



International collaborations in green energy technologies: What is the role of distance in environmental policy stringency?

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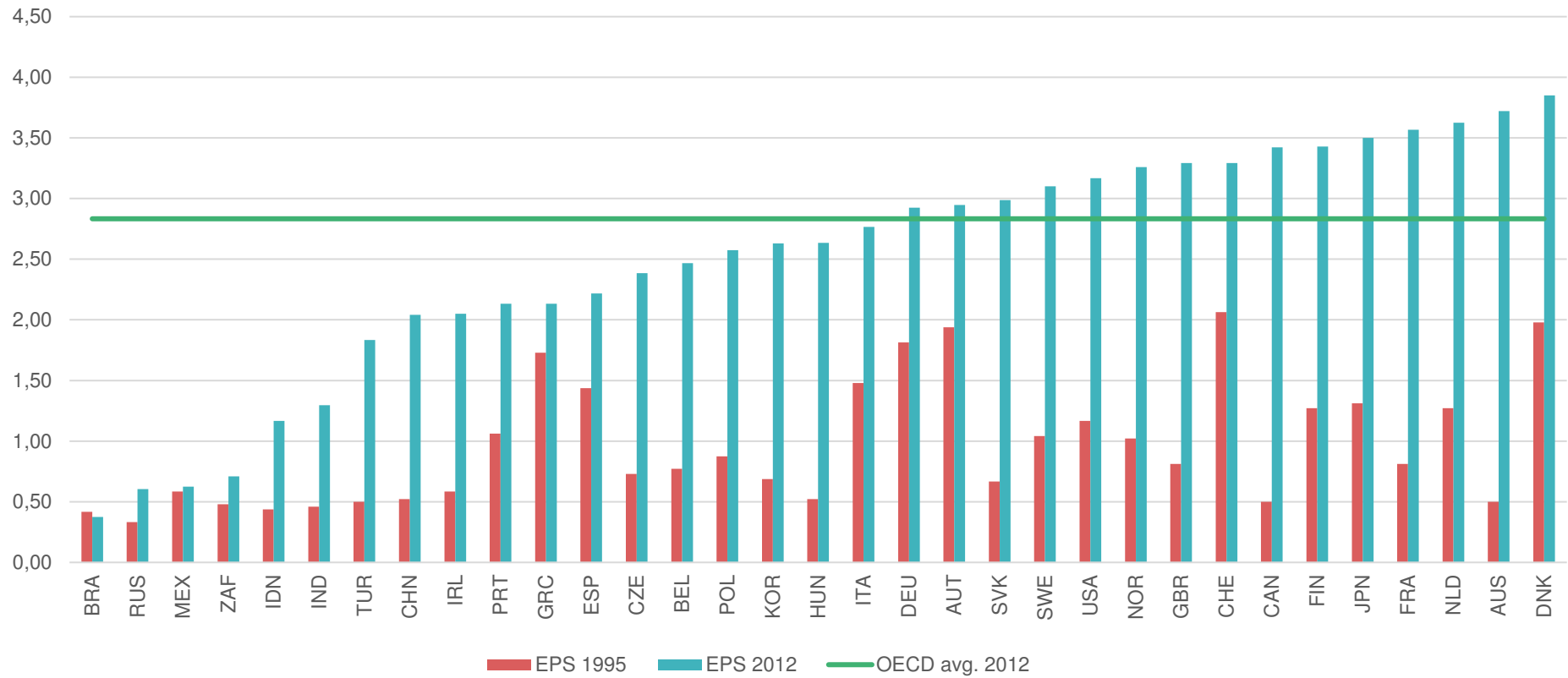
MOTIVATION

- Cross-country cooperation in the development of green innovations brings about sizeable benefits (Haščič et al., 2012; Shapiro, 2014; Haščič and Migotto, 2015) due to the well-known double externality issue
 - Countries collaborate more in climate change mitigation technologies than in other technological domains (Haščič et al., 2012; Kahrobaie et al., 2012; Shapiro et al., 2014).
- The issue is particularly relevant for **energy-related technologies** → developing countries will have to engage heavily in the process of emission reduction, but the majority of innovations is concentrated in the developed countries (Bosetti and Verdolini, 2017).
- The development of international collaborations may stimulate the **exchange of knowledge and technology across different countries**, allowing (in principle) latecomer countries to engage into a process of **sustainable growth**.

OBJECTIVE OF THE PAPER

- To investigate the *intensity of international collaborations in the development of energy-related climate-change mitigation technologies* across OECD and BRIC countries and examine **the role of the distance in the stringency of regulation (demand-pull and tech-push)**, controlling for other types of distance (technological, socio-cultural, institutional)
- Given the nature of green innovations, public R&D allocation and regulations on energy practices affect the development of international technological collaborations (Shapiro et al., 2014)
 - **Environmental regulation is very heterogeneous across countries** in terms of content and in the extent to which the regulation puts an explicit or implicit price on polluting or other environmentally harmful behaviour

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- Given the nature of green innovations, public R&D allocation and regulations on energy practices affect the development of international technological collaborations (Shapiro et al., 2014)
 - **Environmental regulation is very heterogeneous across countries** in terms of content and in the extent to which the regulation puts an explicit or implicit price on polluting or other environmentally harmful behaviour
 - It is therefore important to understand how **distance in the stringency of environmental regulation between countries** (difference in the institutional settings) affect **technological collaborations** and, ultimately, sustainable growth

REGULATION, GREEN INNOVATION AND COOPERATION

- Literature has addressed the role of different types of distance on research collaborations: geographical, cultural, social, technological distance (Picci, 2010; Scherngell and Barber, 2011; Cecere and Corrocher, 2013; Montobbio and Sterzi, 2013)
- What about distance in environmental regulation?
 - It impacts trade flows (e.g. Ederington and Minier, 2003; Levinson and Taylor, 2008; Levinson, 2010) and FDI (Xing and Kolstad, 2002; Wagner and Timmins, 2009), but evidence is empirically unresolved.
 - The evidence on its impact on green R&D or technology transfer is also inconclusive (Dechezleprêtre et al., 2015; Noailly and Ryfisch, 2015; Bosetti and Verdolini, 2017; Marin and Zanfei, 2018).
 - Dechezleprêtre et al. (2015): the more diverse the countries, the lower the cross-border diffusion of green technologies.
 - Bosetti and Verdolini (2017): when regulatory distance matters, it has a positive impact on knowledge transfer

DATA

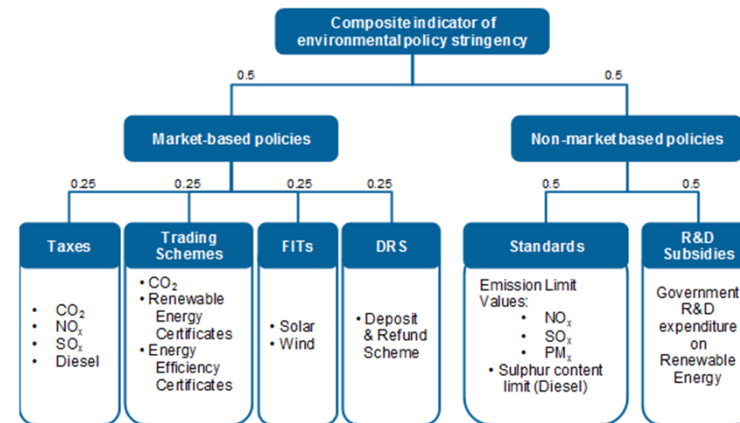
- Combination of different data sources:
 - data on **EPO patents** and international patent collaborations in CCM technologies, particularly in the green energy (ENE) technological domain (**from the OECD**);
 - data on the stringency of environmental regulation (**EPS** indicator **from the OECD**);
 - data on preferential trade agreements (**PTA**) in two areas: energy/environmental laws and IPR/innovation policy/R&D **from the World Bank**
 - data on **FDI from UNCTAD**
 - data on **geographical and cultural differences across countries** from **CEPII**
 - data on the **socio-economic context** (from **World Bank and IEA**)
- Countries: **EU, BRIICS** (Brasil, Russia, India, Indonesia, China, South Africa), **US, Other OECD** countries (including Japan and South Korea)
- Time span: **1995-2014**

THE ENVIRONMENTAL POLICY STRINGENCY (EPS)

- Country-specific and internationally-comparable measure of the *stringency* of environmental policy **ranging from 0 (not stringent) to 6 (very stringent)**
- **Policies**: **environmentally-related taxes, renewable energy and energy efficiency support** (feed-in-tariffs, renewable energy certificates, R&D subsidies), **performance standards** (emission limit values for coal fired power plants and sulphur content limits in diesel fuels) and **deposit and refund schemes**.
- **Stringency**: the degree to which environmental policies put an explicit or implicit price on pollution or other environmentally harmful behaviour
 - “*Stick*” type policies, which directly raise the costs of polluting behaviour, are more stringent the higher the taxes or the stricter the standards.
 - “*Carrot*” type policies, which reward environmentally friendly activities (raising the relative costs of pollution), are more stringent the higher the support such as feed-in-tariffs or R&D subsidies.

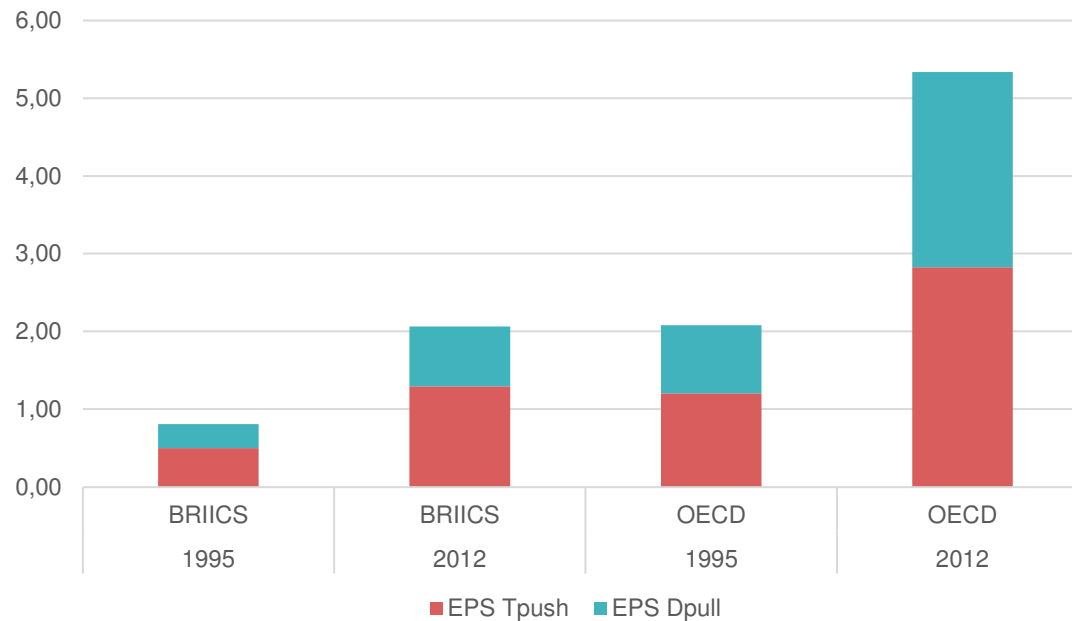
THE COMPONENTS OF EPS

- EPS can be unpacked into market-based and non-market based policy instruments
 - Market-based** instruments do not mandate the use of specific technologies, leaving to the firm to choose the most efficient among suitable alternatives
 - Non-market based** instruments often focus on the requirement (law enforcement) to adopt a specific and more environmentally efficient technologies



- The two instruments might provide different incentives for cross-border collaboration in technology development (Marin and Zanfei, 2018)
- We propose an alternative classification of EPS components, i.e. **technology-push** (R&D subsidies and feed in tariffs) vs. **demand-pull** (trading schemes, taxes on pollution and standards) (Rennings, 2000; Jaffe et al., 2002; Peters et al., 2012; Ghisetti, 2017)
- Policy instruments can act as a stimulus either for companies to develop innovations into green technology domains, or for the market to adopt specific standards or benefit from schemes that foster the diffusion of green technologies

EVIDENCE ON THE D-PULL/T-PUSH EPS (1995-2012)



Over the sample period **BRIICS** just catch-up with the average initial levels of Technology Push and Demand Pull EPS of OECD countries, **focusing in particular on technology-push components.**

On the contrary, **OECD** countries push slightly more towards **increasing the Demand Pull component of the EPS.**

THE MODEL

$$copat_{ijt} = f(distEPS_{ijt}^{Tpush}, distEPS_{ijt}^{Dpull}, avgRTA_{ijt}, diffRTA_{ijt}, controls)$$

Controls:

- GDP per unit of energy use at constant 2011 PPP \$ per kg of oil equivalent (mean and difference)
- total population (mean and difference)
- bilateral distance
- dummy for a common language
- share of the population with tertiary education (mean and difference)
- existence of preferential trade agreements (PTA) between the two countries, including legally enforceable provisions covering two policy areas potentially relevant for patent collaborations:
 - a. energy and environmental laws
 - b. IPR, innovation policies and research and technology
- Involvement in inward and outward FDI flows

DISCUSSION (1)

REGULATION

- The distance in EPS **negatively** affects the intensity of technological collaborations
 - similar regulatory frameworks are necessary to foster collaborations
 - the resulting innovations can achieve compliance in both countries, so that the benefits of cooperation are successfully exploited by both partners (Dechezleprêtre et al., 2015).
- The negative effect is due to the **distance in demand-pull EPS measures**
 - Similarly stringent environmental standards allow both countries to develop innovations that are compliant with standards in both countries (Beise and Rennings, 2005).
 - Co-patents in energy-related technologies result from a highly relational process (Dechezleprêtre et al., 2015): regulatory stringency in the partner country is important for the creation of demand for the new technologies and also for the development of local technological capabilities (Kesidou and Wu, 2020).
- Quite importantly, **no significant effect is found for distance in market vs non-market EPS components**

DISCUSSION (2)

- **RTA**

The average degree of specialization of the country-pair positively affects the number of collaborations, but the difference in the RTA of the two countries hinders their collaboration

→ some similarity between countries' technological capabilities is required to benefit from the joint R&D activity and the shared knowledge and resources

- **Controls:**

→ distance between the two countries reduce collaborations, while common language favours them

→ PTA agreements concerning IPR, innovation policies and research and development show a positive and significant sign: complementarity between technological collaborations and trade

→ PTA covering energy and environmental laws show a (mild) negative effect: substitution effect of trade?

→ FDI flows do not show a significant impact on the technological collaborations

- Ceteris paribus, BRIIC countries are found to collaborate less, particularly so among themselves

CONCLUSIONS AND POLICY IMPLICATIONS

- Policy commitment to a well-defined level of stringency of regulation, can help local firms to cooperate in innovation with international counterparts
 - Stringency of demand-pull policy instruments is relevant in creating a **market for energy-related technologies addressing climate change mitigation**
- Similar levels of **stringency of regulation** between countries triggers not only technology transfer and the diffusion of foreign imported technologies (Dechezleprêtre et al., 2015; Kesidou and Wu, 2020), but also international technological collaborations
 - The design of stringent regulatory frameworks reduces the environmental harmful behaviours AND **stimulates a long-term shift in the innovation capabilities of local organizations** thus promoting sustainable growth
 - Policy instruments supporting local firms' capability building and R&D have to be complemented with regulatory instruments that are devoted to the **development of the market for energy-related technologies**



Thank you!

Comments/suggestions welcome
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