Conclusion

The framework for analysing how to best develop and harness science, technology and innovations for SDGs needs to provide space for the key role of human beings in this process. This is suggested by the review of literature in different disciplines whose subject matter is the cognitive and non-cognitive properties and resources of human beings, and the channels through which they generate novelties. Also, the moral compass represents an important capability of humans in driving STI. Such dynamic capabilities are key for each country to promote STI. In the context of developing countries which often transfer technologies using models of catching up, building dynamic capabilities prepares the way for endogenous technological development and innovation paths, which in turn contributes to learning and the development of domestic dynamic capabilities.

It requires a multi-disciplinary approach in order to fully understand the complex process in which human beings develop dynamic capabilities as the foundation for transformative change. As a common thread running through this human-centred literature is the insight that the human nature is characterised by innate traits, and that these traits enable humans to build psychological resources, personality traits, and intellectual skills within their cultural, social, economic and institutional environments. These capabilities reside in knowledge structures, in procedural knowledge, in mental models or choice architectures in the human mind.

For societies to accelerate scientific research, technological change and innovations for SDGs, it is key to take an inclusive approach and to develop dynamic capabilities in all people within a society, not

[40] Paul W Fay Henman, 2022, *Digital Social Policy: Past, Present, Future*.in Journal of Social Policy 51(3):1-
Available from: https://www.researchgate.net/publication/359298716_Digital_Social_Policy_Past_Present_Future

[41]The literature discusses a wide range of measures such as increase diversity of coding teams, establishing governance and controls, continual monitoring, creating awareness among IT teams, transform beliefs.

just in an elite group. It is not the Silicon Valley entrepreneurs building "unicorns" who drive STI for SDGs, but a society in which all human beings have the opportunity to develop dynamic capabilities. This implies building intellectual, cognitive, affective, emotional and psychological resources to shape innovations and to build their moral compass by sharing moral values which raise consciousness to care for the nature, and to act responsibly for themselves, for their community, and for people even in distant places.

This human-centred approach has been already reflected in the preamble to the ILO Constitution (1919), one of the first international organisations and specialised organisation within the United Nations system, by stating that "Labour is not a commodity". [42] It draws attention to the intrinsic value and dignity of each worker, recognising the content and meaning of work. From a dynamic perspective, this statement, however, also refers to the notion of human beings as the source of creativity and agency in the world of work. Human beings respond to disruptive labour market effects of new technologies by searching for new opportunities, mobilising creativity, and inventing activities around the new technologies. Only when people are enslaved are they degraded to a commodity because they are deprived of their dignity, creativity, agency, and free will.

Policy makers need to rethink the models and frameworks they use for the design of policies to support and harness STI processes. Developing dynamic capabilities needs to be a central goal of strategies to harness and accelerate progress in STI. It calls for new policies in all different domains because learning for capabilities is not limited to particular places or time. They are acquired in a particular context in many different ways: through own experience, learning and socialisation in families and communities, learning from others by working in teams, through teaching in schools, and training in institutions and at the work place. Teaching methods, pedagogy and the learning environment are critical, young people are socialised into innovative thinking and acquire the competences by working with experienced workers in apprenticeship training; the pattern of diversification in the economy, the mix of products and production methods determines the mix of knowledge workers acquire at the workplace. Hence, strategies to promote learning for dynamic capabilities need to embrace education, training, technology, industrial development, trade, procurement and employment policies. Teaching ethical principles and liberal arts in schools and discussing these issues in families and communities shape value systems of human beings, and their consciousness and sense of responsibility.

Further research is needed to deepen our understanding and inform policies on human-centred strategies for promoting and harnessing science, technologies and innovations. A new research agenda is required to direct funding towards interdisciplinary work at the theory, policy and case study levels, and to provide platforms for connecting multi-stakeholders in research, policy, member states, business and civil society.

[42] It has been affirmed by the Declaration of Philadelphia (1944).