1 Evaluating the Impact of Convergence – Towards a Guidance Framework for Future Policy Assessment

1.1 Introduction

This paper describes the background motivation of the OECD Working Party on Biotechnology, Nanotechnology and Converging Technologies (BNCT) to develop and conduct a project on 'Harnessing Convergence for the Next Production Revolution'. The paper outlines the development of the BNCT approach for the impact assessment of emerging technologies and their policies.

Having commenced in January 2017, the BNCT project and the approach developed within it will undergo a proof-of-concept as part of the conduct of the two-year project. The oucomes of the project will be evaluated against the objectives of the project and the milestones of the approach.

1.2 Background

The concepts of 'Convergence' and the 'Next Production Revolution' (NPR) (AKA 4th Industrial Revolution, Industry 4.0, Next Generation Manufacturing) help signify a number of key technological developments with far-reaching social implications. These include the harnessing of machine learning algorithms for industrial production, the exploitation of bio-engineered resources and bio-inspired processes in large-scale industrial processes, and the co-ordination of increasingly complex activities across physical and digital systems. The advancement of the 'internet of things' (AKA cyber-physical systems (CPS)), the use of Big Data into diagnostic machine-learning algorithms, as well as the increasing use of behavioural and social data patterns in CPS (known as CPS2), for example, are likely to exert a deep influence on the patterns not just of production but of everyday life. The potential societal, economic and environmental impacts are recognised to be far reaching.

The OECD BNCT role in conducting analyses of national policies and inconvening discussions between national policy makers plays an important part in the preparation of governments for the advent of the convergence and NPR: as policies dedicated to fostering convergence and CPS2 proliferate, there is value in comparing frameworks used in different countries to ensure that sustainability, privacy and well-being (including economic well-being) are optimized.

1.3 Methodology - Policy Assessment of Emerging Technologies

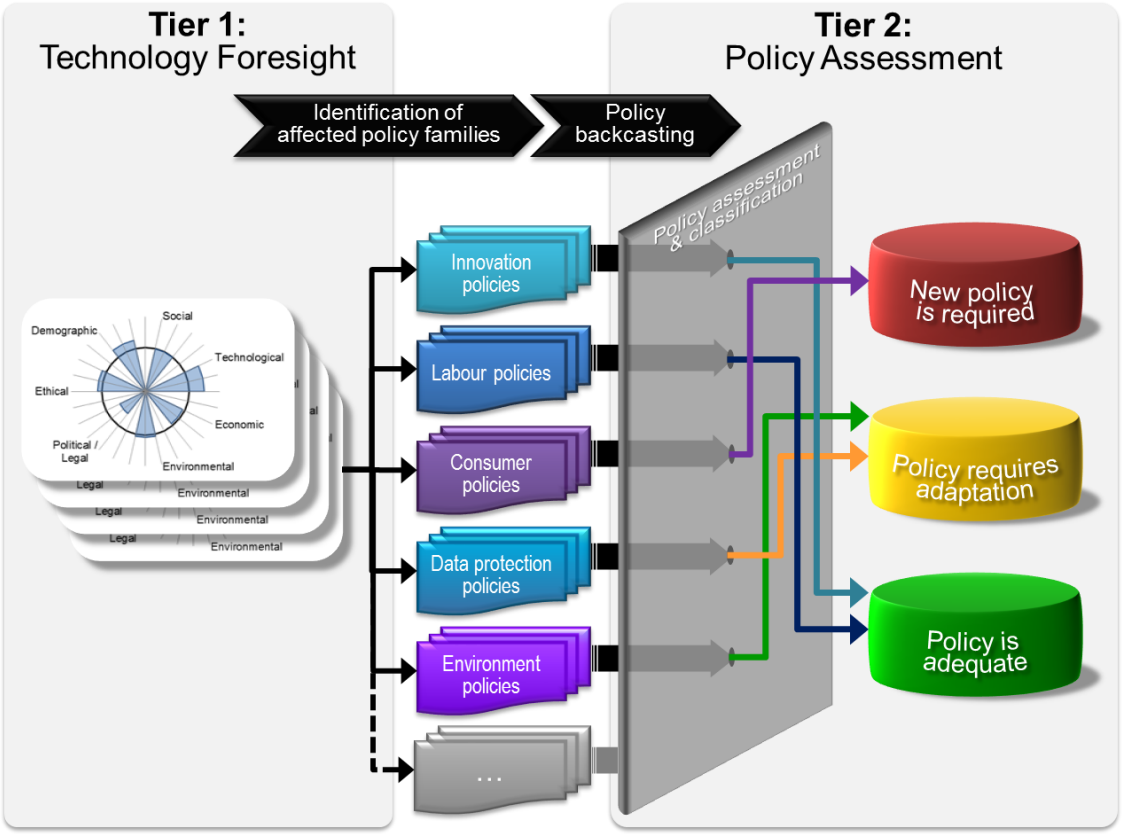
In its project on 'Harnessing Convergence for the Next Production Revolution', the OECD BNCT has now set out, in order to assess both the impact of technologies undergoing a convergence and the impact of policies affecting those technologies.

1.3.1 A two-Tier Approach for the Impact Assessment of Technologies and their Policies

In order to assess both the impact of technologies undergoing a convergence and the impact of policies affecting those technologies, a two-tier approach has been developed. In both tiers, the need for non- traditional approaches of assessment coming from the social sciences and humanities (SSH) and the concepts of responsible research and innovation (RRI) is given specific consideration.

Figure 1 illustrates the overall structure of the BNCT two-tier approach for impact assessment of technologies and their policies.

Figure 1. Illustration of the BNCT two-tier approach for the impact assessment of technologies and their policies.



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Tier 1: This stage of the project is centred around **Project Workshop 1**, where a technology foresight exercise will be conducted, which combines elements of Technology Assessment (TA) (i.e. in particular the elements of "Scenario Workshops" and "Co-operative Discourse" (Decker and Ladikas, 2004), during which experts of humanities and social science will be asked to conduct critical reviews). This step follows the "Scientific Foresight" approach developed by the European Parliament Research Services (EPRS) (EPRS, 2015), in order to identify expected impacts of each one of the

three concrete Technology Application Case -Studies, especially regarding, economic, social, environmental aspects.

Tier 2: This stage of the project is centred around **Project Workshop 2**, where a policy assessment will be conducted, based on the findings of Tier 1. The main policy families concerning the impacted sectors and stakeholder groups identified in Tier 1 are assessed with regard to their applicability to an increasingly complex and converging technology landscape. A detailed policy assessment is conducted on each one of the three technology cases, with a view to evaluating if a generic policy family is adequate, or if adaptations are likely to be required, or if a new policy needs to be developed, in order to cover the advent of convergence. In order to sufficiently illustrate the Case-Studies policies, specific jurisdictions may be selected.

The ultimate outcome of the assessment will be a guidance framework for a future policy assessment that is sufficiently flexible to accommodate rapid technological advances.

1.4 Conduct - Policy Assessment Tier 1: Technology Foresight

As a first step of the BNCT's approach for policy assessment of emerging technologies, a technology foresight is conducted, in order to identify those aspects that will be impacted by the technology in question, in order to subsequently ascertain the policies that are governing the relevant areas.

The technology foresight exercise proposed for this purpose builds on the "Scientific Foresight" approach developed by the European Parliament Research Services (EPRS) (EPRS, 2015). In order to include aspects of social sciences and humanities (SSH) and the concepts of responsible research and innovation (RRI), which are often missing in traditional assessment approaches, the exercise has been combined with elements of Technology Assessment (TA). In particular, this approach draws on the elements of "Scenario Workshops" and "Co-operative Discourse" (Decker and Ladikas, 2004), during which experts of humanities and social science will be asked to conduct critical reviews.

The methodologies of "Horizon Scanning" and "360° Envisioning", proposed by EPRS in 2015, have been further developed, in order to provide a comparative technology foresight exercise: the original guiding framework of STEEPED (Social – Technological – Economical – Environmental – Political/Legal – Ethical – Demographic) aspects has been detailed by a number of attributes assigned to each aspect. Table 1 lists the original descriptions and newly assigned attributes of the STEEPED aspects.

Table 1. Original description of STEEPED aspects (according to EPRS, 2015) and detailing attributes assigned to each aspect.

Description of STEEPED aspects	Attributes detailing each aspect
Social aspects cover changes in social and cultural values and lifestyles.	Inclusivity (intra-national)
	Inclusivity (inter-national)
	Network effect
	Privacy
	Social capital / community engagement
	Equality
	Behavioural changes
	Lifestyle

Description of STEEPED aspects	Attributes detailing each aspect
Technological aspects include how, and in which directions, technology is developing and the diversification of the use of techno-scientific devices.	Innovativity Problem-oriented Accessibility Single-use only (i.e. non-abusability) Efficacy
Economic aspects cover issues related to conjuncture, production systems, different distribution and trade systems, and consumption of goods and services.	Jobs / job creation Value creation Infrastructure independence Skills transferability Affordability Equality within countries Equality across nations
Environmental aspects embrace interactions with our natural habitat and our biophysical environment which is our planet. This category also includes the availability of natural resources.	Resource efficiency Energy efficiency Water efficiency Recyclability Product safety Process safety Environmental quality
Political/legal aspects describe developments or changes in various policy-making and legislative systems or forms of governance.	Market liberty Market coordination Competition Cooperation Democracy / collective choice Liability Individual rights
Ethical aspects cover individual preferences about the diverse values embedded in the broader society.	Autonomy / individual freedoms Access to technology Individuality (incl. disability) Distributive justice Respect for persons Respect for the environment Collective well-being
Demographic aspects entail various aspects of society, looking at the society as a collection of a varied set of social groups based upon parameters such as age, gender, religion, origin, profes-	Age Gender

Description of STEEPED aspects	Attributes detailing each aspect
sion, education, income level, etc.	Origin / ethnicity
	Religion
	Education
	Profession
	(Dis)abilities
	Income level
	Skills

During the technology foresight exercise conducted at **Project Workshop 1**, experts will be asked to judge, whether an aspect attribute is likely to be impacted by a specific technology application in question, and, if so, whether the impact is likely to be positive or negative compared to the current status of the attribute.

1.4.1 Three concrete Technology Application Case-Studies

In order to allow focused discussions during thetechnology foresight exercise at **Project Workshop 1**, three concrete Technology Application Case-Studies have been selected and a detailed application scenario has been described for each one of them. These three concrete **Technology Application Case-Studies** have been chosen to cover different technology-readiness-levels (TRLs) from (a) starting to be deployed (high-TRL: 5-10 years), to (b) still undergoing tests but about to be widely applied (medium TRL: 10-15 years), to (c) technological feasible and widely deployable in the long term (low-TRL: >15 years):

- **Robots in consumer-goods manufacturing** as a high TRL example of automation and robotics in the manufacturing environment) (e.g. sensors, autonomous systems, machine learning algorithms): these technologies are already widely used in industry, but they are also continuously advancing through technology convergence, and their applications are increasingly widened to new application areas of NPR),
- **Autonomous vehicles** as a medium TRL example of Cyber-Physical and Social Systems (CPS2) (e.g. a technology or service that is based on digital algorithms and that makes increasing use of individual data on behavioural and social patterns), and
- **Cyborgs** (i.e. human cogno-info implants) as a low TRL example of functional human-machine interfaces (e.g. personalised regenerative engineering, chip-implants, human enhancement, etc.).

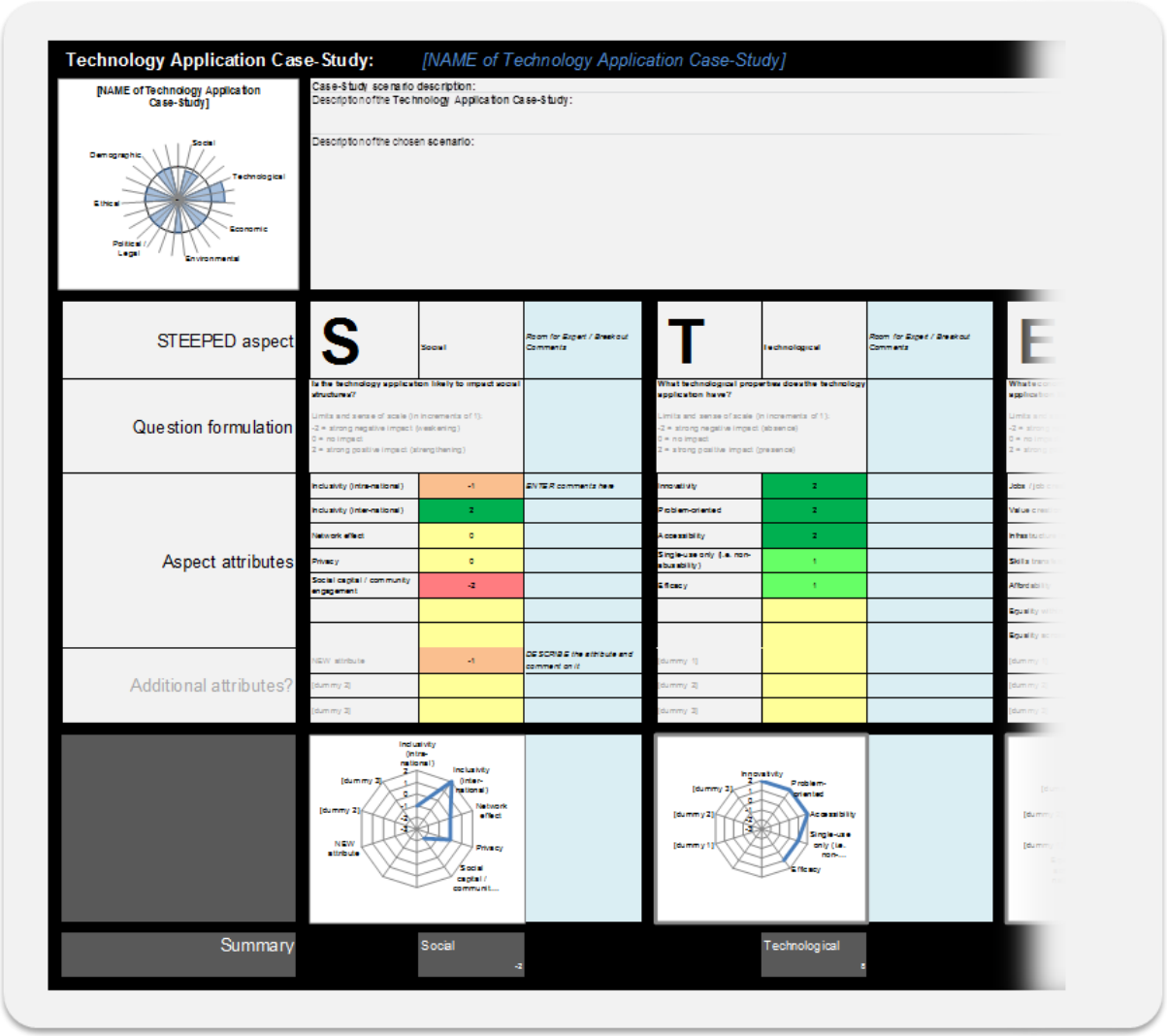
Ahead of the workshop, each case-study will be prepared by the invited experts; each expert will be asked to complete a technology foresight matrix, which lists all STEEPED aspects and attributes, and allows the expert to assign a value between -2.0 and +2.0 (in step-sizes of 0.5) to each attribute, automatically generating radial (‘spider net’) diagrams for each aspect and a summary diagram for the entire Technology Application Case-Study.

This semi-quantitative approach to technology foresight allows workshop participants of varying backgrounds and expertise to discuss and compare their findings and opinions on the Case-Study during the scenario breakout group at the co-operative discourse workshop.

Figure 2 below shows an excerpt of the technology foresight matrix, which all workshop experts are asked to complete for their assigned Technology Application Case-Study prior to the meeting, with a

view to discuss and refine their findings and opinions during dedicated breakout sessions at Project Workshop 1.

Figure 2. Excerpt of the technology foresight matrix. (NOTE the excerpt shown has been completed with an example case-study of '3D Organ Printing' (low TRL) for illustration purposes.)



1.4.2 Preparations of Tier 2: Draft Policy Identification and Initiation of the Policy Backcasting

In order to facilitate the transition from technology foresight to policy analysis, breakout-groups are asked to complete a 'Policy Identification Exercise', if all of the above tasks have been completed and breakout session time allows.

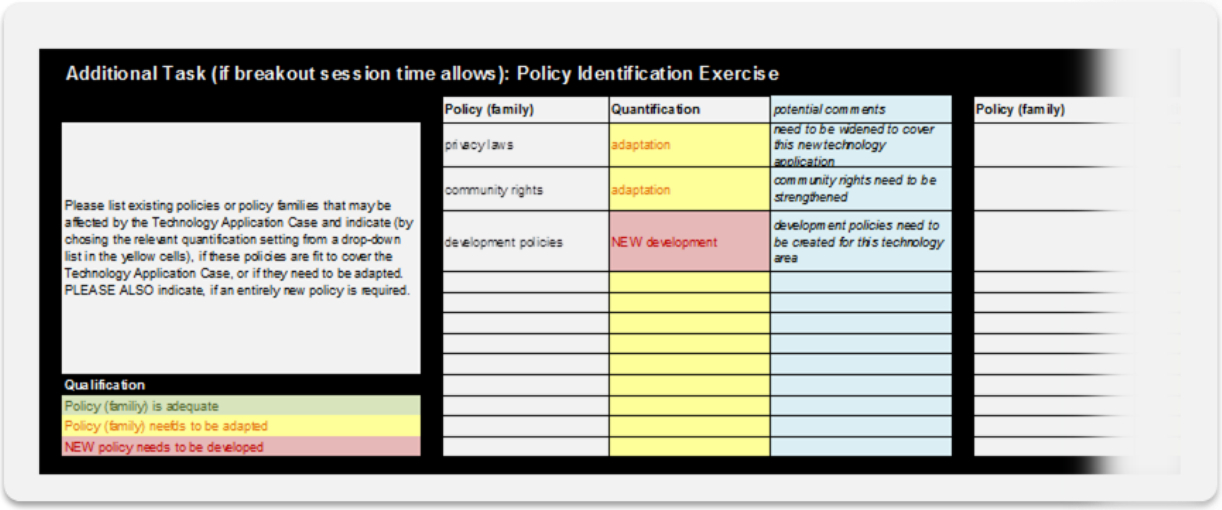
The exercise asks for a listing of those policies (or policy families) within the relevant STEEPED aspect that may be affected by the technology application case.

Experts are asked to enter a descriptive name of the policy (family) into the relevant cell, and to subsequently give a qualitative judgement (by choosing from a drop-down list in the yellow cells) (see below), if

- ‘**no action’** is required, because the policy is adequate to cover the implementation of the technology application case, or if
- policy ‘**adaptation**’ is required, because the existing policy is not adequate to cover the implementation of the technology application case, or if
- the ‘**NEW development**’ of a policy is required, because the relevant STEEPED aspect or attribute is currently not covered by a policy.

Figure 3 shows an example of the Policy Identification Exercise, which participants of Project Workshop 1 are asked to conduct (if breakout session time allows).

Figure 3. Excerpt of the policy identification exercise. (NOTE the excerpt shown has been completed with an example case-study of ‘3D Organ Printing’ (low TRL) for illustration purposes.)



(Source: authors’own creation)

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