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Intellectual Property Rights, Climate Technology Transfer and Innovation in Developing Countries

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Abstract

Does the current international Intellectual Property Rights (IPR) system inhibit or promote climate technology transfer and innovation in developing countries? This study summarises insights from a systematic review of the theoretical and empirical literature and 20 semi-structured interviews with key innovation experts (entrepreneurs, IP officials, and policy makers) in four developing countries (Bangladesh, Kenya, India, and South Africa). We identify three areas where IPR systems may matter: (1) climate technology transfer from foreign countries, (2) indigenous innovation by domestic inventors, and (3) follow-on adaptive innovation building on imported technology.

Our results show that the relevance of IPRs in the climate context is likely overstated and the discussion focus on IPRs is often perceived as distracting rather than helpful. Inventors in developing countries are frequently not aware of IP systems. There is insufficient evidence that weak IP systems hinder (climate) technology diffusion when market opportunities are sufficiently high. Further, most mitigation technologies needed in developing countries are old, low-tech, or nature-based, and IP protection does not play a significant role. Instead, demand-pull policies fostering the diffusion of existing solutions (e.g. policies for creating climate-supportive innovation ecosystems) rather than the invention of mitigation technologies appear more relevant.

Adaptation technologies differ, as local needs are more specific and foreign inventors (especially from developed countries) have little incentive to develop these solutions. Indigenous innovation creating original solutions tied to local needs may be needed fill this gap in the development of relevant technologies. Our results show trade marks and utility models, instead of patents, have great potential to motivate indigenous and follow-on adaptive innovation that meets the local needs.

While the current debate from literature focuses on technology transfer from developed countries, recent technology trends highlight the increasing importance of climate technology innovation and transfer originating from developing and emerging economies. Trade policy could play a more significant role for these technologies than IPRs. We do not find any clear rationale in favour (or against) weakening the current TRIPS regime, for example, by expanding IPR waivers to climate technologies. The study concludes with proposals of how policy in developing and developed countries can promote climate-friendly development.

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1 Introduction

The global diffusion of climate technologies needs to be accelerated to combat the existential risks of climate change (Hagedorn et al., 2019; Steffen et al., 2018; IPCC, 2018). This requires the removal of *'obstacles to knowledge sharing and technological transfer – including intellectual property constraints'*, as recently claimed by the UN Secretary-General Antonio Gueterres.[1] However, it is controversial whether Intellectual Property Rights (IPRs) inhibit or promote the global diffusion of climate technologies, and in particular, whether the WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) needs to be amended in favour of climate technologies.

This question formed part of heated debates dating back to the 1990s and recently refuelled by the discussions about IP during the COVID-19 pandemic. The debate is polarised along a divide between developing and developed countries. Developed countries own the majority of impactful IPRs on climate technologies. By contrast, developing countries are hardest hit by climate change whilst being marginally responsible for it and lack relevant climate technologies for mitigation and adaptation. Article 4.1 of the United Nations Framework Convention on Climate Change (UNFCCC) acknowledges the *'common but differentiated responsibility'*[2] of countries, including mechanisms under Articles 4(1)(c), 4(3) and 4(5) for developed nations to provide technology transfer to developing countries with climate technologies.

However, lack of sufficient progress in mitigation and adaptation at the global level raises the question as to whether existing transfer mechanisms and the current TRIPS framework are appropriate to respond to the urgency of the climate crisis.

In this paper, we review the literature from law and economics on the nexus between IPRs and climate technology transfer and innovation in developing countries to summarise the empirical knowledge that exists to date. To complement the insights from the literature, we conduct twenty semi-structured interviews with experts in developing countries. The analyses are structured along the three areas where climate technology and IP may play a role, that is (1) international technology transfer (ITT), (2) indigenous innovation, and (3) follow-on adaptive innovation.

Climate technology transfer refers to the international transfer of technology and knowledge. IPRs are said to be significant for ITT because reliable IP protection may contribute to a favourable business climate that attracts foreign investors and technology, leading to knowledge spillovers as a by-product. Our study raises doubts as to the significance of IP in this process. IP matters in developed countries but has less significance in developing nations. Other factors such as market opportunities, infrastructure, and political stability are more important, and often represent pre-conditions that need to be established for IP protection to have impacts on climate technology innovation. This observation was also mirrored in the interviews. Interviewees also raised general scepticism about FDI as a channel of technology

[1] https://www.un.org/sg/en/content/sg/statement/2022-05-18/secretary-generals-video-message-the-lau E2%80%99s-state-of-the-global-climate-2021-report-scroll-down-for-languages

[2] https://unfccc.int/resource/docs/convkp/conveng.pd

transfer, as many FDI projects are not characterised by technological knowledge that could be transferred.

IPRs could also hinder ITT if licensing fees make foreign technologies more expensive. However, there is little empirical support that excessive licensing costs inhibit ITT: markets for climate technologies are competitive with many substitute technologies. Many of the relevant climate technologies include low tech and nature-based solutions (NbS) which are not always subject to IP protection. Both the literature and the interviews suggested that promising market opportunities driven by a strong demand for climate technologies are the most relevant factors in cross-border investment decisions of foreign firms. Further, we found that the current focus on technology transfer from developed to developing countries may be outdated, as many developing and emerging countries are becoming relevant exporters of climate technologies.

However, the focus on technology transfer is insufficient as climate technologies do not only need to be made available but to become part of everyday life through technology diffusion. Diffusion is complex and often driven by incremental innovation, which are small improvements adapting a new technology to a specific local context or adding new functionalities, thereby incrementally expanding the scope of use. Incremental, adaptive innovations matter for climate technology in the development context, as off-the-shelf technologies from developed economies are often unfit for regions where infrastructure, supply chains, and skills for technology maintenance are not well established. Inventors from developed countries often have little practical knowledge and economic incentives to invent climate technologies that are tied to the local needs in developing countries. This finding underlines the importance of domestic indigenous climate innovation in these countries to fill this gap.

IPRs can interact with both indigenous and adaptive innovation in climate technologies made by inventors coming from developing countries. Principally, IPRs act as an enabling factor within a climate-friendly innovation system that promotes indigenous innovation. However, so far at least, there is no evidence that they are promoting such innovation. Climate innovation systems need to be built first, before IPRs can play a substantial role.

Key factors that emerged are demand-pull factors, especially costs and regulation. Mitigation technologies need to be cheaper to deploy than fossil-fuel based alternatives. As IPRs could be a barrier to reducing the cost of high-tech climate solutions, adequate regulation may mitigate the impact of IPRs (and other potential barriers) on the incentives to adopt mitigation technologies. In adaptation, technologies do not compete with carbon-intensive alternatives: awareness, technological capacities to develop indigenous solutions, and financial resources are key.

Interviewees expressed that trade marks are preferable forms of IP protection, as they are more accessible for inventors from low-income countries. Trade marks can act as a marketing tool to facilitate (international) climate technology diffusion, as they act as signals of quality and build consumer trust in brands.

Follow-on adaptive innovation based on existing climate technology and the diffusion of these inventions can be inhibited by IPRs due to the novelty trap. The novelty trap may hinder inventors who engage in adaptive innovation because such innovation may not meet the high novelty bar, if defined as a globally uniform standard. Interviewees suggested that wider use of utility models could promote low-cost, indigenous innovation. In the literature, a new form of patent, termed 'diffusion patents', has been proposed as an instrument to address the novelty trap. Further, amendments in international IP law may be considered to more effectively promote (or not hinder) climate-related adaptive innovation from developing countries.

There are several forms of adaptive innovation that are not subject to IPRs restrictions, including organisational innovations. Existing legal mechanisms to promote ITT including those in the UNFCCC do not necessarily capture this sort of innovation, despite their importance as low-cost solutions in developing nations.

In summary, the heated debate on IPRs and climate technology overstates the relevance of IP law as a barrier to the diffusion of climate technology in developing countries. Greater awareness about the instruments that prioritise climate technology diffusion (rather than invention) may be a more impactful approach. This includes strengthening the incentives to create reliable, strong domestic demand in developing nations, which includes the creation of more stringent climate policy. This can be achieved by adopting instruments that reduce local deployment costs, provide targeted financial and technological support, and help in creating domestic climate-related technological and economic absorptive capacities that enable developing countries to produce and maintain climate technologies themselves. A global policy framework for climate technology diffusion needs to be inclusive, ensuring a fair distribution of economic opportunities in a climate-sound economy, whilst considering the future direction of improvements to existing measures that could exclude developing countries from participation (e.g. Border Carbon Adjustments). That being said, there is also not adequate evidence to suggest that the current IP regime is a driver of climate innovation and diffusion. Hence, there is no clear rationale in favour of, nor against, weakening IP protection under the TRIPS Agreement, such as an IP waiver over climate technologies.

The remainder of this report is structured as follows: Section 2 reviews the literature in law and economics on the relationship between IPRs, ITT and innovation relating to climate technologies. Section 3 is dedicated to the fieldwork. Section 4 and Section 5 discusses policy options and technical cooperation measures. Section 6 concludes.

2 Background

This section is composed of three subsections. Section 2.1 introduces the relationship between IPRs and development in theory and explains the peculiarities of climate technologies. Section 2.2 reviews the existing empirical economic and legal literature on IPRs and climate technology transfer. Lastly, Section 2.3 reviews previous evidence on the relationship between IPRs and indigenous and adaptive climate innovation in developing countries.

2.1 IPRs and development

2.1.1 IPRs and innovation/technological advance

This subsection outlines first the microeconomic effects of IPRs on individual inventors, and second the macroeconomic mechanisms between IPRs and development at the country level.

IPRs and innovation incentives. Classical economic theory describes IPRs as a tool to correct market failures. IPRs aim to provide an innovation incentive by ensuring that the inventor can appropriate the gains of an innovation and recoup their R&D expenses (Arrow, 1962). Innovation is considered as a process of knowledge creation: inventors invest time and money to do research and create knowledge that enables the development of new technologies.

Knowledge is a public good: it is non-rival and non-excludable. Once it is in the public domain, it is impossible to exclude others from using it, unless protective mechanisms such as patents, design rights, or copyright are put into place. In theory, IP protection ensures that inventors can hold a temporary monopoly on the protected technology, which enables them to charge higher prices and to recoup their initial R&D investments (Lopez, 2009; Hall et al., 2014). This is a theoretical justification for formal IP protection (patents, design rights, and copyright) from an economic perspective,[3] based on the assumption that inventors' motivation to innovate is profit-oriented.

However, innovation at the micro-level is more complex for three main reasons: First, formal IP is not the only mechanism through which inventors can exclude their invention from others and secure the payback on their innovation. Empirical evidence suggests that firms rely on informal IP protection (secrecy, lead time, design complexity, confidentiality agreements, lock-in) more than they do on formal mechanisms such as IPRs (Hall et al., 2014).

Second, the motivation to engage in R&D and to innovate is diverse and not necessarily profit-oriented. Major breakthrough innovations including climate technologies originated from public research institutions and universities (Hötte and Jee, 2022), and were motivated by scientific curiosity (J. G. Thursby and M. C. Thursby, 2007) or they are outcomes of public research support for fundamental or applied research targeted at solving societal challenges (Mazzucato, 2013). Other commercial and non-commercial inventions, especially in the context of sustainability and development, are motivated by altruistic goals from individual social entrepreneurs or as part of a corporate social responsibility strategy (Bollinger and Neukam, 2021; Phillips et al., 2015; Seelos and Mair, 2009).

Third, formal IP protection is not always motivated by the need to protect the exclusivity over an innovation but to attract finance for commercialisation and scaling-up. Formal IP, especially patents, can serve as a signal of firm performance to external investors, reducing information asymmetries about the quality of an

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[3] One can also apply a legal perspective based on the general right to property, arguing that IPRs enable the inventor to their possession. This study focuses on the economic perspective.

invention when raising venture capital finance (Hsu and Ziedonis, 2008; Long, 2002). Innovative start-ups obtain formal IP protection to indicate their broader innovative capacity to investors and potential acquirers (Graham et al., 2009). Upcoming qualitative research demonstrated that this also holds for climate technology start-ups under certain circumstances (Ring, forthcoming). Patents can also be used as an asset and collateral to reduce the costs of bank lending (W. Mann, 2018; Chava et al., 2017).

While the literature broadly agrees IP can have a positive effect on start-up finance, evidence about whether patents help attract innovation finance for established, larger firms is less clear (Hottenrott et al., 2016; W. Mann, 2018). There are also concerns that the strategic treatment of patents and IPRs may disassociate patents from innovation activities, distort innovation outcomes, and act as an impediment to innovation by technological followers (Macdonald, 2004). In these cases, patents would have a negative effect on overall innovation.

To summarise, the evidence on formal IP protection and knowledge creation by individual inventors and firms is limited and robust only for a subset of technologies (especially pharmaceuticals and chemistry) (Granstrand, 2009). Formal IPRs may be relevant to attract finance to up-scale businesses and the commercialisation of inventions, especially for young firms and start-ups. The use of IP to attract funding can be very important in developing countries, where lack of finance is one of the key barriers to climate-related entrepreneurship (Gabriel, 2016).

Of course, the relevance and choice amongst different types of formal and informal means of IP protections differs depending on the type of technologies, firms, technological complexity, industry structure and competition, as well as idiosyncratic characteristics of inventors. Most quantitative research that aims to quantify the economic impact of IP on innovation and technological change focuses on formal IP, in particular patents, partly because informal IP is harder to measure.

IPRs and technological progress. Taking a macroeconomic view which abstracts from individual inventors and their incentives, this subsection introduces the key theoretical mechanisms of how IPRs interact with technological progress and development. Three major channels are relevant: (1) technology transfer, (2) adaptive and imitative innovation, and (3) indigenous innovation.

First, technology transfer enables domestic technological upgrading through the inflow and adoption of foreign technology. This can stimulate development if the use of advanced technology increases productivity. In practice, technology transfer occurs through trade, foreign licensing, foreign direct investment (FDI), and foreign patenting (Falvey et al., 2006). Stringent IPRs can stimulate technology transfer if they protect foreign technology importers and investors from the risk of imitation and enable them to appropriate the rents of their technology. Knowledge transferred from foreign actors can further stimulate localised learning in developing countries (e.g. China and Brazil). As it will be shown, the empirical evidence of this premise and its pre-conditions is ambiguous. It suggests technology transfer stimulated by stringent IPRs is more beneficial in host countries that are at a higher level of development, have stronger indigenous technological capabilities, trade-openness and a larger market-size with low market power of the technology-importing firm (Falvey et al., 2006).

The second channel is adaptive and imitative innovation, which can be facilitated or hindered by the stringent IPR enforcement. On the one hand, and consistent with the microeconomic theory, stringent IPRs can encourage risk-taking proactive innovative activity. Further, the disclosure requirements of formal IPRs such as patents are thought to improve the spread of knowledge about available technologies, which can encourage adaptive and imitative innovation (Falvey et al., 2006).

On the other hand, stringent IPRs impede imitative innovation relying on reverse engineering, which is important for technological learning (Dreyfuss and Benoliel, 2021). Historically, many successful cases of technological catch-up and development build to a significant extent on learning through technological innovation enabled by the absence of IPRs protection or the lax enforcement thereof (Granstrand, 2009).

In a development context, stringent IPRs may shift profits from domestic, imitative firms to foreign technology exporters (Falvey et al., 2006). Adaptive innovation can be essential to make existing technology useful in the specific context of a developing country with weak infrastructure, financial capacities, and less developed supply chains for maintenance. However, adaptive innovation can conflict with existing IP protection, as it is often low-tech, imitative, and/or insufficiently distinct from existing technology to satisfy the novelty requirement of formal IP protection (Dreyfuss and Benoliel, 2021).

The third channel is the impact of IPRs on indigenous innovation. Indigenous inventions are new to the world and do not imitate existing technology from advanced countries. IPRs may correct domestic market failures, by protecting the inventions of domestic inventors from imitation risks, establishing a commercial incentive for innovation, and help to raise R&D capital. The optimal level of IP protection and compliance with international standards interacts with the level of development and domestic technological capacity. IPRs are an important element of an effective innovation system that promotes domestic innovation once a sufficient level of indigenous technological capabilities is reached (Dreyfuss and Benoliel, 2021; Chu et al., 2014; Chen and Puttitanun, 2005; Fu et al., 2011).

2.1.2 IPRs and climate technology

The literature largely agrees that the impact of IPRs on innovation is technology-specific (Granstrand, 2009). Technologies for climate change mitigation and adaptation have certain distinct characteristics. Many of them are already relatively mature, low-tech or nature-based, and only a subset of climate technologies is actually protected by formal IP, particularly, patent protection. According to the UNEP and UNFCCC (2022) working definition, climate technologies *'help us reduce greenhouse gases and adapt to the adverse effects of climate change'*, whereby the UNFCCC adopts the IPCC's definition of technology as *'a piece of equipment, technique, practical knowledge or skills for performing a particular activity'* (IPCC 2000).

It is common practice to distinguish between three different components of technology (Müller 2003): (1) hardware: the tangible component, such as equipment and products; (2) software: the processes associated with the production and use of the hardware; (3) orgware: the institutional framework or organisation involved in the adoption and diffusion process of a technology. This definition is very generic and encompasses a wide range of solutions. IPRs are only relevant for a small subset of the possible solutions, and even within this subset the impact of IPRs depends on the specific technology.

From an economic theory perspective, climate technologies show another distinctive feature related to their double public good nature. In addition to the positive externality arising from the knowledge created during the innovation process, climate technologies also contribute to the global public good of climate change mitigation. This is commonly referred to as the *'double externality'* problem, justifying public intervention to promote innovation and diffusion (Jaffe et al., 2005).

These two types of externalities arise at different stages of the innovation process: positive knowledge externalities arise during the process of knowledge creation, and positive climate externalities arise from technology diffusion when climate-friendly technologies substitute carbon-intensive alternatives. Also, the diffusion of some adaptation technologies such as dykes against floods or medicines preventing the spread of infectious diseases incorporate positive externalities (Hötte and Jee, 2022). However, some of these externalities (e.g. flood protection) are more localised compared to the global dimension of mitigation benefits, which can have different policy implications.

Positive externalities from climate technologies offer a strong argument for public support for both innovation and widespread diffusion. There may be synergies and conflicts in the relationship between IPRs, innovation, and diffusion. The relationship would be synergetic if stringent IPRs promote the diffusion of climate technology to developing countries and ensure that innovators, typically coming from developed countries, can appropriate the gains of their inventions. This may stimulate further innovation. Yet there would be a conflict if stringent IPRs create technology monopolies, which can be abused to charge excessive prices, refusals to licence, and prevent adaptive innovations which hinder diffusion (Maskus, 2010; Dreyfuss and Benoliel, 2021).

Recognizing the trade-off, economists have attempted to calculate the optimal level of IPRs protection (Oh and Matsuoka, 2016). Non-IP policies such as R&D subsidies and demand-stimulating measures can represent alternative means to stimulate innovation and diffusion, but their effectiveness can depend on IP protection.

However, the reality of climate technology in developing countries calls for a more differentiated view (Maskus, 2010) for three main reasons: (1) Many climate technologies are mature (e.g. fuel-efficiency improvements, photovoltaic (PV) and wind energy) and various competing technology options exist and it is less likely that IPRs are a significant barrier to access to technology. However, this does not hold for emerging climate technologies, e.g. in agriculture, biotechnology, and synthetic fuels.

(2) Cutting edge patent-protected climate technology coming from developed countries (e.g. high-tech batteries for electric vehicles, smart grid technologies, GMO crops and clean information and communication technologies (ICT)) are often expensive and may be unfit for developing countries if they are difficult to maintain.

Often, previous vintages of such technologies and various low-tech (e.g. water and infrastructure adaptation solutions) and NbS (e.g. green roofs and forest restoration) offer reliable, affordable, and effective alternatives. These technologies are mostly not patented, or the patents already expired. Some of them are protected by trade marks, but they bear great benefits for mitigation, adaptation, and offer development opportunities through channels of technology transfer and trade between developing countries (Corvaglia, 2014).

(3) Effective technology diffusion and sustainable use of technology requires more than access. Absorptive capacity is the capability to understand, maintain, use, and eventually adapt foreign technology. This is critical for sustainable development that builds on foreign technology imports (Olawuyi, 2018). Absorptive capacity is also a key pre-condition to build up production and manufacturing capacities which are needed to upscale climate technology diffusion and deployment.

The legal literature to date has focused principally on the early stages of climate technology rather than technology diffusion. Importantly, legal scholars frequently do not adequately distinguish between the invention stage — pre-market research activities — and innovation, the commercialisation and diffusion of climate technology (Ring, 2021). This tendency may lead to over-stating the negative impacts of IPRs such as patents in the domestic context as barriers to follow-on innovation, and to emphasising how patents may impede ITT.

2.2 IPRs and technology transfer

In this section, we review the empirical evidence on the impact of IPR on technology transfer. Following the IPCC (2000), climate technology transfer can be defined as '*a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations and research/education institutions*'. Hence, it includes tangible (e.g. equipment) and intangible innovation (e.g. knowledge and know-how), and it refers to inter- and intranational technology transfer. This section focuses on international transfer.

ITT is embodied by a wide range of activities, including trade, licensing, and FDI. IP protection is important to each route, to a differing degree depending on its role or field of activity. Whether stringent IPRs systems hinder or facilitate ITT has been discussed in various empirical and theoretical contexts. However, previous studies have reached different conclusions, depending on the field of study or empirical focus.

Empirical evidence from economics often indicates a positive relationship between IPR stringency and ITT. For example, Cockburn et al. (2016) shows a positive effect emerging from a stringent IPRs system on the cross-country diffusion of new drugs. Using the European Patent Office (EPO) data of 13 countries, Montobbio et al. (2015) find that IPRs have a positive impact on the strength of the flow of codified knowledge embodied in patent citations and R&D collaborations. In agriculture, it was found that the IPRs contribute to decreasing the yield gap between developing and developed countries (Spielman and Ma, 2016). These studies show that firms tend to prefer to transfer their technologies to countries with proper IP protection systems, particularly in technology-intensive sectors (Maskus, 1998).

Several studies in development and international relations have reported a similar relationship, particularly focusing on trade and FDI-related aspects. Recent studies argued that developing countries need to strengthen their IPRs regime to increase the import of new products and services from foreign countries, although the suggested level of IPR protection varies across country- or sector-specific characteristics.

Olawuyi (2018) points out that the weak IP protection in Africa is one critical barrier to importing advanced technologies, resulting in a lack of absorptive capacity in the long run. Similarly, according to Zhang and Yang (2016), the adoption of the TRIPS Agreement has positively affected inward FDI in developing countries since the mid-1990s. Abdel-Latif (2015) shows that stronger IPRs in developing countries increases developed countries' export of new products, particularly in the patent-sensitive sectors such as pharmaceutical and medical equipment. However, foreign firms' motivations when accessing developing country markets through FDI and trade primarily arises from the economic opportunities in the destination country or region (Elfakhani and Mackie, 2015). Market size, purchasing power, and growth potential are among the key factors to explain FDI and often quantitatively dominate the role of IPR.

A substantial literature in law has mapped the relationship between IPRs and technology transfer. The earliest debates on this topic emerged in response to negotiations of the Conference of the Parties to the UNFCCC in the late 1990s in discussions about whether commitments on climate technology transfer in the UNFCCC should include binding statements about IPRs.[4] In the aftermath of debates over the late 1990s to the mid-2000s, legal scholars have taken up the question whether the TRIPS Agreement or the UNFCCC establishes sufficient obligations regarding climate technology and ITT (Rimmer, 2018; Zhuang, 2017).

Many legal scholars focus on how to amend existing international IP law and policy, assuming that the current stringency of the IPRs system based on the TRIPS Agreement slows down and complicates the ITT process to developing countries by restricting the use of essential technologies. For example, Zhou (2019) argues that the IPRs system poses a severe obstacle to climate technology transfer, discussing potential directions of changes in IP law required to increase technology accessibility. Similar concerns have been raised in relation to plant improvement technologies such as Genetically Modified (GM) crops and new plant varieties, underlining that limited access to agricultural products can undermine food security in developing countries (Vindigni and La Terra, 2016).

This stream of literature relies on the logic that the high cost of technology licensing and patent holders' refusal to licence interrupt technology transfer. TRIPS has been an impediment to ITT from developed to developing countries because it strengthens the patent holders' position. While TRIPS flexibilities, such as compulsory licensing

[4] Jérôme de Meeûs and Alain Strowel, Climate Change and the Debate Around Green Technology Transfer and Patent Rules: History, Prospects and Unresolved Issues (2012) 3 WIPO Journal 179.

or governmental use, have been proposed as a solution, the discussion often focuses on the narrow context of public health and food security (Cheng, 2022; Vindigni and La Terra, 2016).

However, a predominant view amongst the legal literature is the idea that, as market mechanisms, IPRs such as patents are unlikely to be relevant to climate-related innovation in developed countries let alone to be of much significance to ITT to developing countries (Sarnoff, 2011, Tur-Sinai, 2018; Drahos, 2003). Tur-Sinai (2018) notes that without pre-existing market demand for climate technologies, IPRs such as patents will not be an incentive of primary relevance to climate technology innovation due to the double externality that leads markets to undervalue climate innovation. While IPRs may be an enabling mechanism for ITT, the low market demand for climate technologies in developing countries undermines the idea that IPRs promote significant ITT in those contexts.

2.3 IPRs and climate technology innovation

Foreign climate technology can be creatively used in developing countries through several routes. Two paths have been widely recognized: (1) building technological capabilities for indigenous innovation, or (2) improving the usefulness of foreign technologies in the domestic context with adaptive innovation. The two pathways of using climate technologies are complements rather than substitutes (Fu et al., 2011).

A pre-condition for the effective and creative use of existing technology, is a sufficiently high level of *absorptive capacity*. Absorptive capacity is a concept that originates from the management literature and refers to firms' '*abilit[ies] to recognize the value of new information, assimilate it, and apply it to commercial ends*' (Cohen and Levinthal, 1990). In this study, absorptive capacity for climate technology refers to the ability of countries to adopt, use, maintain, and further develop climate technologies.

Absorptive capacity can be developed through indigenous innovation that relies on the support of a functioning national innovation system (e.g. Sasidharan and Kathuria, 2011). Countries that lack the relevant absorptive capacity may fail to adopt foreign clean technologies effectively or to adapt them to tackle the country's local climate challenges (e.g., Li, 2011).

Despite the complementary nature of the two pathways (indigenous and adaptive innovation), one route may be more suitable than another given a country's development stages and circumstances at the technology-, firm-, and industry-level (Aghion and Howitt, 2005). Depending on the pathway through which a developing country uses climate technology, the role, and significance of the IPRs system varies.

2.3.1 Indigenous innovation

Although climate change is global, many climate risks and relevant technological solutions are local (Dodman et al., 2012). Several of the most imminent threats of climate change are concentrated in developing countries, especially where the temperature is higher than the global average. For this reason, there is a high need for climate change adaptation technologies and specific mitigation technologies in developing countries.

For example, food security and economic growth on the African continent is particularly vulnerable to climate risks because of its high reliance on agriculture (20% of Africa's GDP) (Senyagwa, 2022). Indigenous innovation in agriculture-related adaptation technologies may be particularly impactful in Africa, being suitable for region-specific agricultural production. Epidemics, such as dengue fever and malaria, are aggravated by heavy rainfall or high temperatures, such that disease-related adaptation technologies will be increasingly needed. Also, the technologies required for mitigation vary across regions, and often depend on path dependencies arising from the existing energy and transportation systems, production and consumption patterns, and on the availability of supporting infrastructure, and economic and geographic factors.

Due to the regional variation, the technological solutions needed by developing countries are sometimes distant from those in advanced economies. Most climate technologies are developed and possessed by developed countries, and their R&D prioritises solutions to address the issues of developed rather than those of developing countries (Papaioannou, 2014). Inventors from developed countries lack incentives to develop technologies tied to the needs of developing countries, which can be characterised by low purchasing power, weak infrastructure, and the presence of cultural, institutional, and economic barriers to the adoption of new technologies. In other words, the technological evolution led by advanced economies is inclined towards serving the needs of their own needs, while various technological solutions tied to the specific needs of developing countries are not being developed.

Therefore, developing countries require their own technological capabilities for indigenous innovation to address climate issues specific to their regions. Since developing countries are usually short of technological capacity (Ockwell and Byrne, 2016), their indigenous innovations often rely on low-tech solutions that require unskilled or semi-skilled labour and are easier to maintain under scarcity conditions, such as unstable electricity supply or weak supply chains (Fu et al., 2011).

The international IP law system under the TRIPS Agreement is not likely to pose a critical barrier for indigenous innovation in climate technologies from developing countries because those solutions are distant from the interests of developed countries and existing IPRs. In part, this is because IPRs leverage existing market demand, which is geared towards high-tech, expensive inventions with the highest expected payoffs rather than the low-cost, low complexity inventions which are more likely to emerge from indigenous innovation in developing nations (Kapczynski and Syed, 2012).

Moreover, technology transfer from developed to developing countries, which has been at the forefront of academic and policy discourse, is not particularly attuned to this issue. However, ITT between and from developing countries can be important as these countries may share common climate risks and more comparable socio-economic circumstances for technology deployment (Urban, 2018). Recent evidence shows emerging indigenous innovation and subsequent technology transfer from developing and emerging economies (Herman, 2021; Corvaglia, 2014). So far, no clear empirical evidence has been established whether IPRs play a conducive or hindering role in this emerging path of technology transfer.

2.3.2 Follow-on adaptive innovation

While many climate risks are local, countries also face common challenges, such as the transition to clean energy and transportation, regardless of the geographic location and development level. For common climate issues, there are likely to be solutions already in existence by inventors from developed countries. Technological solutions for climate change mitigation, including components of renewable energies, clean transport, and carbon capture, already exist, although low-cost implementation and scale-up remain an issue (Sovacool, 2008).

For existing climate solutions, foreign technology adoption through transfer channels, such as FDI, trade, or licensing, can provide viable routes for developing countries to access and utilise essential climate technologies (i.e., North-South technology transfer). Reliance on foreign technologies is particularly relevant in high-tech areas, such as biotechnology in agriculture, advanced combustion, or batteries, which are characterised by high levels of complexity. To adapt these technologies, an understanding of the frontier knowledge in those respective technology fields is critical.

For developing countries, it is difficult to independently produce these frontier technologies due to a lack of skilled labour and other limited technological capabilities. Adapting existing solutions requires the absorptive capacity to search for and assimilate knowledge properly (Cohen and Levinthal, 1990). Once developing countries successfully adopt foreign technologies, follow-on adaptive innovation can address more region-specific climate challenges, or increase the efficiency of adopted solutions. In addition, the implementation of clean technologies requires follow-on research to optimise technologies for a specific local environmental and socio-economic setting (Raiser et al., 2017). This may include, for instance, adaptation to the local energy grid. Adaptive innovation principally consists of relatively incremental improvements from adopted solutions, building on the knowledge and skill basis of existing technologies.

However, developing countries' efforts to adopt and adapt foreign technologies can be discouraged by IPRs protection. Most climate technology patents are held by a relatively small group of companies based in developed countries. The US, Japan and Germany are the top 3 countries possessing most climate patents granted in the US Patent and Trademark office during 1976-2020 (Jee and Srivastav, 2022). The presence of such exclusive rights and the costs of licensing them can deter developing countries' access to existing climate technologies and discourage investment in follow-on adaptive innovation. Adaptive and imitative innovation also bear the risk of infringing existing IPRs (Dreyfuss and Benoliel, 2021).

The degree to which licensing fees pose barriers depends on sector-specific technological features. On the one hand, in fields such as ICT or medical instruments, thousands of patents may protect aspects of a single downstream product. In these cases, the cost of licensing required to produce a final product is very high due to fragmented ownership over those solutions (Hall and Ziedonis, 2001). The high cost of managing fragmented licensing contracts creates a substantial barrier to developing countries entering the relevant market. On the other hand, in fields such as pharmaceuticals or chemicals, it is commonplace that only a handful of patents are required for producing a final product. The cost of managing contracts is relatively low, although the licensing fee of a single patent is often much higher than in other sectors (Galasso and Schankerman, 2015).

3 Analysis

The empirical part of this study relates to interviews with experts from four different countries (Bangladesh, India, Kenya, South Africa). Each country is considered a case study to investigate whether IPRs pose a barrier to climate technologies in these countries. In this section, we first give a brief overview of the major climate and development challenges of the countries, including their Nationally Determined Contributions (NDC) and explain why these countries serve as interesting cases for our empirical study. Next, we introduce the methodology and give a detailed description of the empirical insights from the interviews. Lastly, we discuss and contextualise the insights considering the NDCs and the literature review above.

3.1 Country profiles and their NDCs

3.1.1 Bangladesh

Bangladesh is a lower middle-income country, classified as a least developed country (LDC) by the UN,[5] with 2,457 USD of GDP per capita (2021) and a 169.4 million population, increasing at a rate of 1.1% annually (2021). About 13.5% of the total population are below the international poverty line (The World Bank, 2022). 24.75% of the country's total energy consumption lies in renewables (2019). Given its low level of economic development, Bangladesh's emissions accounted for only 0.25% of total global emissions (0.55t per capita) in 2021. The country is geographically highly exposed to climate risks. Bangladesh is in a tropical zone with seasonal monsoons, making it highly exposed to extreme weather events. River and coastal floods are expected to become more frequent and intense, arising from extreme rainfall, cyclones, and storms. Prolonged and more frequent heat waves impose a major threat to human health and living standards, especially in urban areas and for outdoor workers.

Bangladesh has shown active engagement in international climate action, particularly in climate change adaptation. It was one of the first countries to complete a Technological Needs Assessment (TNA) for adaptation funded by the Global Environment Facility within the UNFCCC (UNFCCC, 2012). Bangladesh is an important global leader in adaptation, holding the presidency of the 48 nation

[5] https://www.un.org/development/desa/dpad/least-developed-country-category-bangladesh.html

Climate Vulnerable Forum and the Vulnerable Twenty (V20). In its most recent Nationally Determined Contributions (NDCs) (Government of Bangladesh, 2021), the country committed to reduce its emissions by 2030 by 6.73% compared to a business-as-usual scenario, which would be increased up to 15.12% conditional on international financial and technical support.

Agriculture is a major sector of the economy, with about 37.7% of the population employed in agriculture (World Bank, 2021a), and a share of 27% in the country's emissions in 2012. Due to its geography, adaptation against sea-level rise is one of the greatest challenges in Bangladesh. Therefore, climate technologies with the highest importance are related to water and agriculture adaptation. The technological priorities identified in the TNA performed in 2012 focus on water-related adaptation solutions, such as dykes, technology-assisted disaster management, tidal monitoring, tidal barriers, and climate-smart urban infrastructure. Other water adaptation technologies related to water-supply include solar pumping systems, rainwater harvesting, and stormwater reclamation and reuse. These technologies are characterised by a high capital, but rather low IP intensity (e.g. Hötte and Jee, 2022). IP might be relevant in agricultural adaptation and the need for salinity, drought resistant, and short-maturing rice varieties, in addition to training, specialised R&D, and improved land use planning, which are independent of IP.

Bangladesh aims to transform its agriculture-based economy into a manufacturing and service-based economy in the coming decades. Bangladesh's TNA suggests that power and transport are important primary sectors requiring substantial investments (UNFCCC, 2012). These sectors raise emissions in Bangladesh, implying that climate technology adoption and development should not be limited to agriculture and water adaptation, but need to cover other mitigation areas.

Given the urgency of adaptation, Bangladesh has prioritised investment in fields where adaptation can co-benefit mitigation. The key sector requiring mitigation in Bangladesh is energy, which is said to contribute more than 96% to emissions reductions. Key technologies relate to power generation (e.g. advanced natural gas and integrated gasification combined cycle technology, and (home) solar PV) and efficiency in power use (e.g. compact and linear fluorescent lamps).[6] The emphasis on mitigation in the power sector is in line with the country's aim to accelerate economic development and employment through the expansion of manufacturing and service-related sectors.

Most current mitigation actions committed by Bangladesh are rather low-tech and not subject to IP protection. However, some power-related technologies include legally protected solutions, such as renewables, high-efficiency fossil fuel technologies, and electric vehicles. In addition, agricultural technologies related to adaptation largely include science-intensive skills and know-how possessed in developed economies.

[6] https://tech-action.unepccc.org/country/bangladesh

3.1.2 India

India is an example of a lower middle-income country with 2,256 USD of GDP per capita (2021) and a 1.39 billion population increasing at a rate of 1% annually (2021). Despite its relatively low level of CO_2 emissions per capita (1.8t), India is the third-largest carbon emitter in the world given its population, accounting for about 7% of total emissions. Renewables make up 32.93% of the country's total energy consumption in 2019. India puts much emphasis on its need for development and makes strong claims for climate justice, referring to its history and tradition of harmonious coexistence between human and nature.

India's priority areas for mitigation include energy production and efficiency, as well as transportation. India has one of the largest renewable expansion programs in the world. Solar PV, hydro, and onshore wind are the prioritised renewables. To enhance energy efficiency, it invested in areas such as efficient lighting and set minimum energy standards for buildings. To promote clean transportation, India focused principally on the construction of the Mass Rapid Transit System. India is also expanding its support to increase faster adoption and manufacturing of hybrid and electric vehicles, including e-rickshaws which make up about 60% of EV sales in the country. While India's NDC provides sectoral plans for tackling climate change, it underlines the country's *'right to grow'* at the same time.

Regarding adaptation, vulnerabilities in India differ not only across regions, but also across social classes. Overall, the priority areas for adaptation are drought management and flood mitigation in agriculture, which is directly related to nearly two thirds of the population's livelihoods. In addition, since India is one of the countries that are most vulnerable to the impact of sea-level rise, various plans to deal with future risks have been prepared. The plans include Coastal Regulation Zone for restricting industrial activities in coastal regions and Integrated Coastal Zone Management, in which experts from various fields work together to build national capacity to manage coastal zones. Disaster monitoring and emergency response related adaptation technologies are also key funding areas.

India's recent NDC[7] explicitly emphasises the responsibility of developed countries to transfer technological know-how to India and other developing countries to enhance adaptation and mitigation. India advocates that developed countries engage actively in R&D collaboration to facilitate technology transfer. Priority agendas where India requires international R&D collaboration include energy management and storage systems for renewables and clean coal and fossil fuel. India particularly calls for exempting developing countries from IPR-related costs on technologies from developed countries to accelerate climate technology transfer, with a consideration of country-specific circumstances including climate risks, level of knowledge, skilled manpower, and infrastructure.

India's national-level awareness of international R&D collaboration and IPR issues contrasts with that of other developing countries. This awareness implies that India occupies a unique position among developing countries, with strong potential to

[7] https://unfccc.int/sites/default/files/NDC/2022-06/INDIA%20INDC%20TO%20UNFCCC.pdf

adopt advanced clean technologies and to subsequently adapt this knowledge for its own purposes. The successful commercialisation of the e-rickshaw, which is based on technologies from developed countries, is an example of India's potential for adoption and follow-on adaptive innovation as well as responsive markets with a substantial scale. Complex (e.g. EV, smart grid, and some renewables) and relatively discrete (e.g. adaptation technologies related to agriculture and health, especially medicine) climate technologies are relevant to technology transfer to India.

3.1.3 Kenya

Kenya is an example of a lower middle-income country, with 2,006 USD of GDP per capita and a 54 million population, growing at a rate of about 2.2% annually (2021). The country has very low carbon emissions accounting for 0.4t per capita in 2021 (Our World in Data, 2022). While Kenya has abundant oil reserves, these resources are not fully exploited. Instead, renewables make up about 68% of Kenya's total energy consumption in 2019, which is mostly due to wood fuel use in many households and much higher than in other developing countries. For electricity supply, hydropower has been exploited as a primary source, amongst the country's available renewables including geothermal, wind, and solar.

While Kenya is not contributing to climate change, it's key economic sectors, including agriculture, manufacturing, and tourism, are highly vulnerable to climate risks. The Natural Disaster Statistics from the World Bank (WorldBank, 2021b) show that drought is the primary risk area for the country, with most people being affected by water security, as well as riverine floods and epidemics amongst other adaptation challenges. Kenya has a diverse topography, with a variety of climates within the country. Due to higher temperature, the northern and north-eastern parts of the country are experiencing increased aridity and droughts, while the central, western, and coastal regions are exposed to risks of flooding. Temperature rise also causes health-related risks, including bacterial or parasitic diseases.

Given Kenya's negligible contribution to global carbon emissions and high exposure to climate risks, it prioritises adaptation. Kenya pursues mitigation strategies, which also help achieve adaptation goals. Although projections demonstrate that Kenya's emissions will increase by 2030 because of its increasing reliance on fossil fuels for electricity, its mitigation plan shows it is also ambitious for renewable energy under the premise of proper international support, targeting 32% of GHG emission abatement through renewables by 2030 relative to the business-as-usual scenario. The Kenyan 2020 NDC report explicitly states the commitment to climate action can only be made when 79% of the costs for mitigation and 90% for adaptation are supported by developed countries. This support is not only financial, but also includes direct technology transfer and capacity building. In addition to an increasing use of renewables in electricity supply, Kenya's mitigation strategies highlight energy efficiency, increasing tree coverage in its land area, scaling up of NbS, and waste management systems, to name a few examples.

Given that its priority climate agendas are concentrated on adaptation, particularly droughts and flooding, indigenous innovation based on locally specific knowledge and know-how will be very important over the coming decade. Kenya also needs access to medicine, and agricultural technologies related to adaptation, which includes solutions possessed by advanced countries and protected by IPRs. However, the effective use and adoption of final products for health and agriculture adaptation is currently more significant than disputes around IP issues, at least in the short-term.

In many cases, it is also unlikely that foreign technologies meet the local needs for adaptation. Kenyan farmers achieved improved access to IP-protected plant varieties after Kenya's accession to the International Union for the Protection of New Varieties of Plants (UPOV). However, Munyi (2015) documented that most imported varieties (especially floriculture, French beans) were almost exclusively produced for exports by large commercial farmers but not by local smallholder farmers. This underlines that foreign technology is likely unsuited for domestic adaptation needs of smallholder farmers that are of primary relevance for domestic food security.

Moreover, the priority activities for mitigation described in NDC do not explicitly mention the transportation and manufacturing sectors, as the country is not at a sufficiently advanced stage to have the capacity to adopt and manufacture many of these products. In the medium and long term, Kenya requires international support to build the technological capacity to adopt high technologies. Medicines for health-related climate impacts or crops to cope with changes to the Kenyan environment are likely not to be developed by developed countries, excepting the public sector or development-based initiatives. Therefore, Kenya needs to build local capabilities to develop new products addressing its own challenges. This requires support from developed countries towards active technology transfer and capacity building. Demand for access to the indigenous innovation of neighbouring countries with similar adaptation challenges will likely increase. This nascent route of technology transfer could pose IP challenges.

3.1.4 South Africa

South Africa is an example of an upper middle-income country, with 6,994 USD of GDP per capita (2021). The country has a 59.3 million population that annually grows at a rate of around 1.2% in 2021. South Africa's energy and economy are heavily reliant on coal-based infrastructure. Only 10.5% of primary energy consumption based on renewables in 2019. Accordingly, South Africa's emissions are relatively high, reaching around 7.34t per capita in 2021 (Our World in Data, 2022), which is comparable to many industrialised countries.

South Africa's mitigation plan described in the 2021 NDC report shows that electricity is the primary target, and that mitigation efforts should be made first through investment in renewables in the next decade. Solar and wind energy are the two main renewables where South Africa has observed rapidly falling prices since 2015; yet diffusion remains slow. The NDC claim that the efforts in the electricity sector will be followed by transitions in the transportation and hard-to-abate sectors by 2040. The plan implies that access to several mitigation technologies will be needed, especially in renewables, electric vehicles, and various high-tech solutions in hard-to-abate sector.

South Africa is in the drought belt of Africa, making water scarcity to be a primary adaptation challenge. The list of climate technologies prioritised in the NDC reflects this, highlighting adaptation technologies for water supply and sanitation as a priority. Roughly 50% of South Africa's scarce water resources are used by its industrialised agricultural sector,[8] which is a major part of the economy. The targeted technologies include early warning systems for extreme weather, climate-smart agriculture, and new crop species less vulnerable to changing climate conditions. Higher temperatures combined with water scarcity will likely create additional needs for cooling and health adaptation technologies, such as health monitoring and medicines for those, who are vulnerable to extreme temperatures.

Despite South Africa's overall water scarcity, some parts of the country are exposed to a high risk of flooding. Changing precipitation patterns caused by global warming make it more difficult to address these risks. Therefore, flood protection measures and hydro-meteorological monitoring systems are essential. Relatedly, human settlements and infrastructure exposed to flooding and sea-level rise require large investments to build climate-resilient systems based on adaptation technology and institutional programmes, for example disaster management plans and financial assistance.

Summing up, South Africa has a priority on mitigation by 2030, beginning with the energy transition to escape from the carbon dominated economy, and succeeded by the transition in transportation and hard-to-mitigate sectors by 2040. For some renewables such as solar and wind, adoption and scale-up are the main issues since most relevant key patents already expired. However, for complex end products such as electric vehicles, South Africa may experience difficulties in accessing relevant IP due to fragmented IP ownership and the threat of IP litigation. Moreover, given that clean technologies for the hard-to-abate emissions (e.g. in steel, cement, and chemical industries) are still in their nascent stage, achieving goals in these areas may raise international IP issues with the owners of recent key technological solutions. IP may also play a role for carbon capture and storage (CCS) technologies, but this role is minor compared to other barriers, especially the lack of demand and financial incentives. CCS is a relatively capital-intensive technology, such that IP licensing costs would be likely not a key hindering factor.

For adaptation, some parts of the country are suffering from unexpected flooding events and other parts of the country are experiencing drought and water scarcity. Drought causes sector-wide problems, particularly in health and agriculture. Similarly, flooding risks raise adaptation challenges in many areas, including infrastructure and settlement. Many parts of the solutions in infrastructure and settlement areas are low-tech, nature-based, or need indigenous innovation based on knowledge and experience of locally specific environments and circumstances. However, some adaptation technologies such as climate-resilient crops or new therapeutics are likely to be protected by patents because such solutions are often the outputs obtained from substantial R&D investments in developed countries.

[8] Natural Resources Defense Council in the U.S. defines Industrial Agriculture as 'a large-scale, intensive production of crops and animals, often involving chemical fertilizers on crops or the routine, harmful use of antibiotics in animals'.

3.2 Methodology

3.2.1 Overview of the research design

To explore further the relationship between IPRs, climate-friendly innovation and development in lower-income nations, we adopted a case study research design comparing the four countries. Each country is treated as a case study which is instrumental to understanding the relationship between IPRs and climate technology developing countries (Stake, 1995).

Case study research facilitates an intensive study of specific cases to set out broader theoretical generalisations relevant to different contexts. The research included interviews with local experts, including government officials, members of national IP law offices, local climate entrepreneurs, academics, policy experts, and foreign companies with businesses in the focal countries. Interviews are well suited to gather data because they enable participants to relay views in their own words, developing richer data on attitudes, processes, and practices.

We used a semi-structured technique for the interviews, an approach which uses a core set of questions in each interview (the interview guide), in addition to questions that naturally arise during the discussion. This strikes a balance between flexibility and structure. Asking the same core questions allowed us to compare participant responses to each question asked, while preserving space for follow-up questions or for interviewees to raise unanticipated issues. The interview guide contained ten questions. These core questions were determined taking account of the results above, drawing on gaps in the literature, and the key research objectives.

Interview methods have, however, methodological limitations of accuracy and veracity: interviewees can present distorted representations of reality, for instance, through inaccurate recollection. To guard against these risks, steps were taken to check the veracity of comments, such as cross-referencing with data where possible.

3.2.2 Case and interviewee selection

As a qualitative research project, we chose research subjects which best explain the research questions and did not use the probability sampling approaches associated with quantitative research, which selects research subjects randomly from the population of interest. In case study research, selection of research subjects is a two-step procedure: it involves selecting the case (at the country level), and then selecting interviewees within that case (Merriam and Tisdell, 2015).

Developing countries are heterogenous in their needs and capacities. We decided to select countries with different levels of development and economic structure. Using World Bank indicators, we selected three countries categorised as lower middle-income nations (Bangladesh, India, Kenya), whereby Bangladesh also counts as an LDC according to the UN classification. We also studied one upper middle-income nation with high deployment of fossil-fuel energy (South Africa).

Two other considerations drove this choice. First, it was thought better to study pairs of countries in the same region with different economic structures and development challenges (India and Bangladesh; South Africa and Kenya), rather than opting for a more geographically dispersed group of countries that might complicate comparisons. Second, to focus on countries with a broadly similar legal heritage, again with a view to allowing meaningful comparisons to be drawn.

In each country studied, five expert interviewees were selected from the following categories: national IPRs office employees, governmental officials, climate technology firms (local and foreign firms with a local presence), and finally, experts working in academic or policy contexts specialising on climate-friendly innovation, IP law, and sustainable development.

3.2.3 Data collection and analysis

We contacted the interviewees via email or telephone, provided background information on the project, obtaining the appropriate consents to collect and store data. We conducted interviews via video conference software, which lasted between 45 and 60 minutes. We recorded and transcribed the interviews, removing all personal information as far as possible. We developed pseudonyms for interviewee names, using a randomly generated number and letter combination.

Thematic analysis techniques were used on the data relying on the NVivo software (Clarke and Braun, 2021). Initially, the data was coded on a line-by-line basis, followed by focused coding that grouped codes under recurring and predominant themes, following the approach of grounded theory methods (Bryman, 2016). We conducted the thematic analysis using a coding frame, drawing on themes emerging in the data and in the light of findings of the literature review, and other policy documents on IPRs and sustainable development.

3.3 Results

In this section, we provide an overview of the findings on a country-by-country basis, including relevant contextual information on topics raised by interviewees. In each case, we discuss the findings in the following order: national priorities for development; areas highlighted as important avenues for climate innovation; general comments on local IPRs systems including awareness about IPRs; the impact of IPRs on domestic innovative activity; and the impact of IPRs on climate technology transfer and FDI.

3.3.1 Bangladesh

Participants highlighted the following priority areas for sustainable development: education; diversification of the economy to move beyond agriculture and to diversify the current narrow manufacturing base; and employment, given that Bangladesh is a highly populated nation with a large share of young people. Whilst interviewees did not state so directly, the references to diversifying manufacturing likely referred to high concentration of production of textiles, which currently accounts for roughly 80% of exports.

Participants described Bangladesh as a '*new country*', having achieved independence just over 50 years ago, and one which has developed quickly. The shifting status of Bangladesh on the international stage was highlighted, it being pointed out that Bangladesh will graduate from being a member of the United Nations LDC group in late 2026.[9] The highest priority issue relating to climate change facing Bangladesh is that of natural disasters. As a delta nation prone to cyclones, the discussion of the climate crisis principally focused on measures to alleviate the economic fallout of natural disasters, including new loss and damage frameworks. This was seen to be an issue for economic growth and climate change, given the economic fallout of natural disasters.

We asked interviewees what they perceived to be the key issues for climate change in their countries, and in what sectors climate-friendly innovation was thought to be impactful. The need for climate-friendly innovation related principally to energy provision, transport, and agriculture—with a particular emphasis on adaptation technologies for agriculture.

Energy infrastructure was raised in discussions, and the electrification of the centralised energy grid was lauded as a success. Power-cuts were cited as a major impediment to decarbonised energy supply, perpetuating a reliance on diesel generators during power cuts, and costly fuel imports. Off-grid energy, particularly solar power, was seen as a rapidly expanding area.

The transport sector was another area requiring decarbonisation, which is dominated by petrol and diesel. In both energy and transport, participants appeared to describe instances of technology leap-frogging. For instance, e-mobility solutions are a growing market, with comments that suggest leap-frogging towards lower cost, smaller electric vehicles such as e-scooters is taking place.

Bangladesh is a net food importer, yet at the same time, farmers face increasing risks of natural disasters. Climate change adaptation technologies were highlighted as mechanisms to manage the economic fallout of natural disasters and their impacts on agriculture. Existing national plans for disaster management were raised, however, it was thought that greater ties between disaster risk reduction and economic development were needed.

Bangladesh's IPRs system was said to be at an early stage of development. It was estimated that of the approximate 500 patents filed in Bangladesh each year less than 100 patent applications are filed by local applicants, and many of these applications fail at the level of basic procedural requirements. Bangladesh operates a paper-based system to apply for IPRs protection, and applications are not substantively examined. However, a new statutory regime is coming into effect, which has prompted changes

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[9] United Nations General Assembly Draft Resolution on the Graduation of Bangladesh, the Lao People's Democratic Republic and Nepal from the least developed country category (11 November 2021), United Nations https://daccess-ods.un.org/tmp/4288841.48597717.html (Accessed 15 March 2023).

to make the system more sophisticated.[10]

At the same time, patent applicants found the process to apply for a patent very difficult, noting that '*it didn't seem like that there was a viable path to do it*'. Awareness and usage of IPRs protection amongst the general public is quite low. A member of the Bangladesh Intellectual Property Office reported that at '*university level or secondary level, most of our students and even teachers are not aware of intellectual property; how to use [it], how to manage, and how to develop a product within the framework of IP*'.

Many of the adopters of adaptation technologies or agricultural technologies were likely to be unaware of any legal arrangements in place. There was also a perception that the public were relatively '*indifferent*' to the existence of IPRs protection, which may be partly formed by a lack of awareness. Weak enforcement conditions played into these issues. One entrepreneur described the experience of visiting a factory where drawings of IPR-protected inventions were being copied.

Certain IPRs are nevertheless in relatively wide use. This is particularly true of trade marks which were thought to be more user-friendly and more appropriate for the economic setting of Bangladesh. Trade marks are relevant to the large base of small to medium enterprises in the economy as a means of establishing a brand. Moreover, certain regulatory requirements surrounding standards require traders to register their trade marks with the Bangladesh Standards and Testing Institution. Securing trade mark registration was thought to be far more straightforward than making a patent application.

Indigenous climate-friendly innovative activity is low, with very few patent applications filed over climate-friendly innovation. One entrepreneur noted an apparent conflict between '*social impact and tech depth*'. Developing solutions appropriate to the prevailing socio-economic conditions often meant sacrificing novel improvements or higher quality versions of their inventions to reflect local purchasing power or infrastructure.

Bangladesh's IPRs system is undergoing a period of significant change. This is hoped to encourage a broader uptake of IPRs protection and encourage more innovation. In April 2022, Bangladesh enacted a new Patents Act. This Act replaces a 1911 Act, which was a mere transplant of British law at the time. This new Act for the first time incorporates substantive examination of patent applications.

The Act also has the potential to incentivise follow-on adaptive innovation: it will introduce a utility model ('*petty patent*') to accommodate '*low-tech*' solutions which would not meet a higher novelty standard. Utility models offer inventors the exclusive right to prevent or stop others from commercially exploiting their invention, with a shorter duration of protection than offered under patent protection, which typically ranges from six to ten years from the filing date. Utility patents are to be available for a term of ten years in Bangladesh.[11]

Other changes brought in by the new legislation include an extension of the duration

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[10] Bangladesh Patents and Design Bill, 2022 accessible at http://www.dpdt.gov.bd/sites/ default/files/files/dpdt.portal.gov.bd/law/5b9ae827_53be_439e_8268_ec9659102a52/ 2022-04-18-06-32-5b7b0bb010337f495c9dcc05025404a5.pdf>Accessed24February2023.

[11] Section 32(1) of the Bangladesh Patent Act.

for patent protection from 16 years to 20 years.[12] There will also be a 3-month extension on the usual patent examination time of 36 months from the filing if applicants cannot complete the application in a timely fashion.[13]

It was agreed that IPRs had some importance in the context of measures to support technology transfer, but with a low significance compared to other factors.[14] Specifically, IPRs were said to give foreign investors a sense of security in their investment, but that ultimately the decision whether to invest would be driven by the business case. One foreign entrepreneur in Bangladesh highlighted that weak IPRs enforcement in Bangladesh was unlikely to discourage technology transfer if there was a strong enough business case to enter the market. It seems that foreign enterprises are aware of and willing to accept the risks associated with entering the market in a lower-income nation.

Other barriers to technology transfer which were raised referred to a lack of local expertise about how to implement or maintain climate technologies. Further, interviewees mentioned a lack of knowledge about what solutions were available on the international market that could be useful in Bangladesh.

3.3.2 India

Participants noted that India occupies a dual status as leader of lower-income countries and status as a fast-growing, industrialised contender in the global economy. As '*leader of the G20'*, India was thought to be particularly influential on the conduct of developing countries. Participants were aware that in practical terms, global efforts to meet the 1.5 to 2 degrees targets depend on India successfully tackling its emission problem, given its projected population growth and increasing energy consumption over the next 30 years.

Some participants (although this view was not universally shared) expressed that India had a special opportunity for climate leadership amongst developing countries. As a more economically advanced nation, it was thought that it had a comparative advantage to tackle its climate change commitments. This could set an example for other developing countries. However, it was also thought that India may use its status as a developing country to avoid taking on more stringent climate commitments.

Priority areas for climate-friendly innovation centred on energy provision, transport, agriculture, and waste. Recent commitments by current Prime Minister of India, Narendra Modi, for India's net-zero by 2070 target, is thought to have set out

[12] Section 20(1) of the Bangladesh Patent Act.

[13] Section 17 of the Bangladesh Patent Act deals with the examination of patent applications, with the term extension added under section 17(3).

[14] It is conventionally thought that strong IPRs protections encourages technology transfer and FDI: Falvey, Rodney E, Neil Foster, and Olga Memedovic (2006). The role of intellectual property rights in technology transfer and economic growth: theory and evidence. Working Paper. United Nations Indus- trial Development Organization. https://www.unido.org/sites/default/files/2009-04/Role_ of_intellectual_property_rights_in_technology_transfer_and_economic_growth_0.pdf.

a '*road map*' for industry to respond to climate change. It was thought that climate-related goals should be the arrow that guided other development imperatives for '*food security, poverty, education and gender-centric climate action*'.

India has a high reliance on fossil fuels, placing it under pressure for energy decarbonisation. It was said that '*there is a huge carbon problem in India*', with reference made to its energy mix and significant fossil fuel subsidies. However, interviewees were positive about India's ability to make the energy transition, citing its success in the rapid deployment of solar power over recent years. Reliance on diesel generators to manage power outages were also cited as a problem impeding decarbonisation in India. Transport was also highlighted as a priority area, given rising fossil fuel prices in the fallout of the Russia-Ukraine war.

Methane produced by landfill waste was a problem area, as '*every major city in India is drowning in waste*'. In addition to household waste, major contributors to this problem include crop agriculture, such as rice and sugarcane, as well as India's fast-growing poultry market.

As a major exporter of food, agriculture was also a priority area for climate technology. In some cases, there was overlap with other climate-friendly imperatives. For instance, biogas was seen as a particularly attractive means to manage waste produced by agriculture. In turn, the by-products of biogas production could produce fertiliser for farming, much of which is currently produced using natural gas.

Moreover, India is prone to natural disasters and extreme weather, placing significant strain on agriculture, where farmers are faced with the need to manage both drought and excess water because of longer and more unpredictable periods of monsoon. Low-cost, low complexity climate change adaptation technologies are needed to manage the impact of extreme weather on small farm holdings.

The IPR system in India was thought to be well-established, but importantly India was also seen to be undergoing an ideological shift from being a nation that was conventionally antithetical to IPRs to one that maintains strong IPRs protection to promote industrialisation. It was highlighted that India is a developing country which has rapidly developed in its IPRs capacity, with reference made to its near trebling of domestic patent application filing rates. A shift in the acceptance of IPRs was acknowledged: it was mentioned that India now promotes strong IPRs protection in pursuit of industrialisation, whereas it had historically demonstrated less acceptance for IPRs protection.

India was seen as a strong advocate for IPRs policies to suit its national needs on the international stage. It was said that '*India is the most successful at having intellectual property policies that suit their national development objectives*', with reference made to the then Prime Minister, Manmohan Singh's backing of provision for compulsory licensing under the TRIPS Agreement[15] in the lead up to the Doha Declaration on public health in 2001. Similarly, India was said to be a strong advocate for access to

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[15] Agreement on Trade-Related Aspects of Intellectual Property Rights, Apr. 15, 1994, Marrakesh Agreements Establishing the World Trade Organization, Annex 1C, 1869 U.N.T.S. 299 (TRIPS Agreement).

IPR-protected substitute technologies to chlorofluorocarbons being phased out under the Montreal Protocol.

This broader shift in India's policy towards strong IPRs protection is evident in its pharmaceutical and agricultural sectors. Since the early 2000s, India was said to shift from having a strong base of generics manufacturers who manufacture off-patent drugs to increasingly having its own innovative pharmaceutical sector which is patenting its own inventions. India, initially hostile to the possibility of awarding IPRs over genetically modified organisms (GMO), has in recent years become far more permissive as it now approves more patents over GMO inventions, including a recent patent over GMO mustard seeds.

Despite being well-established, on-the-ground experiences suggest that the process of obtaining IPRs protection in India and enforcing those rights remains difficult, with relatively low levels of awareness about IPRs amongst the public. Patents were thought to be overly technical and obscure, while trade marks were deemed more user-friendly. Trade marks were therefore thought to be both more appropriate, including as a means of encouraging technology adoption. For instance, one entrepreneur offering a rainwater management mechanism for rural female farmers used a trade mark to create a brand surrounding the solution. This is recognisable, captures the inventive idea and encourages adoption amongst the poorest populations with low levels of literacy.

In terms of indigenous innovation, participants expressed the attitude that more stringent environmental regulation is needed to create demand for climate technologies. Only after the regulatory environment was geared towards climate technology could IPRs incentivise significant levels of climate-friendly innovation. However, the use of trade mark protection was thought to be more common.

The popularity of trade marks may also be related to low confidence in IPRs enforcement. Because copying levels are high and IPRs enforcement is costly, trade mark protection was thought to be preferable by comparison to designs and patents, which are more costly to register and to defend from copycats. Trade marks, by contrast, were less costly and administratively challenging to obtain, which could be used to build a consumer base of brand loyalty that gave owners an additional protection from copycats offering look-a-like products.

The time-consuming, bureaucratic nature of the court system means that users face a disincentive to pursue proceedings to litigate against copying. One interviewee resisted the traditional foundations of IPRs: they did not want to prevent copying of their invention if allowing infringement would encourage climate technology uptake. They described their approach as Gandhian innovation driven by impact and not profit, '*so that means serving the last person in the queue in the best possible way. My objective of this innovation, rather than making money or rather than earning money through patent rights, I was more eager to make the impact maximum.*'

In the context of follow-on adaptive innovation, IPRs were thought to be inappropriate incentive mechanisms because they encourage the development of higher cost, complex technology.

Indigenous knowledge and NbS were thought to be appropriate low-cost solutions. However, this form of innovation may struggle to fulfil the technical requirements of patent protection. IP law '*rewards the high tech, the novel, the expensive*', not this sort of low-cost solution. Yet it was thought that a traditional knowledge instrument under the international IPRs system could '*counter*' the incentives towards complex technology inherent in patents and designs protection.

However, the same interviewee reflected that the adoption of traditional knowledge instruments seemed a distant possibility. In addition to failure to meet the substantive requirements of patents or designs law, it was thought that these rights are unlikely to incentivise innovation in traditional knowledge, which is often community-generated or owned. IPRs were thought to be inadequately suited to incentivising complex technologies available at low cost to the poor, and poor mechanisms for adaptive innovation. The way IPRs incentivises higher cost solutions was thought to be at odds with local needs, certainly as regards solutions most relevant to agriculture or poorer communities in rural areas.

IPRs protection was identified as having some importance in encouraging FDI. It was noted that investors look to IPRs protection as a '*tick in the box*' when making their investment decisions. However, it was noted that other legal barriers than IPR-related rules impede the adoption of foreign technology in India. For instance, one of the interviewees (a foreign entrepreneur who set up business presence in India) described it being difficult to navigate the complex legal rules to set up a company in India as an outsider without local contacts or knowledge about local rules and regulations.

Consequently, regulatory and bureaucratic hurdles were seen as a barrier to FDI, which acts as a disincentive for firms from entering the market. However, it was thought that the size of the potential market in India may countervail against such reluctance to enter the market. Businesses need an on the ground presence because it gives them a network to manage bureaucratic hurdles. A local presence can take several forms, including large-scale domestic investment or working with local partners.

3.3.3 Kenya

Discussions focused on particular areas for development. These included agriculture (with a focus on food security), manufacturing, and tourism. The prevalence of energy blackouts was said to severely hamper economic productivity. On priorities for development in Kenya, one governmental official reported that a large proportion of the population in Kenya is composed of young people, such that employment and supporting entrepreneurship amongst small to medium enterprises in the '*informal sector* 'were thought to be cross-cutting priorities.

Discussions about climate technology centred around energy, transport, agriculture, and natural disasters. Most of the climate technology patent applications filed annually were technologies relating to energy efficiency or energy technologies which reduce pollution.

The progress of renewable energy in Kenya was thought to be very successful, however, Kenyan reliance on hydroelectric power was thought to be problematic as water resource constraints increase in the future. It has the capacity to expand in solar energy given its natural abundance of sunlight and in biogas amongst farm holdings. Interviewees reported pressure being placed on hydroelectric power due to increasing levels of drought, leading to water shortages affecting agriculture. In off-grid energy, there was discussion of the possibility for leap-frogging to low-cost, modular renewable energy solutions. The Kenyan government has also put in place tax relief on imports of renewable energy technologies to support its uptake.

Comparisons between leap-frogging to climate technology were made to the uptake of information technology in Kenya and the use of mobile banking solutions. Leap-frogging was also discussed in transport, where there are ambitions to meet the growth in passenger vehicles with electric vehicles. Currently, most passenger vehicles in Kenya are high emissions vehicles, with significant impacts on public health. The development of cheaper, e-mobility vehicles for urban areas was projected to become competitive with traditional vehicles using fossil fuels because the e-vehicles can be manufactured domestically, whereas many of the traditional vehicles face costs associated with imports.

In agriculture, participants expressed strong concern at the impacts of drought and desertification on various economic activities in Kenya. Each year, there are increasing levels of drought and the forest cover in Kenya has depleted to less than ten percent in recent years.

In general, participants noted that the IPRs system in Kenya was still young, with a need for greater awareness amongst the public before IP could drive innovation. IP was said to be '*legalistic*' and '*inaccessible*', not a topic which you could '*stop someone on the streets and ask them about it that they will give you an answer*'. Apart from understanding IPRs, the amount of documentation and bureaucracy in obtaining IP protection was said to prevent greater uptake in Kenya. Even amongst academic researchers, it was reported that many universities do not yet have policies on IPR arrangements associated with their research.

When asked about the conditions surrounding copying and enforcement, the environment was referred to as a '*Wild West*', with widespread copying of IPRs taking place, principally in regard to trade marks. Failure to regard IPRs protection may be attributable to the stage of development of the Kenyan economy; one participant suggested that '*Kenya has other problems to be looking after before they look at intellectual property rights*'. However, it was thought that IPRs could be important for future growth in the informal sector to provide standardisation and quality control over the goods and services offered. In general, interviewees noted a need for greater development of the economy before IPRs can become a driver of innovation.

Currently, the Kenyan IP law office pursues a goal of about 500 patent application per year, and over half of those applications come from Patent Cooperation Treaty applications. However, even those firms who seek out IP protection find that the system is protracted, complex, and not user-friendly. One entrepreneur commented that '*the process is like a mirage, it's really not clear*'. For instance, it was thought that until a patent application becomes granted, market competitors could beat the applicants and establish a market presence, defeating the purpose of patenting the invention. Principally, the paper-based nature of the IPRs registration process was thought to pose a challenge.

Further, the lack of a centralised patent application for the African continent was mentioned as a shortcoming, with comparisons made to the expedient application procedure offered under the European Patent Convention at the EPO.[16] However, there are existing regional organisations to pool resources around IPRs protection and to harmonise procedures relating to IPRs on the African continent. The United Nations Economic Commission for Africa and the World Intellectual Property Organization (WIPO) helped to set up the African Regional Intellectual Property Organization (ARIPO) in 1973 under the Lusaka Agreement[17]. To date, sixteen African nations are party to ARIPO under the Lusaka Agreement, including Kenya. Importantly, however, ARIPO does not set out a common application procedure across signatories of the Lusaka Agreement.

It may be that participant comments about a lack of harmonisation of procedures on the African continent relay a lack of awareness amongst foreign firms about ARIPO, or there is scope for possible expansion of its activities across the African continent to include a common application procedure to mirror that adopted under the European Patent Convention.

As in the other countries, Kenyan participants noted that there was a greater usage of trade marks domestically. A foreign firm in Kenya commented that they initially register their trade marks in higher-income countries because the process is faster and more streamlined, before making use of the grace period to register their trade marks in Kenya.[18] The practice of registering trade marks in a home jurisdiction before registering abroad is a relatively standard practice amongst higher-income nations. It is therefore unclear whether the fact that participants registered in their home jurisdiction first is a decision influenced by development levels or the IPRs infrastructure in lower-income nations.

However, trade marks are used by '*the key players, not the small players*'. As net importers of climate technology, there was some concern about the quality of generic imports without trade marks. These involve lower quality climate technologies with less longevity. Similarly, copyright was said to be a form of protection which is more approachable to the public, with greater uptake of those rights in Kenya.

The impact of IPRs on domestic climate-friendly innovation in Kenya was not discussed at length, perhaps because IPRs are not relevant to the state of development in Kenya or because it was said to be a consumer and not producer of climate technology from higher-income nations. The available IPRs protections do not appear particularly well-suited to the form of low-cost or non-technical solutions being developed domestically.

The established system of utility models (or '*petty patents*') in Kenya was actively used, with far more utility models applied for than patents. The associated lower

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[16] Convention on the Grant of European Patents (European Patent Convention) 1973 1065 UNTS 16208.

[17] Lusaka Agreement on the Creation of the African Regional Intellectual Property Organization (ARIPO) as amended on August 13, 2004, entered into force 13 November 2004.

[18]As to the grace period, see the Paris Convention for the Protection of Industrial Property, Art 4 (creating a 6-month period in which a trade mark applicant can claim priority from a filing in another Member State).

novelty standard involved was said to be more amenable to the inventions offered on local markets. The COVID-19 pandemic, moreover, was described as an event that instigated widespread domestic innovative activity to provide low-cost, low complexity solutions in a manner that may have interesting parallels for climate change.

Traditional knowledge and methods of preserving the natural environment were thought to be an important form of innovation, with significance to rural and poorer communities, although participants noted it was not widely used and or publicised amongst the general population. However, it was acknowledged that the relevant inventors of those solutions lack adequate awareness of IPRs, and that the available rights themselves may not be particularly well-catered to the nature of innovation in traditional knowledge.

IPRs were not at the forefront of factors that were thought to influence FDI or the decision to enter the Kenyan market. The outlook on entering the Kenyan market was broadly positive, one foreign entrepreneur noted that the environment was '*a lot more dynamic*', noting that there were less bureaucratic hurdles involved in establishing a business presence than in higher-income countries.

The existence of the IPR system was thought to bolster investor confidence, particularly by comparison to other nations in the region, however, being aware that its IPRs protections '*may not be perfect but it's work in progress*'. IPRs protection was implicated by broader rule of law concerns surrounding corruption that undermine confidence to enter the market.[19] Participants believed that foreign firms face lower infringement risks when bringing climate technology to Kenya because of its lower capacity to reverse engineer imported technologies, especially in heterogeneous, complex renewable energy technologies. By the same token, this deficit of technical expertise in Kenya poses challenges to climate technology adoption, which relies on domestic skilled labour such as engineers.

In terms of technology transfer, interviewees expressed dissatisfaction at the levels of climate-friendly technology transfer from developed countries to Kenya: it is an issue that '*constantly keeps coming up and needs to be addressed*', but that prevailing initiatives on the international stage are inadequate.

The emigration of Kenyan scientists to work towards research at foreign research institutes was raised as an area which could provide an opportunity for knowledge transfer to Kenya. However, it was thought that temporary research collaborations abroad are relatively unequal. Those projects were not designed to facilitate knowledge-sharing after completion and returning Kenyan scientists lacked the knowledge to negotiate protection over their intellectual contributions to those projects, which could have created knowledge transfer to Kenya.

Lower regulatory hurdles to market entry compared to developed countries was reported to be an encouraging factor for climate technology firms to enter the market. Technology transfer between other nations in East Africa was said to take place

[19] The Kenyan Industrial Property Institute which is responsible for IPRs protection in Kenya has a corruption prevention committee to address allegations of corruption.

informally, given the existence of communities which traverse national borders, with efforts being made to create formalised commitments to identify synergies to support technological capacity.

3.3.4 South Africa

Participants defined sustainable development as that which advances the needs of the present with future generations, but with policies that are particularised to the specific needs of the community. There was also an emphasis on rural development and employment. South Africa was described as facing a dual burden in meeting high expectations of its response to the climate emergency as the second largest economy in Africa, while being a '*poor country*' without the resources to do so at the rate expected by the global community.

Areas highlighted for innovation in climate technology included waste management, energy, and water purification, however, discussions were dominated by the prevailing energy crisis in South Africa. Coal power was highlighted as a major issue, where South Africa faces substantial pressure from the international community '*to abandon coal completely*'. Abandoning coal power would be very challenging given instabilities in the national energy grid.

Power outages were cited as a particularly pressing problem for decarbonisation. So-called '*load-shedding*' arrangements are in place to manage the stability of the energy grid, a technique whereby energy providers cut off electricity supply to groups of consumers to protect the energy grid (Faranda et al., 2007). These power outages place strain on the economy, particularly as regards the manufacturing and agriculture sectors, which are reliant on a stable supply for electricity for the purposes of irrigation or manufacturing processes. The negative repercussions of power outages on the environment relate to the widespread use of diesel generators by consumers and businesses alike to compensate for regular power cuts.

The energy crisis in South Africa has been a persistent problem for the last 15 years. In 2022, a national state of emergency was declared in relation to the instability of South African electricity provision, where approximately 288 days of electricity supply were lost in total.[20] Years of underfunding, corruption, mismanagement, and poor maintenance over the years are responsible for the instability of the energy grid.

While renewable energy takes up a small portion of the energy mix in South Africa, pervasive power cuts and increasing costs of fossil fuel to power generators are encouraging the uptake of electric battery systems. Incentives to encourage consumer uptake of renewable energy are at early stages, in a few provinces only. There was uncertainty and insufficient local knowledge about the available technologies to be able to discern what solutions best fit South Africa's needs.

The IPRs system in South Africa is relatively well-established, however, it remains relatively unsophisticated and awareness about IPRs amongst the general public was poor. Various interviewees used the terminology of IPRs protection as being

[20] Cecily Macaulay, 'Eskom crisis: What does South Africa's state of disaster mean? (10 Feb 2023, BBC) https://www.bbc.co.uk/news/world-africa-64594499 Accessed 22 Feb 2023.

'*legalistic*' rights for the elite, and that '*no ordinary people know about it*'. For instance, in activities to promote understanding about IPRs, stakeholders commented that there was a lack of understanding about core ideas, such as what the difference is between patent and copyright protection. However, there appeared to be relatively active training, capacity building, and IPRs education programmes by the South African Intellectual Property Office to promote IPR awareness. Local legal advice on intellectual property law is scarce, given the highly specialised nature of the market, with two or three firms making up the bulk of the market.

One feature of the South African patent examination is that patents are automatically granted if they meet procedural requirements, and that applications are not substantively examined.[21] One interviewee suggested that this could incentivise patent applications in South Africa, given the bureaucratic hurdles to obtaining patent protection are low. This may refer to the fact that an automatic system obviates the back and forth between patent examiners and patent applicants associated with amending patent claims during the process of obtaining a patent under a system with substantive examination. Another interviewee thought that the automatic patent grant system could reasonably attract foreign business because of its speed and low bureaucratic hurdles to patent grant.

However, it was commented that investments are currently being made at the South African Intellectual Property Office to establish substantive examination in the coming years. It is more likely that grant without examination was an interim procedure to be replaced with substantive examination as the South IPR system became more advanced. The lack of substantive examination means that applicants (and potential investors) can have little confidence in the validity of a patent should they need to try to enforce it.

Domestic innovation was not thought to be strongly influenced by IP protection, either positively or negatively. One interviewee noted that IPRs had little impact on local innovation before South Africa signed the TRIPS Agreement or afterwards. It was thought that IPRs promote development because they promote economic growth. However, in a country with a significant divide between the rich and the poor, prevailing knowledge about these rights remains concentrated amongst elites, undermining the potential of IPRs as a tool to alleviate poverty or for socio-economic advancement.

Geographical indications were thought to have a particular impact on development, as a means of recognising cultural heritage and development in rural communities, such as bead-making artwork indigenous to communities in South Africa.[22] Participants also noted that the establishment of IPRs protections in South

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[21] Substantive examination in this context refers to the legal tests that must be passed for a patent to be granted, which include the tests of novelty, inventive step, sufficiency, and support.

[22] It has been thought that geographical indications (GIs) may serve as an important part of rural development strategies: Carsten Fink and Beata Smarzynska, 'trade marks, Geographical Indications, and Developing Countries', in Development, Trade, and the WTO: A Handbook (B. Hoekman, A. Mattoo and P. English (eds), The World Bank 2002); Petra van de Kop, Denis Sautier, Origin-Based Products: Lessons for Pro-Poor Market Development (Royal Tropical Institute (KIT) and French

Africa could be impactful on promoting the uptake of IPRs systems on the African continent, with reference made to South Africa's position on the negotiation of the intellectual property law chapter of the African Continental Free Trade Agreement.

Interviewees reported substantial interest from foreign investors and international commerce in the South African market. There was said to be an unprecedented interest in renewable energy projects on the African continent, with '*a lot of investment coming in from a lot of different angles, it's definitely something I think every single person at my company can agree is something we've never seen before*'.

There was some pushback against the idea that those investments were IPR-driven, however. Another interviewee noted that there was little evidence on the impact of IPRs on technology transfer in South Africa such that one could only '*speculate*' on its possible benefits at this stage. Efforts to ensure IPRs are effectively enforced was seen to be important to bolster investment confidence, particularly as regards trade mark enforcement and the counterfeit industry. However, counterfeit goods were highlighted as a major problem in South Africa, tarnishing its reputation in international trade.

Interviewees generally agreed that IPRs were important for foreign investor confidence. However, participants also thought that claims about the impact of IPRs on FDI may be inflated given a large degree of foreign investment is not in technology. As one interviewee mentioned, investors were more likely to invest in the South African mining industry rather than in science and technology. While commodities markets are still a large proportion of the economy, the existence of strong IPRs protection may carry less weight for international investors because they are not investing in technology per se.

3.4 Discussion

Having described the country-by-country findings, this section outlines the common themes that emerged from the interview data, including conceptions of sustainable development and its relationship to climate change (Section 3.4.1), the impact of IPRs on domestic indigenous and adaptive innovation (Sections 3.4.3-3.4.4), and the role of IPRs in technology transfer and FDI (Section 3.4.2). This section concludes with an outlook (Section 3.4.5).

3.4.1 Sustainable development, IPRs, and climate change

Participants offered differing conceptions of sustainable development, although these were broadly aligned with the most common definition as set out in the UN Sustainable Development Goals (SDG) defining it as '*development that meets the needs of the present without compromising the ability of future generations to meet their own*

Agricultural Research Centre for International Development (CIRAD), Amsterdam 2006). However, any such initiatives must recognise that any policies for GIs derived from developed countries must be specifically adapted to the needs of developing countries, including issues such as resource constraints: Sarah Bowen, 'Development from Within? The Potential for Geographical Indications in the Global South' (2010) 13 The Journal of World Intellectual Property 231.

needs'.[23]

Most participants saw climate change as a cross-cutting theme implicated in all economic advancement. They stressed that climate action was necessary for economic growth in the long run. Sustainable development *'puts the environment and the social dimension first and the economy second, and that's it'*. The minority thought *'you need to have economic growth and income growth to be able to afford resourcing other goals'*.[24]

Variation in conceptions of sustainable development related to the economy of the countries. For instance, participants in Kenya and Bangladesh prioritised climate change issues, which may be because of their relatively lower development levels and high vulnerability to climate disasters. For instance, Bangladesh is one of the most disaster vulnerable nations in the world, and disasters have significant socio-economic consequences (Shah Alam Khan, 2008).

South African and Indian interviewees framed sustainable development around the *'green economy'*, job creation and economic growth. It was about considering industrialisation's costs *'vis-à-vis the local population, the human environment, the plant environment'*. This framing may be because they are more advanced economies reliant on fossil fuels who need to transition from traditional energy sources towards clean development.

Participants noted that expectations from higher-income counties brought climate change and development into conflict. On the need to phase out coal, a participant noted that *'the demands have been from the global community...[but] we may have our own unique needs as South Africa'*. This was a clash between *'global demands versus the local ones'*.

It was thought that higher-income countries should support developing countries more because they have greater resources and have produced the most historical emissions, including support for loss and damage mechanisms. Participants in Bangladesh, for instance, used the terminology of being a *'victim'* of climate change: a nation experiencing its effects while not responsible for the bulk of greenhouse gas (GHG) emissions.

A common theme was also how the economic shock of the COVID-19 pandemic and the war in Ukraine affects action on climate change. It was said that *'the main priority for the economy and development for Bangladesh in the coming decade is perhaps first of all to ensure sustainable macroeconomic equilibrium in the post-COVID recovery'*. On the war between Russia and Ukraine, it was said that *'I can tell you the effects are felt in Kenya'*, or that *'fuel pricing is now the highest it's ever been in India'*.

Another critique of development was levelled at the NDC towards emissions reductions as part of the common but differentiated responsibilities (CBDR) under

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[23]This is the most common definition, as set out by the World Commission on Environment and Development entitled Our Common Future in 1987: Jennifer Elliott, An Introduction to Sustainable Development (Taylor & Francis Group 2012) 8.

[24] The burden of climate change adaptation is known to have unequal impacts on women: Margaret Alston, 'Women and adaptation' (2013) 4 WIREs Clim Change 351; Geraldine Terry, 'No climate justice without gender justice: an overview of the issues' (2009) 17(1) Gender 5.

the United Nations Framework Convention on Climate Change (UNFCCC). The country-by-country basis of NDCs to reduce emissions was critiqued as *'the collapse of international solidarity'*. This structure places the burden on individual nations. One participant argued that a single, global goal would have galvanised more support from higher-income nations to support developing countries.[25] Effectively, the NDCs create particularised obligations based on development levels first, weakening overall climate ambitions, and creating less conditions for international solidarity on climate action. This development first focus can lead to *'business as usual'* context in certain parts of the world.

Relatedly, the global and non-mandatory obligations under the UNFCCC were criticised. One participant noted that after many meetings of the Conference of the Parties (COP), that *'we have not come anywhere, really'*. Another participant stated, *'Every time there was an agreement, it was by the skin of the teeth with a lot of wishy-washy language which anybody could interpret as anything. You could drive a truck through that language. But that was the only way you get an agreement. That's meaningless. It's totally meaningless.'*

These criticisms were also targeted towards the Paris Agreement.[26] In general, its reception amongst interviewees was not positive. The Paris Agreement was not thought to have encouraged much domestic action on climate change. On their compliance with the Paris Agreement NDCs, interviewees in Bangladesh and Kenya were positive, whereas participants in India and South Africa were not.

The Paris targets were criticised because they focus on emissions reductions, disregarding issues which disproportionately affect developing countries, including the preservation of natural habitats, biodiversity loss, and disaster risk reduction.[27]

The COP meetings were seen as *'high profile discussions'* formed by the interests of *'big companies'* and higher-income nations. Developing countries said they are not *'the actual players'* in COP discussions. The current *'focus on greenhouse gas emissions as opposed to focusing on all the different environmental dimensions arising in the case of climate change'* is incapable of providing a *'comprehensive solution'*. It was thought that the current *'climate change debate itself is all about energy policy, all about economic development policies as if biodiversity was a completely different world'*.

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[25] The architecture of the CBDR under the UNFCCC has faced significant academic commentary, as the CDBR mechanism effectively gives lower-income nations a *'right to pollute'* because of their development levels, when alternative arrangements could have been agreed, such as a system that places obligations on higher-income nations to support emissions reductions in less developed nations: Christopher D. Stone, 'Common but Differentiated Responsibilities in International Law' (2004) 98 American Journal International Law 276, 293–294.

[26] UNFCCC, Decision 1/CP.21, 'Adoption of the Paris Agreement' (29 January 2016) UN Doc FCCC /CP/2015/10/Add.1, Annex (Paris Agreement). The Paris Agreement is a binding treaty under Article 2(1)(a) of the Vienna Convention on the Law of the Treaties (signed 23 May 1969, in force 27 January 1980) 1155 UNTS 33.

[27] The Paris targets have been referred to as a 'focal point' to coordinate a variety of activities to safeguard the environment: C Jaeger and J Jaeger, 'Three Views of Two Degrees' (2010) 1(3) Climate Change Economics 145.

This does not reflect how climate change is perceived holistically in developing countries. As one participant noted, *'we believe earth is a mother, we never consider earth as a service provider, which is the common parallel in the COP summit'*. The 2022 biodiversity COP was cited as a promising development towards a holistic approach to climate change. Proposals for a loss and damage mechanism and compensation for non-economic loss and damage were thought to be a first step in that regard, but do not respond to the structural elements of the UNFCCC which guide the governance of the climate crisis.

Discussions about sustainable development also centred on how well multilateral frameworks relating to climate change and to intellectual property law are aligned to meet the needs of developing countries. Interviewees raised the architecture of the TRIPS Agreement, noting that it differs from that of the UNFCCC, such that these treaties enshrine different approaches to development. In principle, the goal to harmonise intellectual property law internationally under the TRIPS Agreement is to operate on a flat, uniform basis that does not treat signatories differently according to development levels.[28] By contrast, the UNFCCC is *'framed largely around that Global North-Global South equation as opposed to the IP treaties that seeks the one-size-fits-all universal model'*.

An expert experienced in the international intellectual property law system explained the architecture of the TRIPS Agreement in more detail. That is, development occupies a secondary position because the TRIPS Agreement was initially founded on the principles of trade liberalisation and globalisation, an outlook which equates development with economic growth. This ideology, associated with the Washington Consensus, was said to be at the foundation of related multilateral organisations, such as the World Intellectual Property Organization (WIPO).

WIPO was described as a *'bargain'* between the developed and developing countries: *'The best way to describe WIPO is that it's an organisation of primary interest to developed or advanced countries because they are the one with the technological basis to use intellectual property...In that multilateral environment, you can't have an agenda which is of primary interest only to one group of countries. It has to be a composite agenda, and so that is the cost, if you like, for developed countries of having an international organisation that is universal.'*

Echoing the same sentiment, another participant gave the example of the stalemate at WIPO on the adoption of a broadcasting treaty which has lasted the past fifteen years to illustrate the difficulty in reaching *'common ground because of the different levels of development of the countries involved'*.

Acknowledgement of the differences in development levels between countries was not thought to be adequately integrated into the foundations of the TRIPS Agreement

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[28] While the architecture of the TRIPS Agreement is designed with full international harmonisation of IPRs as its goal, special arrangements are in place for least developed countries, including an extended transition period to become compliant with the obligations of the TRIPS Agreement under Article 66.1. The deadline for the transition period was extended in 2021 to 1 July 2034, and has previously been extended twice before.

or WIPO, whose agendas emerged from higher-income nations. Rather, development was confronted in the aftermath of the decolonisation movement, as newly independent nations challenged the IPR framework as a perpetrator of developmental divide.[29] The inclusion of the Development Agenda, adopted by the WIPO in 2007, reflects a pivot from the longstanding free-market ideology of the Washington Consensus (Netanel, 2009). However, the Development Agenda occupies a secondary position in WIPO's activities, setting out a series of recommendations for development, rather than forming a key part of its mandate.

The second feature at the forefront of discussions about international IPR protection and climate change was regarding the faltering cooperation at the WTO amidst broader failures of universal multilateralism. Again, development was a source of division in this sphere. A participant noted that, *'I think that we are going through a phase. . . where universal multilateralism, for norms at any rate, is not working. It's very difficult, and it's not any particular group's fault. . . you see a proliferation of plurilateral arrangements and agreements, and it's not unrelated to the decoupling with China and the alliance multilateralism that the United States is pursuing to have its own arrangements for the Indo-Pacific and so on . . . it's going to be difficult to see how something can do that in this climate where the world can't agree on anything.'*

Fragmentation also referred to a lack of alignment between the goals of the UNFCCC and the WTO: the idea that overlaps and *'synergies'* between the objectives of the climate and trade treaties are not being developed. Participants noted that both the UNFCCC and the TRIPS Agreement provide obligations on technology transfer, but without any interpretive aids as to how those provisions are to interact.

In addition to synergies, there was the potential for conflict between TRIPS and the UNFCCC. One participant referred to existing obligations on climate technology transfer enshrined in the UNFCCC, as well as other international agreements, including the Convention on Biological Diversity.[30] However, any such conflicts cannot be addressed due to the lack of hierarchy between treaties or any other provision in place about how to deal with their common subject matter.

At another point, international obligations on ITT were described as aspirational or theoretical, as ideas which were '*nice for classroom discussion*' but not issues which were being actioned. Failures of international cooperation under multilateralism were a background factor that framed discussions about the impact of the international IPR system on climate-friendly innovation in developing countries, which are discussed in the following sections.

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[29] For an overview of how this debate affects discussion of technology transfer in relation to climate technology, see: Jérôme de Meeûs & Alain Strowel, 'Climate Change and the Debate Around Green Technology Transfer and Patent Rules: History, Prospects and Unresolved Issues' (2012) 3 World Intell. Prop. Org. J. 179.

[30] Articles 4(1)(c), 4(3) and 4(5) of the UNFCCC set out obligations on higher-income nations for ITT of climate technologies. The participant also referred to Article 16 of the Convention on Biological Diversity.

3.4.2 Technology transfer and foreign direct investment

It was thought that having IPRs protection created the right conditions for ITT and FDI. However, none of the countries studied reflected the view that sufficient levels of technology transfer are effectively realised.

Participants directly resisted the view that IPRs posed a barrier to ITT. The example of China and its leadership in solar energy was discussed in this context, '*IPRs really hasn't been a big barrier to diffusion of innovation…I think, you know, the best example would give you is for China to be able to become a leader in solar photovoltaics and clearly there wasn't a lot of IP there holding back their ability to become the key manufacturer in solar*.' However, it was not explicitly discussed that the lack of enforcement of IPRs may have contributed to the fact that IPRs have not been a barrier to China's technological catch-up.

Participants expressed that *'all the studies'* show that the adoption of IPRs systems increases technology levels. Having an IPRs system makes investors feel *'safe'*, provides foreign businesses with *'more security than just a market lead'* domestically, and that having IPRs protection in a developing country is *'a big tick in that box as part of the investment decision'* for international investors.

Despite these general comments about the necessity of having IPR protection, participants noted that the full benefits of ITT and FDI were not yet realised. The international harmonisation of IPR under the TRIPS Agreement has not *'automatically translated into all these wonderful goodies'* for developing countries but is seen as *'a process'*. The participants from Kenya and Bangladesh indicated the low relevance of IP at their stage of development as an explanation. It was thought that a certain level of development must occur before those benefits accrue, but that IPRs in and of themselves were not driving development. These findings are consistent with the literature discussed in Section 2.2 that reports positive associations between IPRs stringency and FDI, which are much weaker or insignificant in countries with a low level of development.

Participants noted various flaws associated with technology transfer obligations under existing international legal frameworks. Article 66.2 of the TRIPS Agreement places an obligation on higher-income nations for technology transfer, including the transfer of climate technology. Article 67 also requires developed countries to provide technical and financial assistance to facilitate the implementation and enforcement of IPR protection in developing countries. One issue highlighted with Article 66.2 is that it only applies to LDCs as recognised by the WTO, who are unlikely to have the local innovative capacity or resources to make use of technologies from higher-income nations.[31]

Moreover, there is no systematic process for climate technology transfer. Many of the initiatives, which are said to fulfil Article 66.2 obligations, can be taken to fulfil pre-existing commitments as part of other development or climate-related obligations. It was suggested that the same technology transfer initiatives that go

[31] 35 of the 46 LDCs on the United Nations List are WTO members: WTO, 'Least-developed countries' https://www.wto.org/english/thewto_e/whatis_e/tif_e/org7_e.htm>LastAccessed14March2023.

towards TRIPS obligations could count towards obligations under the UNFCCC framework for climate technology transfer.

Another explanation for the lacking realisation of the benefits is that higher-income nations are not perceived to have made genuine attempts to use technology transfer as a capacity-building tool to develop innovation systems in developing countries. It was said that *'they give us some technology, give us some training, capacity building and not the technology transfer in the proper manner'*, or that *'it's the company coming, whether from the States or from the United Kingdom, coming and establishing itself, and it's not really a transfer of technology'*.

It was commented that if pre-existing commitments towards technology transfer under Article 66.2. had been met and had built up genuine innovative capacity in developing countries that the COVID-19 crisis would not have been so devastating. Rather, developing countries would have had innovation systems in place which would have enabled them to produce vaccines.

It was also thought that FDI was not technology-driven, that it was more oriented towards commodities markets. Because foreign investment from higher-income nations is not targeted at innovative activities, it is in that sense not *'IP-driven'*. The presence of a large mining industry in South Africa, for instance, means that much foreign investment is dedicated towards mining projects to meet demand for coal in countries such as China, rather than investment in cleaner forms of energy production.

Conversely, even where FDI related to climate technology, this was also deemed as having certain problematic implications. For instance, the resourcing of commodities such as lithium for renewable energy technologies or electric vehicle batteries in developed countries was criticised. These activities encourage more waste because components such as lithium are not easily recyclable and more environmental degradation because they promote extractive mining practice. In essence, having *'moved from something that was going to be clean and sort out the problem to creating another problem'*.

Even though ITT relies on various enabling factors to be effective, the main barrier interviewees raised regarding ITT was cost, not IPRs protection. It was said that *'at the end of the day, the key constraint to developing countries is cost'*. Of course, IPRs are a factor that determine the cost of climate technology because these exclusive rights enable IPRs owners to use monopolistic pricing to make technology more expensive. Comments on the cost of climate technology suggest the issue of affordability went beyond IPRs protection to costs associated with buying technologies as final products from higher-income nations. These costs apply to both IPR-protected technologies and those whose IPRs protection has lapsed.

Moreover, IPR costs account only for a small fraction the costs of climate technology, next to costs for materials, labour, and production in higher-income countries, leading to expensive products. One interviewee noted, the costs of raw materials will be roughly the same, regardless of where a climate technology is produced. Higher-income nations import those commodities. If climate technologies were produced in developing countries, labour costs may not be necessarily much cheaper given a scarcity of expertise or local innovative capacity.

However, climate technology from higher-income nations is likely to be more expensive to procure due to tariffs, as well as operational and maintenance costs which may not suit the capabilities of developing countries. The issue of cost goes beyond IPRs protection, in essence, because most climate technology is developed within and produced by developed countries (Jee and Srivastav, 2022).

Beyond the issue of purchasing technology, access to finance was mentioned as a barrier to technology transfer. An interviewee gave the example of the large-scale investment that is needed to develop a solar energy plant, which requires *'an upfront investment for asset lifecycle of say 20 to 30 years'*. The public sector in most developing countries is incapable of providing the resources to support such large-scale investments. However, it is unlikely that this statement applies to the case of India or South Africa. Particularly the cost of energy technology was thought to pose challenges given it involves such a high upfront capital expenditure. These statements reinforce the idea that the costs associated with climate technology are not reducible to the ability to engage in monopolistic pricing due to IPRs protection.

ITT between different lower-income countries was not discussed at length, and appeared to be a nascent development, or at least a process that was not being conducted in a formalised manner. This finding is supported by the empirical literature on this topic (Dechezleprêtre et al., 2011; Corvaglia, 2014). For instance, technology transfer between Kenya and neighbouring nations is occurring informally through trade between communities that straddle national borders.

The heterogeneity of climate technology also poses a barrier to technology transfer between developing countries, but perhaps not to transfer within the same region. Adaptation technologies for agriculture developed in one country may have benefits for neighbouring countries with similar climates or agricultural patterns. It was thought that there was need for regional capacity-building amongst developing countries to scope out possible synergies because *'what works in Bangladesh may also work in Sri Lanka'*. However, there are no formal initiatives to coordinate these practices and there is little record of these activities to understand their scale or efficacy.

It seems that participants believed IPR protection to be a necessary enabling mechanism to attract foreign firms, which would have benefits in the long-term. However, they critiqued its practical impacts in the short-term. Interestingly, faith in the long-term importance of IPRs as an enabling mechanism was at odds with the experience of participants thus far. For example, a participant in Bangladesh noted that there are *'very few companies that have moved away from this area of the world because of lack of intellectual property rights'*. One way of accounting for this apparent dissonance is that IPRs should be understood as *'part of the enabling factors'*. These enabling factors include a commitment to the rule of law, a strong business case for entering the market, possibilities for entering reliable local partnerships, and low bureaucratic hurdles. However, the differential views on the impact of IPRs on FDI may be reconciled by the fact that the impact is contingent on the level of development, as also found in the literature (Section 3.2).

The need to reduce counterfeiting was a high priority in all the jurisdictions studied. One interviewee also raised the environmental impact of counterfeits, specifically, obligations on government agencies to seize and destroy vast quantities of counterfeit goods each year. Concerns about copying, however, were not extended to patents, designs, or trade secrets because it was thought that developing countries lacked the capacity to reverse engineer technology. In any case, even if technical inventions are being copied, it is unclear that those inventions are IPR-protected, given the low levels of patenting in the jurisdictions studied. Lack of knowledge about IPRs was again raised to explain why counterfeiting was such a problem. This suggests that knowledge and cultural barriers around enforcement and copying may be stymying the development of more stringent local IPRs protection and enforcement.

While participants did not make positive evaluations about formal technology transfer initiatives, the existence of leap-frogging activities is a positive indicator for the potential for rolling out low-cost, modular climate technologies. One interviewee noted that there were strong opportunities for leapfrogging in renewable energy technology, given the existence of older generation technology which had become much cheaper, stating *'why would you need to build a coal-fired power plant if you can achieve the same with a renewable plant that is more efficient and less costly to you?'* Leapfrogging was occurring, for instance, in renewable energy, especially in off-grid energy, and as in e-mobility solutions for urban areas.

Plummeting costs and the emergence of modular solutions has lowered the barriers to the adoption of renewable energy in rural regions in developing countries.[32] Developing countries rely less on existing fossil-fuel intensive infrastructure surrounding energy provision, promoting the adoption of renewable energy, without involving a transition away from traditional sources. For instance, the rapid uptake of mobile telephone technologies in lieu of traditional landline-based communications is frequently lauded as a leapfrogging success story on the African content, and as a shift which has promoted development in the region (Aker and Mbiti, 2010). Mobile applications for microfinance and flexible payment systems make renewable energy and battery technologies more accessible, which previously involved high upfront installation costs.[33]

Another finding regarding technology transfer was the role of China as the main producer of climate technology for developing countries (Urban, 2018). It was noted that China is quickly becoming the leading manufacturer of solar PV, being instrumental in driving down production costs. Chinese mass-produced battery technologies are being imported for sale under local brands. The presence of Chinese FDI was especially strong in African nations; one participant went so far as to say, *'China is doing more for Kenya than any multilateral organisation'*.

Participants expressed concern about developing countries becoming *'dumping sites'* for low-cost, lower quality climate technologies exported from China. The

[32] Barriers forecasted include factors such as cost, local technical capacity and know-how (Murphy, 2001).

[33] Installation is often a significant component in the costs of electricity supply (Bhattacharyya, 2019). The prevalence of mobile technologies is said to have led to broader financial inclusion in regions of Africa because mobile money solutions are thought to be more accessible than traditional banking (Ahmad et al., 2020)

quality of these mass-produced, non-IPRs protected solutions was thought to be dubious. As net importers of climate technology, trade marks, and branding were said to be important markers of quality. Beyond the quality of Chinese exports, various interviewees expressed concerns about emerging markets with lower quality climate technologies being imported to developing countries more generally.

3.4.3 Indigenous innovation

IPRs cannot, at least yet promote significant levels of local climate-friendly innovation in developing countries. In all the jurisdictions studied, barring India, the majority of IPRs protection filed for domestically was thought to come from foreign firms not local innovators, a finding which is reflected in the empirical literature on this topic (Corvaglia, 2014).[34]

Developing countries face a dilemma in terms of attempting to use IPRs to promote climate-friendly innovation because IPRs require a certain level of development to promote innovation (Kim et al., 2012). Moreover, in at least two of the countries studied, it appears that existing IPR and the broader innovation eco-system are still too underdeveloped to promote significant levels of climate innovation. In Kenya and Bangladesh, where IPRs registration systems are paper-based, with low levels of awareness amongst the public, and few IPRs applications per year, it is difficult to imagine that IPRs promote climate technology development when the role of IPRs in those innovation systems itself is still emerging. As one interviewee stated, *'intellectual property comes after technological development'*. In general, the findings reinforce the idea that IPRs are an enabling mechanism within a well-functioning innovation system rather than a mechanism that induces R&D.

Comparing India with the other nations studied, one might expect this much more established IPRs system to promote more climate-friendly innovation. However, interviewees did not attribute high levels of innovation to IPRs. In India's case, a lack of innovation in climate technology likely has more to do with the broader innovation system, including inadequate environmental regulation, which does not create sufficient incentives to develop or adopt climate technology.

In this context, IPR protection appears to be a mechanism that supports the existence of a climate-friendly innovation system once other incentive mechanisms to orient technological change towards the climate are in place. On IPRs in Kenya, it was commented that *'innovation has always been there, it's the law that is coming now'*. Another interviewee noted that IPRs protection only becomes relevant once policies to create demand for climate technology are in place. From these two statements it can be inferred that IPRs are an enabling mechanism, particularly as regards technology commercialisation and adoption. But it is only efficacious in the presence of other policy levers to promote climate-friendly innovation.

Certain IPRs are used more widely in all jurisdictions, particularly, trade marks and utility models. Usage of these rights may reflect the state of economic

[34] Despite increasing patent filing rates in lower-income nations, this innovation is often not indigenous, with many filings coming from foreign innovators (UNEP, EPO and ICTSD, 2010).

development in those nations. One interviewee commented that in all economies, the uptake of IPRs systems follows a common trajectory as the economy advances: *'you start with trade marks, inevitably, because trade marks have existed since markets existed... slightly later when markets start to develop... you look at utility models and patents'*. It was said that *'trade marks are more commonly used in every poor country'*. Trade marks may be a particularly attractive mechanism for promoting innovation in climate technologies in developing countries, as these IPRs can protect low-cost, low-complexity solutions. This can be deployed at scale because they are accessible to larger, poor populations.

Trade marks are also attractive because they may be more suited to local levels of knowledge about IPRs and weak enforcement conditions. Trade marks may promote the adoption of adaptation technologies in rural communities by creating a brand or an easily communicable idea around a solution that helps that idea promulgate. In the example of an agricultural solution given earlier, we saw that trade marks can encourage technology adoption amongst the poorest population with low levels of literacy. While trade marks do not prevent copying of the product or technology, the use of trade marks builds a consumer base around brand loyalty. Moreover, the procedure for trade mark registration is more straightforward and established compared to other IPRs.

3.4.4 Follow-on adaptive innovation

Participants reflected positively on the use of utility models as incentive mechanisms for low-cost, low complexity climate technology. Low-cost climate technology may be more easily procured, and it is more conducive to adoption on the ground. For instance, one interviewee referred to oral saline technology for the treatment of diarrhoea as an example of a highly impactful technology which can be easily deployed in lower-income nations.

At the same time, low-cost, simple solutions are unlikely to fulfil patent protection and thus utility models may be an appropriate incentive mechanism for low-cost inventions. One interviewee reported that to obtain utility model protection, inventions need *'not necessarily supposed to be inventive, but they can be at least new'*. It was thought that it was hard to balance the needs of those technologies being low-cost, simple, and sustainable. For instance, plastic bottles containing water are used as a source of light on rooftops in poorer communities without electrification, and yet, that solution is not long-lasting, and it is likely to be difficult to control the disposal of plastic bottles after use.

There are various drawbacks that follow this line of reasoning. For one, the use of cheap or readily accessible materials in follow-on adaptive innovation may conflict with sustainability. Moreover, while there are certain benefits to the deployment of utility models in lower-income nations, previous studies have identified drawbacks to these mechanisms. A lack of substantive examination creates conditions of legal uncertainty and higher infringement risks, and there is no guarantee that utility models induce higher rates of local innovative activity, which may instead be registered by foreign firms (Suthersanen, 2006).

IPRs for more complex, technical solutions such as patents or designs, by contrast, may be less suited because they reward high complexity innovation which can be less suited to the needs of developing countries. The substantive requirements of patent law necessitate the presence of certain levels of technical complexity, and the expense of procuring formal protection means that patents typically incentivise expensive, complex solutions[35]. The novelty standard in patent law may be a particular barrier to climate-friendly innovation in developing countries, a topic that was raised in interviews and reported in the literature (Dreyfuss and Benoliel, 2021).

One of the requirements for patent grant is that the invention is novel. To be novel, it must not form part of the prior art, that is, the invention must not conform to the stock of pre-existing inventions. For inventions that fail the novelty test, it is often said that the prior art *'discloses'* the invention; the invention is traceable from the prior art. The novelty standard may impose a burden on developing countries because it is a global, absolute standard. In most nations, disclosure in one part of the world is sufficient for that disclosure to form part of the prior art, against which all patent applications are judged for the novelty standard.[36] In practice, the novelty test therefore sets the level of technological advance in higher-income nations as the benchmark for which the standards of patentability in developing countries are judged, in what has been termed the *'novelty trap'* (Dreyfuss and Benoliel, 2021).

The novelty trap has problematic implications for local climate-friendly innovation, particularly, as regards adaptive innovation or low-cost, low complexity technologies that could improve social welfare because they will fail to meet the novelty standard. As one interviewee stated, the '*IP system can provide some protection for innovators at the expense of things which may be easier, cheaper, whatever may be more adapted to the Global South*'. Another interviewee referred to the problem of counterfeiting in Kenya as evidence that IPRs fail to promote low-cost innovation.

It was thought that locals would not copy IPR-protected innovation if it was affordable, and that the point of obtaining IPRs protection is that it facilitates monopolistic pricing, such that IPRs are simply the wrong tool to promote low-cost innovations. The burden of this higher novelty requirement on low-cost, low-complexity innovation supports the idea that utility models may be important forms of IPRs protection for climate-friendly innovation.

The impact of the novelty trap on adaptive innovation is problematic, while much foreign climate technology is too complex or not sufficiently suited to local needs for adoption without modification (see also Section 3.3.2) (Raiser et al., 2017). One interviewee commented that even if inability to obtain IPRs protection over low-tech

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[35] IPRs are poor mechanisms for 'frugal innovation; low-cost, fast innovative activities that occur under resource constraints in lower-income nations (Radjou et al., 2012). To exemplify the idea that IPRs only promote expensive technologies, the writers give the example of a healthcare checklist as the sort of low-cost, low complexity invention with great social benefits that intellectual property law does not reward (Kapczynski and Syed, 2012).

[36] WIPO also collated data on the novelty and prior art policies of several Member States, finding that in most cases, disclosure anywhere in the world forms part of the prior art: WIPO, Information Provided by the Members of the Standing Committee on the Law of Patents (SCP) Concerning the Definition of Prior Art Brief Summary, 6, WIPO Doc. SCP/6/INF/2 (Nov. 2, 2001).

solutions may not impede local innovation, it may prevent the uptake of those technologies internationally: *'[w]e have many high-tech solutions in rich countries but what's needed are low tech solutions, but if there is a barrier to protect these inventions and if [IPR] isn't a barrier to local development, then it might be a barrier to upscaling green technology diffusion'.*

An example given was that of the e-mobility sector, where the existing solutions have had to be adapted to local needs, using Internet of Things technologies to have the *'agility'* to fit consumer needs. IPRs, if impeding such activities to adapt technology locally, may impede climate-friendly adaptive innovation.

Of course, there are forms of adaptive innovation which IPRs do not impede, including organisational and service innovations which are not capable of IPR protection. Interviewees noted that the availability of low-cost renewable energy solutions was facilitated not only by technical advances, but by frontend and service innovations in renewable energy supply. This includes service-based or subscription-based means of accessing renewable energy, using mobile technology for lease-to-own arrangements over the installation of distributed renewable energy, or pay-as-you-go services to cover the costs of supplying solar energy. It is not clear that IPRs are particularly relevant to such developments and are not necessarily impeding such adaptive innovation.

3.4.5 IPRs, climate change, and development: outlook

The research findings can be summarised as follows. First, IPRs do not appear to form a significant barrier that prevents developing countries from achieving their climate goals. While interviewees did express some concern that the increased cost of climate technology covered by IPRs posed a barrier to accessing technology, in most cases, there were other more significant barriers that would have prevented access even if IPR-based barriers were relaxed. Lower development levels and underdeveloped local innovation systems appear to be the main barrier to climate-friendly innovation. To the extent IPRs pose a barrier it is more in terms of lack of knowledge and low usage of IPRs in developing countries. However, IPRs were not described to actively impede climate-friendly innovation.

This finding is undergirded by the fact that IPRs systems play only a minor role in local innovation systems. Domestically, a lack of awareness about IPRs, the irrelevance of IPRs to low-tech, nature-based technologies, low levels of IPRs enforcement, and copying predominate. Moreover, IPRs did not appear to be relevant to foreign firms in developing countries. By and large, this was because foreign firms were not engaged in technology-driven business in those jurisdictions or because the business case for entering the market countenanced their low expectations surrounding the efficacy of IPRs protection.

Firms who cited that IPR protection is important for their investors explained that they tended to obtain IPR protection in higher-income nations to attract investment, while entering developing countries with the knowledge that any domestic IPRs may not be effectively protected. In this sense, foreign firms appeared to adopt a pragmatic stance, being aware that IPRs protection was weak in developing countries and adapting their business operations to work around those issues.

Relatedly, both foreign and local firms stressed that local innovative capacity typically did not compete with the technology of foreign firms, which was more technologically advanced (although this was less true for India and South Africa). In sum, interviewees suggested that IPRs are not a significant barrier to climate-friendly innovation in lower-income nations.

Second, the benefits of IPR systems in developing countries are not fully realised. Technical cooperation measures could be to develop the role of IPRs in local innovation systems. Such proposals may target trade marks and geographical indications as an entry point to teach domestic firms how to effectively benefit from IPR. There is also a need to promote adaptive innovation, including the visibility of domestic climate technology as it is often more suited to the local context, as well as incentive mechanisms such as utility models to promote these activities. Awareness and accessibility programmes will need to be develop. There is also the need to re-examine the impact of international standards on local conditions, including the possibility of the novelty trap impeding climate-friendly innovation.

The third finding relates to the precarious nature of universal multilateralism and the need to use international instruments in a concerted effort to promote trade, development, and climate change. The principal issue is the need for greater global cooperation to alleviate global problems. When discussing the outlook for the future, lessons learned from the pandemic were used to frame the challenge ahead. For many, the pandemic highlighted the failure of multilateralism and global cooperation, where IPRs created conditions for higher-income nations to secure the bulk of vaccine doses. The extent of unequal access to vaccines was described pithily: *'if you're not from Europe, if you're not from America, if you are not from China or some of those big countries, you might as well go without the vaccine'*. The pandemic demonstrates the necessity of *'putting global interests before national interests'*.

COVID-19 vaccines were described as technologies with *'a public goods dimension'* calling for special measures to procure widespread access. IPRs were generally thought to be a barrier to the dissemination of vaccines, particularly, in India and South Africa, where there was thought to be adequate manufacturing capacity to produce vaccines. The limited waiver over patent rights was not expected to ameliorate this problem.[37] Discussions about the debates about IPRs and COVID-19 vaccines gave way to considering the responsiveness of the TRIPS Agreement to crisis, in the context of ongoing discussions at the World Health Organisation of a potential *'pandemic treaty'*.

Moreover, participants reflected that existing mechanisms under the TRIPS Agreement hinder climate-friendly innovation for the benefit of developing countries, but that the discussions of IPRs waivers in recent years would be of little assistance to developing countries. In broad terms, it was thought that access to technology was a common problem posed by the pandemic and by climate change.

However, differences between these crises were highlighted, it being noted that

[37] Amy Bounds, 'WTO agrees partial patent waiver for Covid-19 vaccines' (Financial Times, 17 June 2022) https://www.ft.com/content/9cfa15b6-dab8-4cc6-9ab4-c192c6ad0e0b Accessed 23 February 2023.

'climate change isn't like COVID, it's doesn't get the same sense of urgency' and that climate change is an *'abstract, global goal... where it's all slow and steady, where the implications of this is all in the long term'* whereas COVID-19 is an *'immediate emergency'*. One framing for these differences is to contrast climate change as a chronic emergency with COVID-19, an acute crisis (Burrell and Kelly, 2021). Consequently, participants thought the policies of the pandemic may provide a poor blueprint for climate technology transfer to developing countries, highlighting three key differences between both scenarios.

First, unlike medicines, climate technology is less amenable to being imported to developing countries because it might *'be more efficiently made in the country of consumption, it's not like medicines which are very low volume, and they can be made in one place in the world and exported everywhere else by flight'*. The increasing domestic manufacturing capacity in South Africa and India may bode well for future climate technology production. During the pandemic, by contrast, one of the key arguments against the waiver was the lack of advanced manufacturing capacities to produce COVID-19 vaccines or the required storage facilities (Hilty et al., 2021). This has not proven to be the case in India and South Africa, which are now manufacturers of COVID-19 vaccines. While Bangladesh or Kenya may lack such capacity, participants suggested that they may have capacities to produce mature climate technologies such as renewables.

Second, amongst climate technologies, there is not one life-saving drug, but a *'handful of keys'* to solving the problem: *'it's not like a molecule which provides a silver bullet'*. Compared to vaccines and other COVID-19-related innovations, most climate technologies involve a relatively greater complexity, such as different component *'connections between multiple batteries and so forth'*. There may be several patents or other IPRs over a single climate technology (Fair, 2009). This undermines the idea that the IPRs reform proposals for vaccines or technologies associated with COVID-19 have salience for climate technologies.

Third, there are far more actors involved at every stage of climate technology innovation, presenting more of a competitive market than in the context of COVID-19 vaccines. This means that more substitute technologies available amongst the variety of technologies needed. These factors make it unlikely that IPRs protection can prove a barrier to accessing climate technology; the variety of actors and technologies involved undermines the possibility that owning a single IPRs creates the monopolistic conditions seen during the pandemic.

Moreover, the maturity of certain climate technologies such as renewable energy means that many of these solutions no longer have formal IPRs protection. IPRs have expired over many older solutions, which are now available in the public domain; for *'solar panels, you don't need to use the latest thing, but you can use something that where patent has run out and still disseminate that at scale'*. These inventions are therefore available for use in developing countries at no cost.

Of course, solutions in the public domain due to expired IPRs will not be the most advanced solutions, nor does the free use of those solutions automatically translate to their usage in developing countries. Developing countries may lack the funds or technical expertise to adopt those technologies, and off-patent solutions from developed countries may be unsuited to the domestic context of a developing country.

The fourth overall finding of the interviews is that participants found that a policy response to climate change needs to leverage demand-led innovative activity. This finding explains why it is that the IPR waiver proposals of the pandemic were resisted as applied to climate change, and why IPRs were not regarded as a barrier to innovation. It was said that *'industry is already taking the responsibility, we have seen in South Africa that big business is doing a lot...they are driven by their consumers'*, or that an inadequate scale of innovation will be achieved unless policymakers *'follow market principles* and work with the private sector to deliver the advances needed. The need to leverage private and public demand towards climate technology meant that participants resisted proposals for waivers of IPRs, which is a supply-side instrument.

Weakening IPRs protection would undermine investor confidence and have chilling effects on innovation. The suggestion that the problem of technology diffusion and access to technology could be resolved by weakening IPRs, without funding, capacity-building, or alternative measures, was regarded as a cynical *'minimalist'* approach to tackling the problem. The weakening of IPRs is of little assistance to developing countries, which lack the local manufacturing capacity or other complementary assets required to produce and disseminate climate technology, a point that was highlighted during the pandemic. A waiver also does not address the issue of know-how required for the most climate technologies.

In sum, to the extent COVID-19 acted as a point of reflection to consider responses at the WTO surrounding IPRs and climate technology, it was thought that the IPRs waiver debates were something of a *'storm in a teacup'*; a campaign that misdirected critical energies towards the wrong targets. These findings inform the following section on policy options emerging from this study.

4 Policy options

This section outlines possible policy options to promote the climate technology transfer and development. International IP law is not the only relevant policy area. Climate policy, finance and trade beyond IPRs matter. Thus, this section is structured along different domains of policymaking:

Box 1: Summary of Policy Options

(1) International IP law and the TRIPS Agreement

Compulsory licensing: Compulsory licensing (CL), which allows free use of a designated patent, is often perceived as distracting rather than helpful in the context of climate technology transfer. A few potential exceptions exist, such as adaptation solutions for agriculture (e.g. GM crops) and health (e.g. medicine), which have highly overlapping technical characteristics to the pharmaceutical technologies in which CL has been applied.

Patent eligibility: Exclusion of climate technologies from patentability has been discussed as a way to facilitate technology transfer in light of previous successful cases such as India's pharmaceutical innovation driven by imitation. However, this is a high-risk option in that such exclusion could substantially reduce future investment in innovative climate technologies.

Wildcard patents: Wildcard patents can extend the protection period to encourage commercialisation of climate technologies in developing countries. However, its fairness is controversial in that it could decrease competition by unfairly blocking competitors from market entry. Moreover, practical difficulties are expected, such as challenges in reasonable comparison between private and public benefits derived from wildcard patents.

Patent term extensions: Extension of breadth and length of patent protection has been discussed given the double externality in climate innovation. However, our results imply that the extension would rather hinder the deployment of many mitigation solutions in which a range of relevant patents is already expired.

(2) Climate policy and finance within the UNFCCC

Legal interpretations: The climate policy of UNFCCC and the trade policy of WTO conceptually conflict. The former highlights the different responsibilities of different countries and distinctive approaches to climate technologies, while the latter builds on the principles of equal treatment and free trade. These two entities should coordinate better to make the existing mechanisms work effectively.

Technology transfer: More frequent and systematic update of TNA is required to use it as an input for improving existing trade, IP, and climate policies on technology transfer. In doing so, increased attention to the South-South technology transfer is required in particular. The priority agenda is proper support for the technological capability building of local businesses in developing countries.

Financial mechanisms: For mitigation, local- and technology-specific patent buyouts for licensing can be considered in sectors where patent is relevant. However, according to our results, majority of areas will primarily require other financial supports focusing on demand-pull, such as deployment subsidies and public procurement. For adaptation, targeted financial support in areas where private incentives are particularly lacking should be prioritized, especially through the support for technological capability building.

(3) Trade and Investment policy beyond IPR

Barriers to trade in climate-friendly goods: The removal of barriers to trade in climate technology and products may promote climate technology transfer by reducing costs and barriers to access.

Trade-related investment measures: Trade-related investment measures that support FDI (e.g. TRIMs) may become more targeted towards climate technology.

4.1 International IP law and the TRIPS Agreement

We first discuss various IP-related policy options that have been put forward in the political and academic debate (Maskus, 2010; Cheng, 2022; Zhou, 2019; Maskus, 1998), and make an assessment in light of this study.

This study provided mixed evidence on the role of IPRs for ITT: while the interviews mostly suggested that IPRs are not a primary consideration motivating ITT, statistical evidence suggests that the strengthening of IP enforcement can have a positive impact on ITT, especially in countries at a higher development level (Section 2.2). It was commonly found that IPRs are not easily accessible to businesses in developing countries, and that many are not aware of IP.

Interviewees were predominantly from developing countries, and although several participants were from foreign companies with a business presence in developing nations, the evidence on whether foreign firms make their investment decisions based on IPR systems is somewhat limited.

To synthesise the interview data with existing literature, we briefly review the key amendments and extensions to the TRIPS Agreement that have been proposed:

Compulsory licensing: A compulsory licence (CL) for a patent may be granted by an authority to an individual or firm *'to make, use, sell or import a product under a patent [...] without the permission of the patent owner'*[38]. CL is permitted under the TRIPS Agreement only if reasonable efforts to obtain a regular licence have failed. This condition may be waived under circumstances of an emergency or particular cases of public non-commercial use.

In the past, CL has been mostly used in the medical context, although its practical assistance remains disputed. Moreover, CL has been subject to political and academic discussion (Gurgula and Hull, 2021; Abbott and Reichman, 2020; Cheng, 2022). Proponents of CL draw an analogy between climate change and the pharmaceutical sector, where it was shown that CL can help reduce prices and improve access to essential medicines (Stavropoulou and Valletti, 2015; Baten et al., 2017; Urias and Ramani, 2020; Liu, 2015; Raju, 2017).[39] They argue that CL may also be an effective instrument to facilitate access to climate technology and to promote technology transfer and follow-on innovation (Ahn and Yoon, 2020; Cheng, 2022). Others, referring to COVID-19, have considered how the discussion around climate technology and IP can be informed by recent experiences.[40]

The results of this study raise doubt whether CL would be an effective instrument,

[38] WTO glossary term: https://www.wto.org/english/thewto_e/glossary_e/compulsory_ licensing_e.htm.

[39] Other quotes: https://www.un.org/sg/en/content/sg/statement/2022-05-18/ secretary-generals-video-message-the-launch-of-the-world-meteorological-organization% E2%80%99s-state-of-the-global-climate -2021-report-scroll-down-for-languages

[40] For example, this claim was raised by Director-General Ngozi Okonjo-Iweala of the WTO in early 2022 (https://www.wto.org/english/news_e/news22_e/dgno_28jan22_e.htm) and discussed on various blog articles (https://hsfnotes.com/ip/2020/11/13/ip-in-a-time-of-crisis-what-does-the-pharmaceutical-sector-have-to-do-with-a-low-carbon-future/).

and both references from the literature and interviewees suggested that a focus on CL is distracting rather than helpful. This does not only hold for the climate context. While this view was not universally shared, several interviewees reflected that IP was not the main barrier to developing countries accessing and producing essential medical products, including vaccines. Instead, absorptive capacities including technological capabilities, skilled personnel, infrastructure, and manufacturing capacities were the key limiting factors, and CL would not have helped in most cases.

Various interviewees stated, however, that the IP system may act as a barrier to low-cost, low complexity climate technology. As one interviewee said, IPRs may prevent the diffusion of low complexity climate technology diffusion: '*we have many high-tech solutions in rich countries but what's needed are low tech solutions, but if there is a barrier to protecting these inventions and if this isn't a barrier to local development, then it might be a barrier to upscaling green technology diffusion*'.

Most relevant climate technologies are rather old and no longer subject to IP restrictions, and for other forms of climate solutions (organisational and low-tech innovation, and NbS) IP does not always apply. IP might have an impact on access to novel technologies in synthetic fuels, plant varieties, etc. (Maskus, 2010). However, we did not find evidence that this is already the case, even though the argument is sometimes brought into the discussion.

For medicines, it was shown that CL can reduce prices and thereby improve access for the poor. This argument is less valid for climate technology where many substitute solutions exist and market competition prevents abusive pricing. The probability that markets for climate technologies become oligopolistic is rather limited, due to lower economies of scale compared to pharmaceuticals. Most climate technologies are very capital-intensive unit-wise.

There may be exceptions, e.g. in climate-robust GM varieties, that can be cheaply scaled up once a relevant variety has been found. The capital-intensity highlights that investment costs are the more significant cost factor compared to potential IP licensing costs. Moreover, in cases where the lines of argument above do not hold, competition policy could be the more appropriate and targeted response.

However, there is little evidence that formal IP protection stimulates significant innovation or diffusion of climate technologies, such that we can also not infer any negative effects of CL. Moreover, CL would target a limited geographical and technological scope and not undermine the regular commercial activities of innovating firms, meaning it should not have a negative impact on innovation. Of course, there is much heterogeneity amongst climate technology, and there may be cases where CL measures can negatively impact climate technology innovation (see Section 2.1.1).

Patent eligibility: It had been also proposed to exclude climate technologies generally from patentability. Some parties have put this proposal forward in discussions within the context of the UNFCCC (Santamauro, 2013; Maskus, 2010; Cheng, 2022). This would require significant changes of Article 27.1 of the TRIPS Agreement, which defines the patentable subject matter. An alternative approach could rely on the Article 27.2 *'public ordre'* exclusion, which can be applied for technology to *'avoid serious prejudice to the environment'*. However, this provision has never been applied to climate technology.[41]

The Indian generics industry is an example where the absence of patents has promoted innovation, allowing small firms to copy and produce drugs. This contributed to the rise of India as the *'pharmacy of the world'* as a source of cheap medicines, especially (but not exclusively) to the benefit of the poor (Liu, 2015).

However, the applicability of this principle to climate technologies is limited. The production of most climate technologies is subject to larger capital requirements, while pharmaceuticals is said to be more IP-intensive and licensing fees matter as a cost factor in some cases (Maskus, 2010). Further, most relevant climate technologies that require upscaling, especially in renewable energy, are either no longer patent protected or those patents only refer to incremental improvements.

As was reflected by one interviewee, the earlier years of solar PV deployment in China do not appear to have been impeded by IPRs. It may be that the lack of IPRs enforcement in China supported its capacity in renewable energy technologies. This contributed significantly to the drop in solar PV prices and subsequent widespread diffusion. However, this process was aligned with a well-designed, targeted industrial strategy with significant capital support from the Chinese government (Shubbak, 2019).

One could argue that in more nascent technologies e.g. hydrogen the entry of a large-scale, low-cost player like China could be desirable to achieve rapid cost reductions globally, while allowing for a relaxed treatment of IPRs. But this is speculative, as the above-mentioned supporting conditions are needed and the Chinese rise was supported by the decline of renewable energy support in high-income countries in the aftermath of the financial crisis (Quitzow, 2015). It is unlikely that the current technological leaders would miss existing market opportunities themselves.

The full exclusion of climate technologies from patentability is risky, as it could undermine incentives for global innovation and ITT. In the microeconomic context, it could also reduce inventor incentives to innovate, collaborations reliant on IPRs, and individual inventors' ability in start-ups to raise capital. The absence of patent protection could also undermine FDI incentives, and countries practising the exemption would be reliant on their domestic capabilities to copy and produce (Maskus, 2010). The results of this study do not allow concluding whether concerns about a global slowdown of climate technology innovation and diffusion can be empirically justified. CL may represent a viable and less risky alternative to the exclusion from patentability.

Another rationale that can be brought up to justify the exemptions is a price-reducing effect, which does not seem to apply in the context of climate technology. At the global level, the Indian pharmaceutical and Chinese solar PV industry are significant examples of price-reduction effects for critical technologies, but they cannot be solely attributed to the lack of IPR enforcement. Instead, this is more likely an outcome of well-designed industrial policy in combination with the essential

[41] https://www.wto.org/english/tratop_e/trips_e/ta_docs_e/8_3_overviewclimatechange_e.pdf

access to knowledge. Other, less extreme instruments such as CL and diffusion patents (see below) may achieve the same purpose but be more narrowly designed to respond to specific technologies and IPR owners.

Wildcard patents: Wildcard patent extensions in the context of climate technology would permit firms to extend an existing patent of their choice in exchange for commercialising a climate technology for which there is a limited market or there are other disincentives to deploying it. Such a wildcard mechanism had been discussed to encourage pharmaceutical firms to innovate in new antibiotics, for which there is a limited commercial incentive (Maskus, 2010).

However, there is great scepticism about this idea (also in the context of medicines), as the induced shifting of IP costs can be hardly justified by any rationale of fairness. The burden of IP costs would be shifted to those relying on the product relying on the profitable patent. Further, the unpredictability associated with wildcards may undermine investments by competitors, that would plan and prepare their market entry, if they could reliably anticipate the regular expiry of a patent.

Wildcards are also technically complicated, as an exact calibration of the mechanism regarding the scope and duration of the extension is difficult. If not well calibrated, the private rents extracted from the extended profitable patent may vastly exceed the public benefit achieved through the commercialisation of the new technology, which raises great concerns related to justice.

Patent term extensions: Contrasting with the proposals to weaken existing IP protection, there is also a discussion on extending the length or breadth of climate related patents. This discussion is motivated by the notion of the double market failure in climate innovation, arising from positive knowledge externalities and climate change mitigation benefits (see 2.1.2). The rationale suggests innovation incentives would be strengthened by extending the monopoly rights of patent holders by creating greater commercial gains (Santamauro, 2013; Maskus, 2010).

Based on the results of this study, there is little evidence that this would be an effective or necessary means to stimulate innovation and diffusion activity, neither in developed nor in developing countries. This is in line with the scepticism raised in previous studies (Maskus, 2010).

The original motivation of patent term extensions originates from the medical sector, where the term extensions were thought of as a means of increasing the patent reward or as a means of compensating applicants for long durations of examination processes, which sometimes take up to 10 years in the pharmaceutical industry. This rationale is less applicable to most climate technologies.

There may be exceptions, e.g. GMOs, but compensations for regulatory delays may be already covered by existing rules. It would be of greater importance to speed up the examination process, potentially with a preferential treatment of climate technology, justified by the critical importance of the time dimension in mitigation and adaptation action.[42]

In the context of climate technology, patent term extensions may have negative impacts. Many climate technologies are more cumulative compared to discrete molecular inventions, as in medicines. Thus, current inventions build on previous ones (e.g. solar PV, batteries, hybrid engines). In these cases, patent term extensions may even hinder subsequent innovation (Maskus, 2010).

For most climate technologies, mechanisms that focus on the demand side and enabling environments are of primary importance. Many – especially those that matter in a developing country context – are *'old'* technologies, and patent term extensions may have negative impact if they limit the scope of imitative and adaptive innovation. For example, many of the solar PV technologies deployed (and developed) in developing and emerging countries rely on technologies with expired patents. An extension of the duration might hinder the exploitation of available technological solutions.

Other IP discussions: Another flexibility within the TRIPS framework that has been used in the context of pharmaceuticals are anti-evergreening provisions. This flexibility may be used to prevent firms from extending the lifetime of a patent through different practices over a period than would be normally permitted by law (Liu, 2015). This may be a barrier to competition, leading to excessive prices for new drugs. However, as – suggested by the interviews and literature – the prioritised technologies are traded on competitive markets with a wide range of technological substitutes. Whether abusive evergreening practices become a matter in the future, for example with respect to GMOs, may need to be monitored, but to date, there is no evidence that this flexibility plays a role.

4.2 Climate policy, finance, and the UNFCCC

Climate policy at the UNFCCC can have two important implications: First, from a law perspective, the UNFCCC can provide a framework for the interpretation of existing TRIPS flexibilities and other additional and/or existing regional trade agreements in the climate context. Second, from an economic perspective, the direct transfer and financial mechanisms may strengthen the demand for climate technologies, directly and indirectly, by encouraging the commitment of developing nations to adopt more stringent climate policies. Larger national commitments may help redirect domestic demand toward climate-friendly technology, including domestic ones.

This study has shown that the demand side is a key driver of ITT and innovation and appears to precede IP as a pre-condition for climate innovation, especially but not exclusively in the context of developing countries. It had been argued that existing financial and technical mechanisms in the UNFCCC primarily focus on the

[42] In May 2022, the USPTO announced the launch of a Climate Change Mitigation Pilot Program that includes a prioritised examination of climate technologies. https://www.uspto.gov/about-us/news-updates/uspto-announces-launch-climate-change-mitigation-pilot-program.

transfer of climate technologies from developed to developing countries but may be less suited as means to promote ITT from developing countries (Corvaglia, 2014). For example, the Clean Development Mechanism (CDM) or Joint Implementation (JI) projects exclusively focus on transferring technology from developed to developing countries, while mechanisms for technology exports from developing and emerging countries are largely absent.

4.2.1 Legal interpretations

International climate agreements and international trade policy (including the TRIPS Agreement) differ conceptually. While international cooperation within the UNFCCC builds on voluntary cooperation, the standards set by the WTO are mandatory, including legal enforcement mechanisms. However, the increasing number of successful cases of climate litigation gives evidence that the UNFCCC, national climate laws, and NDCs can be successfully leveraged as a basis for interpretation in court decision-making (Wegener, 2020). Thus, there may be scope to leverage UNFCCC clauses for the interpretation of TRIPS exemptions, such as the waiver conditions, and for decisions by the Dispute Settlement Body.

A challenge in the potential alignment of the UNFCCC and the TRIPS/WTO treaties relies on their conceptual differences, which was also highlighted by the interviewees (Section 4.4.1). The WTO rules are motivated by the idea of free trade, encoded in the principles of equal treatment. Members of the WTO are required not to differentiate across technology fields and origin of the invention. With the Doha Declaration, the WTO deviated from this principle, allowing exceptions for developing countries and specific technologies (pharmaceuticals) (Cheng, 2022).

The Doha Declaration also acknowledged the need for technology transfer from developed to developing countries and established the Working Group on Trade and Technology Transfer (WGTTT) with the mandate to work out recommendations of how ITT could be realised in practice.

In contrast, the UNFCCC adopts a structuralist view acknowledging a *'common but differentiated responsibility'*, that accounts for differences in the level of development, capabilities, and historical responsibility for climate change (Oh, 2019). In addition, to achieve its objectives through economic and technological policy, climate agreements naturally discriminate against carbon-intensive products and technology.

The debates around climate change challenge the utilitarian rationale of TRIPS, and raise the question whether climate technology needs to be treated differently by IP law, policy, and administration (Cheng, 2022; Zhou, 2019). Technology transfer is one key pillar of the UNFCCC and over the years the mechanisms to facilitate the transfer have become increasingly elaborate. However, it has been argued that the terminology in the UNFCCC is too vague to assess whether the technology transfer-related obligations of developed countries are met (De Coninck and Sagar, 2015). Despite the broad framework needed for technology transfer set by the UNFCCC, the relevant formulations are vague, which also undermines their usefulness as an interpretative basis for TRIPS and other trade agreements.

Zhou (2019) argues that the fragmentation of the WTO and the UNFCCC into two separate domains of international policy prevents the effective realisation of synergies between the two frameworks. The author suggests that the UNFCCC and WTO institutions should coordinate better to make the existing mechanisms more effective. For example, they could outline in detail the extent to which specific climate technologies qualify as a public good. The UNFCCC could be established as authority to interpret the ITT provisions in the TRIPS Agreement, whenever climate technologies are concerned.

Further, recent years have given rise to an increasing number of bi- or plurilateral Preferential Trade Agreements (PTA). It was already discussed at the UNFCCC to adopt general clauses to ensure, that any international agreement on IP *'shall not be interpreted or implemented in a manner that limits or prevents any Party from taking any measures to address adaptation or mitigation of climate change, in particular the development and enhancement of endogenous capacities and technologies of developing countries and transfer of, and access to, environmentally sound technologies and know-how'* (UNFCCC, 2010). Such clauses may guide the interpretation and design of existing and future agreements. So far, clear statements regarding IP were not adopted in the final text, mainly due to the resistance by developed countries (Zhou 2022).

National climate law and NDCs may be used as interpretive aids for amendments to IP law much like climate litigation (Wegener, 2020). Climate litigation is a very nascent field, but it may be further explored whether and how the legislations and commitments may be designed to help overcome IP-related barriers, whenever they arise.

References to technology transfer within the TRIPS and UNFCCC agreements exclusively refer to technology transfer from the developed to developing countries, and ignore the possibly critical role of climate technology transfer originating from developing and emerging countries (Brewer, 2008; Corvaglia, 2014). A more explicit acknowledgement of the importance of technologies from less developed countries could guide and promote legislation supporting this dimension.

Further, the UNFCCC could explicitly acknowledge the relevance of technology transfer among developing countries and differences in the required capabilities for climate technology production. This could offer a basis for the interpretation of trade treaties to allow for discrimination favouring developing countries.

4.2.2 Technology transfer

Since the inception of the UNFCCC in 1992, a wide range of mechanisms and institutions to support the transfer of climate technology from developed to developing countries exists. Article 4.5 of the UNFCCC requires developed countries to facilitate technology transfer to enable developing countries to meet their commitments, and Article 4.7 is the clause that allows developing countries to make their commitments contingent on technological and financial support from developed countries. Later agreements specified more detailed mechanisms such as the CDM and JI in 1997, the TNA, the Technology Mechanism (TM) in 2010, and the Technology Framework in the Paris Agreement (Abdel-Latif, 2015; Zhou, 2019).

Among the existing tools, the TNA can be very effective in the context of IPRs and ITT. The TNAs, established in 2001, provide a base to understand country-specific technological needs and to create action plans for technological development. So far, two rounds of TNAs were conducted covering more than 80 countries. The TNAs could be used to assess whether IPRs are a barrier to meet specific needs and might serve as a basis for the potential activation of TRIPS waivers. However, in case the TNAs would be used as a legal mechanism, they would have to become more frequent, more systematic, and principles to ensure objectivity would be needed. This could be a complicated process, especially given the low relevance of IPRs in general.

A general shortcoming of the existing mechanisms is their focus on transfer from developed to developing countries, ignoring the increasing relevance of developing and emerging countries as sources of climate technology (Corvaglia, 2014; Brewer, 2008). While this reflects the rationale of the UNFCCC of a differentiated responsibility and burden sharing, the exclusivity may be inefficient in speeding up the global diffusion of climate technologies for four major reasons.

First, climate technology developed by inventors from lower income countries may be more suited in a developing country context. Second, climate technologies produced by lower income countries may be significantly. Third, supporting climate innovation in developing and emerging countries may increase the commitment to climate policy as it becomes an economic opportunity. Fourth, technological solutions developed in developing countries contribute to the building of relevant technological capacities. A revision of the existing mechanisms of the UNFCCC could account for this to promote climate technology transfer *from* developing countries. For example, technologies from countries below a certain development level could be directly supported whenever they represent a viable solution. The TNA may give guidance.

Further, some mechanisms like JI or CDM already incorporate elements of local capacity building, for example by promoting the cooperation between actors from developed and developing countries. The early implementations of the mechanisms showed a poor performance regarding the delivery of verifiable emission reductions, their contribution to stimulate climate investments from the private sector and to promote technology transfer and innovation in developing countries. The participation in CDM projects was very unequally distributed, with a concentration on four host countries (China, India, South Africa, Brazil) and low participation rates of Least Developed Countries (LDC) (Corvaglia, 2014; Kainou, 2022; Lo and Cong, 2022).

The CDM (and JI) mechanisms may be reconsidered putting more emphasis on long-term capacity building of project partners in developing countries, for example through well-calibrated local content requirements (LCRs), incentives to collaborate with local firms, or training requirements (Corvaglia, 2014). LCRs are controversial and should be limited to components that can be produced locally or in other developing countries with a similar development level at a sufficient quality and reasonable prices. Successful catch-up histories from China, India, and Brazil suggest that often these requirements have been complemented by other means of industrial policy (Fu, 2011; Cheung and Ping, 2004).

The possibilities of small- and medium-sized local businesses and LDCs to participate in the CDM can be improved by reducing administrative burdens and/or transforming these mechanisms to become low-carbon investment support instruments with fair and transparent access rules. However, proving climate additionality becomes more challenging when lowering the participation hurdles. This could be addressed by differentiating the certification criteria by level of development of the host country and projects size. The mechanisms may also be tailored more closely to the (conditional) commitments stated in the NDCs. This could help make technology transfer and mitigation contributions more explicit (Zhou, 2019).

Similar mechanisms may be developed to promote more technological cooperation between developing countries, for example through technology transfer, trade, and partnerships in R&D and deployment.

Further, the Paris Agreement opened a door for the greater incorporation of non-market approaches, including NbS. In some cases, these solutions represent superior substitutes for imported climate technology from the developed countries. A systematic review of the existing mechanisms could help assess whether and how the existing mechanism sufficiently account for non-market solutions and how existing support and transfer mechanisms can redesigned to create a level playing field between market and non-market solutions from both developed and developing countries. The Subsidiary Body for Scientific and Technological Advice (SBSTA) could be mandated to undertake such an assessment, potentially collaborating with the TNA or building on its country-specific expertise.

4.2.3 Financial mechanisms

Climate finance may be a key mechanism to motivate the commitment of developing countries to engage more in mitigation. It could also make mitigation be an economic opportunity in these countries by supporting upfront investments, for which domestic financial means are often lacking. Adaptation finance is conceptually different and may be considered as a means of compensation for incurred damages and to strengthen global resilience.

Within the UNFCCC, there are various financial mechanisms and facilities such as the Global Environmental Facility (GEF), the Green Climate Fund (GCF), and special funds for adaptation and LDCs. In the context of the Paris Agreement, it was aimed to strengthen the linkages between the Finance Mechanism and the Technology Mechanism. Here, we briefly outline how these existing tools may become more targeted towards supporting technology transfer and domestic innovation.

Regarding IPRs and patents, it was proposed that climate finance could be used for patent buyouts. This means the acquisition of IPRs or licences of specific technologies to make them available at reduced fees, potentially with preferential access for developing countries and public entities (De Coninck and Sagar, 2015; Zhou, 2019; Maskus, 2010). Maskus (2010) suggested that a global emissions-reduction fund (GERF) could be created, analogously to the Global Health Fund, to provide incentives to develop climate technologies for specific mitigation needs in developing countries. The instruments could be a mix of direct grants, prizes, and geographically limited patent buyouts, but also subsidies for ITT and local implementation.

The need for patent buyouts may be explored in cases where IPRs truly represents a barrier. However, given the low relevance of IPRs, it may be an inefficient instrument, as often cheaper solutions exist that are not subject to IPR-related constraints. Further, general buyouts would likely be insufficiently targeted as technological needs vary across countries and other instruments such as needs-based TRIPS waivers could be the narrower and more specific instruments. However, the political feasibility of TRIPS waivers may be lower. Whether IPRs on a specific technology represents a barrier is often country-specific. Thus, potential buyouts would need to be locally and technologically specific.

Generally, climate finance is often considered as a lever to mobilise private finance. While it remains true that financial incentives matter, analyses from an innovation ecosystem perspective suggest that climate finance should go beyond the provision of financial incentives as other barriers to adaptation and mitigation prevail. In addition to using climate finance to support deployment of technology, it may also be used to support demonstration and pilot installation projects, which contribute to local capacity building and testing of domestic and foreign technology in the context of developing countries. This may be particularly helpful to assess requirements of adaptive innovations in existing technology.

Climate finance could also be used to fund institutions that support knowledge exchange and networking among technological practitioners, which are relevant components of a domestic innovation ecosystem. Funds could be also made available for risky projects in hard-to-abate emission reductions, which are difficult to finance due to the uncertain outcome regarding their realised emission reductions and economic viability. The risk eligibility criteria of projects could be revised taking account of the inherent uncertainty of innovation outcomes (Ryan Hogarth, 2012; Warren, 2020). It can be learned from existing initiatives that provide risk capital to innovation in development projects such as the public-private initiatives The Lab[43], which is, among others, supported by the German Federal Ministry for Economic Affairs and Climate Action, or the Global Innovation Fund.[44]

The results of this study suggest that the demand side may be more significant to speed up the low-carbon transition, as most technological solutions do already exist. This should be reflected in the allocation of budgets for climate finance. Demand side instruments include, for example, deployment subsidies and support for public procurement and investment, possibly allowing for local content or training requirements whenever they can contribute to local capacities. Public funding is particularly needed in areas where private incentives are lacking. This is for example true in the case of adaptation projects to the benefit of the public, such as seawalls or adaptation in urban infrastructure. Public procurement for adaptation could also be targeted towards indigenous innovation to enhance domestic technological capacities for locally specific adaptation solutions.

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[43]https://www.climatefinancelab.org/

[44] https://www.globalinnovation.fund/

4.3 Trade and investment policy beyond IPR

A *'global paradigm'* of technology transfer – as claimed by Brewer (2008) – requires more of a focus on trade and investment policies, not only at the WTO but also at the national and bilateral levels. Trade and investment policies are particularly relevant in the following regards: (1) The removal of trade barriers in climate technology and products may promote transfer by reducing costs and access barriers. (2) Trade-Related Investment Measures (TRIMs) that support FDI may become more targeted towards climate technology. We review the mechanisms regarding their effects on accelerating climate technology transfer and innovation in developing countries.

4.3.1 Barriers to trade in climate-friendly goods

Trade and climate technology transfer can be promoted by reducing tariff and non-tariff barriers to trade (Corvaglia, 2014; Maskus, 2010; Brewer, 2008; De Melo and Solleder, 2020). The removal of barriers to climate-friendly solutions and the penalisation of harmful goods has been on the agenda of international trade policy for almost four decades. Globally, there is an increasing number of PTA with environmental provisions for pollution abatement and climate technologies. Brandi et al. (2020) counted 680 PTAs in the period 1984-2016. It was shown that environmental provisions may promote domestic environmental legislation and increase exports of the preferentially treated goods, including exports from developing countries (Brandi et al., 2020).

However, the participation of developing countries in international agreements is low (e.g. at the WTO in the Doha Round in 2001 and in the negotiations on an Environmental Goods Agreement (EGA) launched in 2014), leading to substantial disagreement and the suspension of the negotiations. The controversies relate particularly to the definition of what qualifies as an environmental good that is eligible for a preferential treatment. Tariff reductions for climate-friendly goods require the identification of eligible product categories, which is where the developing-developed country differences need to be factored in.

There is a distinction between the so-called *'list'* and a *'project'* approach. Developed countries tend to favour the list approach that defines a list of eligible product categories, typically based on the 6-digit Harmonized System product classification commonly used for the imposition of tariff rates. Developing countries, in contrast, tend to promote the project approach of liberalising trade only for the duration of environmental projects. The project approach is thought to account better for the diversity of standards and capabilities in different countries and could be combined with project-based arrangements to facilitate knowledge transfer and local capacity building (Brewer, 2008; Corvaglia, 2014).

In addition, a uniform treatment of climate-related goods and services in trade may preclude developing countries from active participation. Any approach being taken to lift barriers to trade would need to ensure that the definitions of standards are inclusive, and potentially differentiated by participating countries' level of technological capabilities. Given the heterogeneity of countries by development level and technological capabilities, it would be difficult to establish uniform standards. De Melo and Solleder (2020) found that many developing countries do not feel addressed due to the low relevance or inexistence of domestic markets for products on the list, nor would they have benefitted as exporters.

This raises a more general question about what comes first: domestic technological capabilities to produce climate-friendly products and technology, or participation in the respective trade agreements? This question has – to date – not been conclusively answered by the literature, especially given the technological heterogeneity of the relevant product categories. An example are the experiences made with the Montreal Protocol which banned ozone-depleting substances. Likely, the technology came first, and the agreement second (Maxwell and Briscoe, 1997).

However, trade agreements with climate provisions can still be powerful tools, when technology is available, as is the case for many climate technologies. Trade policy can help strengthen and upscale existing technological capacities, but the key question here is whether and how a fair participation of developing countries can be ensured. Today, many developing countries have already become important source countries of climate technologies (Corvaglia, 2014).

It may be also explored how domestic standards for sustainable supply chains in developed countries can promote knowledge exchange with producers in developing countries, while not undermining their ability to participate in global supply chains (e.g. the German *'Lieferkettengesetz'*).

4.3.2 Trade-related investment measures

Beyond the investment mechanism within the UNFCCC framework, there are other international investment and FDI supporting arrangements, such as the TRIMs agreement at the WTO level. Agreements like TRIMs have been installed to facilitate FDI, but TRIMs do not include any requirements for technology transfer and interviewees reported that many FDI projects do not effectively lead to technology transfers (see Section 3.4.2). Agreements like TRIMS usually contain restrictions on LCRs, trade balancing, and export restriction policies, which could be relaxed to ensure that both the foreign firm and the host country benefit from FDI (Corvaglia, 2014).

The current restrictions on LCRs are controversial, even though their effectiveness of LCRs is highly context- and technology-specific. Arguably, these requirements may be effective instruments to enforce the participation of domestic industries in FDI projects and have been effective instruments in the toolbox of South-East Asian and Brazilian catch-up policies (Andrenelli et al., 2019; Fu et al., 2011). However, whether such measures have a positive effect on local capability formation and knowledge spillovers between foreign and domestic firms depends strongly on their design and context.

In the short run, these measures may increase production costs, if pre-existing manufacturing and technological capacities are insufficient (Probst et al. 2020), which however, could be considered as learning costs. A minimum level of domestic technological and industrial capacities are often pre-requisites that such measures have a positive effect on technological catch-up (Scheifele et al., 2022). Often when these measures were applied successfully, they have been part of a larger industrial strategy that includes, for example, R&D and educational policies (Fu et al., 2011).

Corvaglia (2014) outlined that LCRs could be tailored to promote domestic capacities in climate technology. However, these measures should be carefully calibrated and restricted to components that can be reasonably sourced locally to alleviate negative effects on market entry decisions by foreign firms, local technology costs and availability. Other means such as training requirements and support for collaboration with local firms in areas that are less dependent on pre-existing capacities, for example in service-intensive sectors, may be less risky than inflexible LCRs.

However, for the most pressing climate problems, there are many domestically produced solutions (including NbS). It may be explored how foreign investment measures can help to attract foreign capital to scale up these solutions. The key difficulty again is the discrimination between domestic and foreign producers, which however would be important to promote local capability formation. Analogous to the debate on diffusion patents (Dreyfuss and Benoliel, 2021), a solution may be to define eligibility criteria which is not based on nationality but on the development level of the country of origin.

4.4 Other relevant policy areas

There are various other policy areas that interact with climate technology and capability formation in developing countries. For example, labour migration, student exchange programmes, education, and research partnerships could be more effectively used as vehicles of knowledge transfer to developing countries through formal and informal channels. Also, other investment support policies in developed countries should be revised to operate in favour and not against climate technology deployment in developing countries. For example, a Hermes Cover could impose minimum climate standards including a stop of support for FDIs in emission-intensive technology or related mining,[45] and preferential treatment for climate-friendly investments, analogous to the discussion in Section 4.3.2.

5 Technical cooperation measures

In this section, we review cooperation measures in developing countries that help improve local innovation systems for climate technology. Then, we assess how existing approaches to technology transfer by developed countries may be reconfigured. In each subsection, we distinguish between IPR and non-IPR related measures.

Shifting the paradigm of innovation systems towards sustainability should embrace transformative changes and diverse pathways (Schot and Steinmueller,

[45] https://www.urgewald.org/sites/default/files/media-files/DUH_urgewald_Klimakrise_08.pdf

2018). This does not simply assume that the developed countries create all innovations and that developing countries try to catch up. Instead, it emphasises mutual efforts between both regions. Local knowledge production and adaptation of existing solutions by the developing countries play a critical role in this paradigm. The results above show that indigenous innovation and transfer from other developing countries are important to address local problems.

Measures for innovation system support should accommodate various components of the system, i.e. diverse actors, institutions, and activities and their substitutive or complementary relationships (Granstrand and Holgersson, 2020). The suggested cooperation measures for indigenous and adaptive innovation in developing and technology transfer by developed countries should be collectively considered and regularly evaluated, as their effectiveness may interact and change over time. These efforts should contribute to gather experience, while harmonising the diverse set of actors and institutions with different motivations (Kivimaa et al., 2017).

Box 2: Summary of Technical Cooperation Measures

(1) Innovation systems in developing countries

Domestic IPRs related measures

Utility models: Utility models protect less sophisticated technological solutions with lower novelty standards. Our interview results and economic history of using this system for catch-up (e.g. East Asia) imply that utility models have a great potential to motivate domestic innovative activities in developing countries, subsequently contributing to their climate technology self-sufficiency.

Trade marks: Interviews and literature suggest trade marks can be an effective tool to encourage local business-based indigenous and adaptative innovation for tackling climate change. In addition, trade marks can address information asymmetries between climate technology providers and customers regarding product/service quality.

IPR training: Our interview indicates a low level of awareness of the IPR system in developing countries. Support to integrate IP training into their existing educational system and entrepreneurship programs can be helpful.

Non-IPR measures

FDI restrictions: Restrictions on FDI such as mandatory joint ventures can be enforced to make more effective ITT to local firms. However, negative consequences of the forced relationship should be considered, such as the transfer of marginal and outdated technologies or weak trust relationships between partners.

Technology capability building: Direct support aiming to improve the technological capability of developing countries is needed, such as funds for training the local firm employees and establishment of R&D collaboration network between local universities and foreign investors.

Demand-pull policy for mitigation: For mitigation, demand-pull policies beyond the IPR system should be considered to increase the size of green markets. The instruments include subsidies, tax deductions, standard settings, green public procurement and carbon-pricing.

(2) Improving the developed countries' approaches

International IPRs related measures beyond TRIPS

Patent pooling: Patent holders such as firms, universities and research institutions can deposit their climate-relevant IP into the pools to reduce the costs of licensing. Recent empirical evidence shows a positive role of pooling in the diffusion of medicine, implying the potential effectiveness of pooling in some climate technology areas.

Patent landscaping: Patent landscaping can be used to facilitate the process of application and examination of climate patents. Technical assistance through landscaping can significantly decrease the cost of search and licencing, particularly in the complex technology areas that include a range of overlapping IP rights.

Practical considerations: The boundary of climate technologies can evolve over time. To implement preferential treatment of climate technologies and products, a more robust approach to defining climate technologies is required.

Non-IPR measures

Removing trade barriers: Trade barriers should be further removed based on the routes such as reduction of tariffs on climate products and services. The process of setting standards for the trade barrier removal should be inclusive enough to avoid discouraging developing countries from participation.

Border Carbon Adjustments (BCA): Penalising carbon-intensive exports through BCA can encourage developing countries' adoption and development of climate technologies. However, doubts exist as to the measure's effectiveness, given its potential negative impact on developing countries such as reduction of foreign investment and demotivating local producers. An inclusive direction for modifying BCAs should be considered, such as the reallocation of revenues raised by BCAs to climate finance developing countries.

Climate Clubs: The Climate Clubs can be an alternative structure to the UNFCCC because they penalise free-riders in global commitment to climate action. Although the Climate Clubs can self-enforce once the number of members is large enough, it could reinforce the existing North-South divide unless they inclusively support developing countries' participation and access to benefits.

5.1 Innovation systems in developing countries

5.1.1 Domestic IPR measures

Our interviewees acknowledged that many inventors in their country are not aware of the patent system, and IPRs systems themselves are complex and bureaucratic. It was also mentioned that other IPRs such as utility models and trade marks are very suitable in the context of developing countries (see Sections 3.4.3 and 3.4.4). This section discusses how the domestic IPRs system of developing countries can be supported.

Utility models: The wide adoption of the TRIPS Agreement has led to the emergence of an absolute standard of novelty (Dreyfuss and Benoliel, 2021). Inventions that do not meet the global novelty standard cannot be patented in any of the member countries. However, the standard is prohibitively high for developing countries, given their limited technological capabilities. Many useful but below-novelty standard technical solutions have a great potential to be commercialised domestically and across various developing countries. The low level of ensured protection can disincentivize domestic investment in indigenous innovation and the adoption and adjustment of foreign technologies.

Interviewees from Bangladesh and Kenya mentioned that utility models can be an alternative protection mechanism useful in their countries. Utility models, which can be considered as a second-tier patent system, protect less sophisticated technological solutions with lower novelty standards. This system can be used to protect against imitation of inventions, which are not eligible under the global standard of novelty. This system can be understood as a type of *'diffusion patent'*, that is, a system that aims to increase the diffusion of technologies that are critical to meet local demand.

Utility models to promote domestic innovation and technological catch-up have been successfully used in various Asian countries, including Japan, South Korea, Taiwan, and recently China (Lee, 2013). Also, many developed countries, including countries from the European Union, use the utility model to promote incremental and adaptive innovation by local firms (Suthersanen, 2006).

Utility models can promote inventive activities and capability formation in developing countries, contributing to technological self-sufficiency[46] (Dreyfuss and Benoliel, 2021). In addition, utility models can be considered as an instrument to promote technology transfer among developing countries, which received little emphasis in existing international agreements (Corvaglia, 2014). Initiatives to adapt international agreements to implement utility models need to account for the trade dimension, which is very relevant for the transfer of climate technologies, particularly when low-tech climate solutions originating from developing countries are concerned.

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[46] In face of supply chain disruptions (not exclusively within the context of developing countries), the concept of self-sufficiency in essential technologies received increasing attention (e.g. the EU Chips Act, https://ec.europa.eu/commission/presscorner/detail/en/statement_22_891).

Regarding compatibility with the international IP law, utility models are – for the most part – not in conflict with existing international IP law (Dreyfuss and Benoliel, 2021). However, to promote domestic innovation and technological catch-up, a preferential treatment of local applicants can be favourable in some cases. This can raise issues with the non-discrimination principle arise if the preferential treatment is based on the applicant's origin. There are ways to ensure consistency with TRIPS, for example by broadening the class of beneficiaries to nationals from countries at a similar level of development (Dreyfuss and Benoliel, 2021). Technical cooperation from developed countries can support developing countries in designing and implementing the utility model, ensuring its consistency with international IP law.

Trade marks: WIPO defines a trade mark as '*any sign that individualizes the goods of a given enterprise and distinguishes them from the goods of its competitors*' (WIPO, 2008). Trade marks are used by firms to protect their unique brand symbols and names from imitation. Trade marks incentivise firms to invest in their brand quality and reputation, thereby benefiting not only firms but also customers. Reputation and credible quality of a brand can help firms capture value from their investment even in the absence of a robust IPRs system (Gao et al., 2017).

However, trade marks do not protect inventions and their underlying technological ideas themselves. A few recent studies have shown that some developing countries have intensively used trade marks compared to other types of IPRs such as patents (e.g. Nguyen, 2020). Trade marks are relatively straightforward to understand and implement, which are among the main reasons for the high utilization of trade marks in developing countries. Our interviewees pointed out that the complexity of the patent system is a major barrier to using it. Also foreign investors rely much on trade marks instead of patents.

Our interviewees also highlighted that trade marks can be used as an effective tool to address information asymmetries between climate technology providers and customers. Interviewees expressed concerns that their countries have repeatedly faced problems with low-quality technology imports (e.g. from China) that undermine trust in the reliability of imported climate technologies (see Section 3.4.2). Supporting the developing countries' effective use of trade marks could mitigate the issue to some extent.

Trade marks can also be useful to local businesses based on indigenous or adaptive innovation for climate change mitigation or adaptation. Trade marks can help small businesses create brands to effectively diffuse their products and services. One of our interviewees from India mentioned a successful case of trade mark usage for the diffusion of a rainwater management system for female farmers in rural areas (see Section 4.3.2). As IPRs and innovation systems in most developing countries are weak, this cannot be fixed comprehensively in the short term. Taking advantage of trade marks can be a realistic and practical approach.

In some sectors or countries where incentives for FDI and technology transfer are strong, IPRs are often not regarded as a critical barrier to investment decisions (Nguyen, 2020). However, in other sectors, support for building a strong trade mark system in developing countries can potentially increase the FDI inflow and climate technology transfer from advanced economies. Economic and international development literature has often argued the positive relationship between strong IPRs systems in a developing country and the inflow of foreign capital and technological knowledge to the country (see Section 3.2). A robust trade mark system might contribute to increasing the overall climate technology transfer from developed to developing countries.

Trade marks have been widely used not only in marketing-intensive sectors, but also in technology-intensive sectors such as pharmaceuticals and information-intensive sectors such as IT services (Mendonça et al., 2004). Given the broad sectoral coverage of trade marks, all categories of clean technologies are within the boundary of trade mark protection. Previous empirical studies show that the volume of trade mark registrations is positively correlated with the overall innovation and economic activity of a certain country (e.g. Mendonça et al., 2004). Based on the correlation, we can envision positive effects of supporting the establishment of a robust trade mark system in developing countries.

IPR training: Apart from the potential usefulness of domestic IPRs systems based on the utility models and trade marks, our interview results revealed a low level of public awareness of the IPRs system. Therefore, support to integrate IP training into the curriculum design of local universities and entrepreneurship programs in developing countries would be useful. The educational support would be synergetic with other measures that directly support the establishment of the domestic IPR system.

Experiences of developed countries in setting up their IP education programs (e.g. Soetendorp (2006) and IP education toolkit of the European Patent Office[47]) can be adapted to the context of developing countries and climate technologies. Through IP education, more inventors, researchers, and potential entrepreneurs in developing countries would become aware of the IPR system. They would learn how to take advantage of the system, especially of trade marks and utility models, when scaling up their business and capturing value from their innovation. At the same time, it is important to raise public awareness for the large market potential of local climate solutions. Their market is not restricted to their home country, but can be extended internationally, especially to neighbouring countries with similar meteorological and socio-economic conditions.

5.1.2 Non-IPR measures

Our interview results suggest a relatively low relevance of IPRs for climate technology transfer and innovation compared to other factors. This subsection reviews non-IPR measures in the national innovation system that can facilitate climate technology transfer. Focusing on the aspects mentioned by the interviewees, we suggest technical cooperation measures related to FDI restrictions, absorptive

[47] https://www.epo.org/learning/materials/kit.html

capacity building, and policies stimulating the demand for climate technologies.

FDI restrictions: Interview participants commonly reported that foreign firms mainly use FDI to establish themselves in the market or to extract primary resources, but effective technology transfer does often not happen (see Section 3.4.2). Countries can put restrictions on FDI to make ITT to local firms happen more effectively (Andrenelli et al., 2019). For example, a mandatory joint venture (JV) or acquisition requirements oblige foreign firms to have partners in the host countries. Such requirements often force the transfer of tacit knowledge and know-how from the foreign investor to the local partner. Previous studies provide empirical evidence that JV or acquisition requirements can produce more productivity spillovers from the foreign firm to the local firm than fully owned FDIs (e.g. Javorcik, 2004; Ghebrihiwet, 2017).

However, some evidence indicates the opposite, showing that forced technology transfer through channels such as mandatory JV is likely to fail because foreign investors transfer marginal or outdated technologies (Chang et al., 2013). The absence of shared goals can destabilise the trust relationship between partners, which is a key factor of a successful JV (Cosbey and H. Mann, 2014).

Given the pros and cons, support for developing countries can help them avoid foreseeable negative consequences of FDI restrictions. For example, the transfer of marginal or outdated technologies can be mitigated by supporting developing countries in defining the boundary of technology transfer more clearly before they formally establish a JV with a foreign partner.

Technological capability building: According to the interview results, the primary condition to enhance the ITT is building the national-level absorptive capacity. Empirical studies show that domestic investments to acquire absorptive capacity are necessary to foster technology transfer (e.g. Keller, 2004). While action by local firms and the government is important, various cooperation measures can be designed and implemented to support this process. For example, developed countries can support the establishment of R&D collaborations between foreign investors and local universities, provide funds for education and training of local company employees, and help create a network between foreign and local firms.

Demand pull policy for mitigation: Our interview results show that strengthening the demand for climate technology can be one of the strongest incentives for domestic innovation and the market entry of foreign firms (see Section 3.4.3). To effectively leverage the engagement of the private sector, the government should use policy instruments that create demand for climate technologies.

For climate change adaptation technologies, country-specific demand often already exists in developing countries, but it is often subject to limited financial capacities. Mitigation is often the second priority for many developing countries, given their low emissions (with some exceptions), urgency in adaptation, and limited budgets. They usually seek mitigation co-benefits while they are prioritising adaptation technologies (see Section 3.1).

Therefore, demand-pull policies need to be implemented, specifically for mitigation technologies. For example, the government can provide subsidies or tax deductions for consumers of mitigation technologies and/or impose carbon prices on emission-intensive technologies to improve the relative cost performance of climate-friendly solutions.[48] Energy efficiency standard setting can be used to effectively remove energy-inefficient products from the market (e.g. Grubler and Wilson, 2014). The government can also set minimum standards for the energy efficiency of widely used products.[49] Green public procurement is another example of demand-oriented policy, which aims to reflect environmental criteria for the procurement of products and services used in the public sector.[50]

When public budgets are constrained to implement subsidies or green procurement, effective regulation, and its enforcement. Possible instruments are standard setting or carbon-pricing. The revenue from carbon-pricing can be redistributed to the citizens or to reduce prices of climate-friendly alternatives, to reduce the cost burden for the poor.

Reallocating the revenues from carbon taxes as a flat rate to the citizen comes with two additional benefits. First, it can raise public support for climate policy if citizens directly benefit, and second, it is a regressive instrument because higher-income groups often cause more emissions.

5.2 Improving approaches of developed countries

5.2.1 International IPR measures beyond TRIPS

Patent pooling: Patent pooling is another proposal in the debate about climate technology and IPRs (Maskus, 2010; Santamauro, 2013; WIPO, 2009). Patent holders such as firms, universities, and research institutions would be encouraged to deposit their climate-relevant IP into the pools. Users of the patents would pay an ex-ante agreed royalty fee, whereby the rate may be reduced for developing countries. Climate patents in these pools would be supplied at a single location, which significantly reduces licensing costs, especially for complex technologies whose deployment requires a multitude of licences (Maskus, 2010).

Patent pools have been widely discussed and implemented in the context of ICT innovation, focusing on the bundling of complementary technologies to facilitate the commercialisation of complex products. Relatively recently, the patent pool idea has been leveraged in the biomedical sector for a different purpose, aiming to promote the diffusion of innovation in certain geographical regions, particularly low- and middle-income countries (e.g. SARS vaccines and tropical diseases) (Van Zimmeren et al., 2011). Recent evidence from the Medicines Patent Pool (MPP), a voluntary licensing-based pool aimed at facilitating the diffusion of HIV/AIDS drugs in

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[48] http://energy.gov/savings/energy-efficient-commercial-buildings-tax-deduction

[49] https://www.sciencedirect.com/topics/engineering/energy-policy-act

[50] http://ec.europa.eu/environment/gpp/what_en.html

developing countries, shows the pool substantially increased licensing probability. MPP's impact on the market (price reduction and quantities sold) is also found to be positive, although the magnitude of market impact was much smaller than that for licensing (Galasso and Schankerman, 2022). In the context of COVID-19, the MPP further expanded its mandate to cover COVID-19 products, although it is too early for an empirical assessment of its effectiveness.

This evidence suggests the potential effectiveness of patent pools in promoting the diffusion of climate technologies, especially for adaptation solutions in health and agriculture that are technologically comparable with the MPP case.

In the climate technology agenda, there was an initiative called *'Eco-Patent Commons'* (EcoComms). This project collected climate patents on a voluntary basis. However, the initiative was ended in 2016. This case is referred to as an example that free access to climate technologies does not increase their diffusion. However, this conclusion is questionable because the incentive for private firms to pledge valuable climate inventions in the pool was limited (Contreras et al., 2019).

The success of patent pools depends on the incentives for patent holders to engage in high quality contributions. Public research institutions may be key contributors to enabling effective patent pools that cover high quality inventions. Further, MPP used *Donor Prize Fund* to incentivise voluntary engagement of economic actors in pooling. Fundings obtained from donors (e.g. UNITAID) rewarded eligible patent holders based on their contributions (Cox, 2012).

Patent landscaping: Patent landscaping has been discussed as a means of technical assistance that requires international coordination with the aim to facilitate the process of patent application and examination. Various climate technologies especially those building on microelectronics, biotechnology, and software rely on various, partly overlapping patents. This can be a barrier to licensing, as multiple patent owners need to be identified and multiple licences need to be negotiated. Particularly, in developing countries, the capacities to disentangle the jungle of licensing requirements is limited. Technical cooperation measures and international collaboration can aim at building up comprehensive, public information systems that facilitate the assessment of ownership structures of claims. This could be a tool to help both examiners and licensees (Maskus, 2010).

Practical considerations: Implementing a scheme with a preferential treatment of climate technologies in IP law requires a robust definition and identification method for these technologies and their distinction from non-eligible ones (Cheng, 2022). The generic definition of climate technologies as means that *'help reduce emissions'* is too unspecific to be uniformly valid across regions and time.

The word *'reduction'* implies a reference point, which bears conceptual difficulties in the complex and dynamic context of innovation. For example, a technology that reduces emissions of coal power plants may be climate-friendly in comparison to incumbent coal combustion technologies, but it is not climate-friendly when being compared to alternative sources of energy. There is both a dynamic and regional element because the phasing out certain technologies shifts the reference technology, which may also differ across regions.

One possible solution to identify patented climate technologies would be the use of the Y02-tags of the Cooperative Patent Classification (CPC) system (Angelucci et al., 2018).[51] The tags are assigned to patents during the examination process and classify patents into a wide range of climate-relevant technologies covering for example adaptation, energy, transport, and green ICTs. These codes are widely used in scholarly research, but as technology evolves, the CPC codes co-evolve and change over time. The WIPO Green inventory offers an alternative method to identify climate patents,[52] but it is subject to similar issues. Any legal implementation based on patent classifications would need to be highly adaptive to the pace and possible directions of technological change, which are both subject to uncertainty.

The controversies around the creation of the EU taxonomy for sustainable financial products illustrate the challenges in practically implementing binding labels that determine the eligibility for a preferential treatment, influence the direction of public and private funds, and ultimately the direction of technological change. Given the high economic relevance and impact on the profitability of business models and technologies, the political process to set the standard is subject to particular interests and lobbying. Given the differential views of national governments on climate technology and preferred technological pathways (for example, in nuclear energy, natural gas, combustion engines), it may be time-consuming to achieve an agreement.

Alternative approaches to qualify climate technologies as eligible for e.g. TRIPS waivers could be country-specific. For example, the results of TNA could be used to identify key climate technologies, and to indicate them in the country's NDCS. Such an approach would alleviate concerns about a potentially negative effect of weakening IPRs on innovation, as country-specific waivers do not weaken IP at the global scale. One could argue that those countries with the greatest technological needs for specific technologies should be also those with the largest market potential in these areas, which may be a pull factor of innovation. This argument would not be valid if the application of waivers is exclusively applied to a narrow set of technologies serving the needs of developing and least developed countries with a weak purchasing power. Hence, the effect on the returns to innovation for the inventor would be limited. However, objective country-specific assessments that are detailed enough to qualify individual patents may be complex to implement, also as they would need to be adaptive and might be prone to political influence.

5.2.2 Non-IPR measures

Removing trade barriers: As discussed earlier, trade barriers are still significant and there is a great potential for reducing them (Corvaglia, 2014; Brandi et al., 2020; Maskus, 2010; Brewer, 2008). If such an approach is taken, it would be important to

[51] https://worldwide.espacenet.com/classification?locale=en_EP#!/CPC=Y02

[52] https://www.wipo.int/classifications/ipc/green-inventory/home

ensure that developing countries are not excluded from the benefits of preferential trade in climate-friendly goods and services. A longer discussion of the issue can be found above (Section 4.3.1).

Border carbon adjustments (BCAs): Trade policies could be also used to penalise carbon-intensive trade by imposing BCAs. BCAs are thought to impose a CO_2-price equivalent tariff on emission-intensive imports to create equal conditions with producers from countries, where cost-increasing climate policies such as CO_2-prices apply. The primary motivation of BCAs is the avoidance of carbon leakage, i.e. the relocation of emissions from regulated to non-regulated countries (Condon and Ignaciuk, 2013). It is argued that BAC could provide an incentive for the adoption of climate technologies abroad, as the cost burden imposed by the BCA would be proportional to the emission-intensity of the production process.

However, doubts can be raised about the need and effectiveness of BCAs. They are difficult to implement technically, and so far, the concerns about carbon leakage are primarily theoretically motivated but empirical evidence is lacking, which undermines the primary motivation of BCAs (Grubb et al., 2022). It is also questionable whether BCAs would stimulate climate technology adoption and innovation in developing countries, if not even having the opposite effect.

Maskus (2010) outlines four possible reasons why the impact of BCAs on climate transfer to developing countries may be negative. First, the protectionist nature of BCAs may reduce the incentive for producers from high-income countries to engage in FDI. Second, producers in developing countries may lose market access, which in turn can negatively affect investments in newer (and often cleaner) production technology. Third, the administrative burden to prove the emission content of exported products can be prohibitively high and costly. Fourth, the threat of trade restrictions imposed by high-income countries can undermine the willingness of participation in international climate negotiations.

While the occurrence of the first three arguments is contingent on the details of implementation of BCAs and their supplementation with other instruments (Cosbey et al., 2019), the latter argument may be non-negligible. The results of the interviews of this study indicated that climate negotiations are often considered as a project of developed countries, while developing countries pay the bill for the lack of action without being effectively compensated. Implementing a mechanism that limits the economic opportunities of developing countries may further undermine their willingness for cooperation and the UNFCCC principle of a common but differentiated responsibility (Böhringer et al., 2022; Eicke et al., 2021; Cosbey et al., 2019).

Modifications of BCAs, such as using the revenues raised by BCAs to finance climate change adaptation and mitigation in developing countries, can be an inclusive direction of implementing the measure.

Climate clubs: The concept *Climate Clubs* combines carrot and stick tools, like the preferential treatment of climate-friendly products and technologies, and the penalization of those who do not comply, for example, by applying BCAs. The idea of climate clubs is inspired by the success of the Montreal Protocol. The concept of Climate Clubs debated today is based on the ideas promoted by, amongst others, Nordhaus (2015) and has been proposed and adopted at the G7 level, promoted by the German government.[53]

The Climate Club is self-enforcing once the number of members is large enough, as the net benefits of compliance outweigh the benefits of non-participation. The benefits of participation are given by the preferential access to the market of the participants; hence the benefits grow with the number of participants. In contrast, the benefits of non-participation are those arising from not being obliged to comply with the climate regulation as included in the agreement. If these benefits arise from, for example, producing emission-intensive steel, the benefits shrink with the number of Climate Club members, as the size of the residual unrestricted market shrinks.

Climate Clubs can be supplemented by additional multilateral arrangements, such as investment, cooperation, and R&D partnerships and exemption rules for developing countries. Recent research suggested Climate Clubs can be an alternative structure to the UNFCCC because they can effectively penalise free-riders (Nordhaus, 2020).

However, scepticism can be raised from a developing country perspective. A systematic literature review has recently shown that the development perspective is widely ignored by the literature on climate clubs and BCAs (Overland and Huda, 2022). If climate clubs were implemented without measures to enable developing countries to participate, there is a significant risk that existing technology gaps between developed and developing countries are strengthened. The third pillar of the existing proposal adopted by the G7 encourages club members to engage voluntarily to support developing country members in capacity building and technology transfers, and to reconsider existing agreements to better align with developing countries' needs. But these means remain on a voluntary basis and are not well specified.

While Climate Clubs may be an effective tool to promote the diffusion of climate technologies, there is a considerable risk that future markets for climate technologies will be exclusively dominated by developed countries. This risk could be alleviated by granting developing country members preferential access to Climate Clubs with lower compliance requirements, potentially combined with targeted support for capacity building. Our interviewees consistently stated a general scepticism regarding the Paris Agreement and the activities at the UNFCCC level as being driven by the interests of large corporations and high-income countries (see Section 3.4.1). Climate Clubs could reinforce the existing divide if they exclude developing countries from the economic benefits of taking part.

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[53] https://www.g7germany.de/resource/blob/974430/2153140/a04dde2adecf0ddd38cb9829a99c322d/2022-12-12-g7-erklaerung-data.pdf?download=1.

6 Conclusions

This study reviewed the relationship between IPRs, innovation in climate technologies and sustainable development. Based on a systematic screening of the economic and legal literature, we identified three core areas where IPRs and climate technology interact. First, IPRs could promote ITT through the channels of trade and FDI; second, IPRs can stimulate or hinder indigenous domestic innovation in climate technologies; and third, IPRs interact with adaptive and imitative innovation that is often needed to make existing climate technology better suited to the local context.

Based on a literature review and semi-structured experts from four developing countries (Bangladesh, India, Kenya, and South Africa), the key results of the study can be summarised as follows:

- The heated discussion about IPRs in the climate context does not reflect its actual relevance for combating climate change. More attention should be paid to the demand side. The key constraint that hinders developing countries in widely deploying climate-technologies is not related to IPR but costs. Demand side policies should aim at reducing costs.

  Both the literature and interviews suggested that the focus on IPRs is distracting. The debate about IPRs dates back to the 1990s, when many technological solutions were not yet developed. Hence, there was a significant need for the development of climate technologies at the supply side. 30 years later, the key challenge is technology diffusion. Also the literature is biased in this regard, and most innovation research has focused on technology supply.

  While most climate solutions are in their maturity stage or relatively low-tech, there are potential exceptions in which IPRs matter, such as recent advances in hydrogen, biofuels, and GM crops. Given the conceptual difficulties in defining the boundary of *'climate technology'* (see Practical Considerations in Section 5.2.1), the range of cases where IPRs matter can change. Although this study concludes that IPRs have little relevance for most climate solutions that are relevant in developing countries, future studies are needed to address the special cases separately.

Box 3: Relation to COVID-19

The debate on IPRs in the context of climate technologies was refuelled by recent discussions about the TRIPS waiver for IP-protected COVID-19-related medical products, including vaccines. Proponents who advocated relaxing IP protection argued that the climate crisis should be considered as an analogue to the global health crisis of COVID-19 and that IPRs waivers should be analogously applied. In the interviews, various comparisons and contrasts were drawn between COVID and climate change, and the conflicting attitudes participants expressed signal to the complex nature of these issues.

The key analogies and differences between both discussions can be summarised as follows:

Analogies: For both climate and COVID-19 technologies, IPRs is not the key barrier to the production, innovation, and diffusion in developing countries. Instead, the lack of a sufficient absorptive capacity including technological capabilities, relevant supply chains, and manufacturing capacities, before IPRs may become a relevant factor. Hence, in both cases, the heated discussion on IPRs is likely rather distracting than helpful to address the most urgent problems.

Differences: (1) COVID-19 medicals were a supply side problem, while climate technologies suffer from the lack of demand. In the climate context, the technological solutions already exist for most problems, but their diffusion is sluggish due to an insufficient demand. This was different for COVID-19, where the technological solutions were not yet available at the peak of the crisis. (2) Climate and COVID-19 technologies are heterogeneous. While pharmaceuticals and medical products are generally very IP-intensive sectors, most of the relevant climate technologies are not and IP-licensing fees are a minor cost factor compared to capital costs, if they occur at all. Many technologies are already mature and no longer IP protected and/or low-tech and NbS exists. (3) The market structures are different: For most climate technologies, the markets are competitive with multiple substitute technologies. Hence, arguments about excessive pricing due to the abuse of patent-induced monopoly rights do not hold.

These analogies and differences reaffirm the general conclusions of this study, stating that IPRs is likely not the bottleneck in speeding up the global diffusion of climate technologies.

- The key reasons why IPRs are not an issue for climate technologies in developing countries are the following:
    1) Many relevant climate technologies are old, and previous patent protection has expired. Further, the majority of climate problems can be addressed with low-tech or NbS, which bear several advantages compared to high-tech alternatives: Often, NbS and low-tech solutions are much cheaper; NbS often bear many co-benefits, e.g. biodiversity; they are easier to maintain under local conditions; and looking at the NDCs, low-tech often are sufficient to meet the goals.

       NbS and low-tech solutions are less prominently discussed in the literature, which may indicate a bias in the attention they received so far. The NbS literature is rather nascent and there are difficulties of empirical measurement. Similarly, also the database for tracking the diffusion of low-tech climate solutions is poor, which naturally leads to a bias in the empirical economic literature.
    2) Worries about excessive pricing arising from technological monopolies of patent holders often do not apply because many competitors offer alternatives.
    3) There may be few exceptions where IPRs might play a role, and it may be proven whether there is a case of including them in the TRIPS flexibilities. But this is subject to the following considerations: First, it is challenging to define eligibility criteria for specific technologies and countries, and second, if exceptions were only allowed for LDCs, the TRIPS waivers are likely not to have a large impact due to lacking technological capacities in these countries.

- Technology transfer: The relationship between IPRs and climate technology transfer and FDI is contingent on the level of development. Stringent IPRs can promote technology transfer and FDI, but only at higher level of development, i.e. after certain pre-conditions are met. Interviewees from Kenya and Bangladesh stated that IPRs in their countries do not play a role, which is consistent with the literature.

  Moreover, existing mechanisms for ITT in international agreements including the UNFCCC and WTO are not effective: mechanisms with exceptions for LDCs are not effective because these countries are confronted with other issues and need to build up absorptive capacities first.

  Further, FDI projects in developing countries are often not IP-driven and targeted towards natural resource extraction or low-cost manufacturing projects. This rarely implies a transfer of relevant technology and knowledge. Existing clauses for the promotion of ITT and FDI are too unspecific to be effective, and targeting policies that promote FDI as a vehicle of technology transfer require further specifications. To make FDI more effective as a means of diffusing climate technologies globally, existing FDI support policies need to be more targeted.

Industrial policy measures that enforce a greater technological collaboration and knowledge transfer between foreign and local firms could be effective tools to promote technological learning and the creation of domestic industrial and technological capacities. Public FDI support could be redesigned to make joint learning happen. The JI mechanism of the UNFCCC framework could provide a template.

- Indigenous innovation: IPRs can be an enabling factor within a climate-friendly innovation system, but they are not found to be a driver of innovation and R&D. This was clearly found in the interviews (including interviewees from India), and the empirical literature is not unambiguously supportive, differently from the theoretical innovation literature in economics.

  A functioning innovation system for climate technologies needs to be built first; after that, IPRs can play a role therein. Key factors that emerged are demand-pull factors, especially costs and regulation. Climate technologies need to be either cheaper to deploy than fossil-fuel based alternatives and/or an adequate climate regulation is needed.

  For the creation and support of local innovation systems, lower-level means of IPRs protection such as trade marks and utility models are preferable as they are more accessible for inventors from developing countries. Trade marks do not protect inventors' IP, but they are relevant as a marketing tool that enables inventors to appropriate the gains of investments in quality and product developments. Trademarks also facilitate (international) climate technology diffusion because they are signals of quality and help create consumer trust.

- Follow-on adaptive innovation: IPRs can inhibit adaptive innovation and the diffusion of these inventions due to the novelty trap. Inventors and investors risk infringing pre-existing international IP if they engage in developing and upscaling adaptive innovation, which is often low-tech and a minor amendment of an existing technology.

  In a domestic context, this does not necessarily hinder in the production of adaptive innovations. But it impedes the international diffusion of these low-cost, low-complexity solutions, which may often be better suited for the development context compared to high-tech solutions from developing countries.

  Diffusion patents were proposed as an instrument to address the novelty traps, but it may be considered whether international IP law could be amended to promote (or not hinder) the diffusion of climate-related adaptive innovations from developing countries more effectively. However, there are many kinds of adaptive innovation that are not subject to IPRs restrictions, including organisational, frontend, and service innovations. The existing international mechanisms to promote ITT could pay greater attention to the international diffusion of these solutions.

- Climate technologies from developing countries: Developing and emerging countries entered the market for climate technologies. This is poorly reflected in existing agreements, and few mechanisms exist that promote transfer of climate technology originating from these countries. The rise of developing and emerging countries as important source countries of climate technologies requires a shift of the attention from IPRs to trade and investment policy debate. This would not only help speed the diffusion of low-cost climate solutions that suit the developing country context. It would also support innovation and sustainable development in developing countries and would make them become a more active player in the growing global market for climate technology.

  Trade policies could be designed to promote transfer of climate technologies originating from developing countries, for example by the reduction of tariff and non-tariff barriers to trade. Existing trade agreements with environmental provisions often exclude developing countries from active participation. This could be addressed by revising the eligibility criteria that define climate products allowing for a differentiation by the level of development.

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