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The Design of Clean Trade and Investment Partnerships

The European Commission's Clean Industrial Deal Strategy marks a shift in the EU's Green Deal by emphasising green value chains and removing barriers to climate-friendly investments. It aims to enhance the global competitiveness of European industry, especially against major players like China, through partnerships and strategic use of the EU's regulatory and technological strengths. The strategy does not aim for self-sufficiency due to high energy costs and resource scarcity, but instead promotes cooperation with third countries. Clean Trade and Investment Partnerships are central to this approach, targeting secure supply chains, joint investments and fair market competition. These partnerships will leverage initiatives like the Global Gateway to strengthen Europe's role in global green markets, though their success remains uncertain amid global competition.

The European Commission's Clean Industrial Deal Strategy is the most visible sign of a recent paradigm shift within the EU's Green Deal (European Commission, 2025a). It puts a new focus on the development of green value chains by supporting lead markets and eliminating barriers to investments in climate-friendly technologies. In this respect, the competitiveness of European industry in global markets is a key issue. Due to high energy costs and scarcity of domestic resources, this cannot be achieved via the path of autarky.

For this reason, the Commission has announced Clean Trade and Investment Partnerships with third countries that will become an integral part of the Clean Industrial Deal. They focus on improving the management of strategic dependencies and securing Europe's position in global value chains. They will mobilise investment for joint projects, including funds from the Global Gateway Initiative (European Commission & High Representative, 2021). They will also ensure fair competition in common markets for green products by harmonising product-related regulations.

It remains to be seen how promising such agreements are in the context of competition with countries like Chi-

na, which also invests heavily in securing supply chains through partnerships. To increase the EU's position in this race, it is necessary to clarify how Europe can use its specific resources (values, technological and regulatory expertise) as a competitive advantage in shaping such partnerships in order to create sustainable growth prospects for itself and for partners. This article proposes a strategy for prioritising cooperation instruments based on a partner country's resource potential and framework conditions.

Goals and instruments

With the Clean Trade and Investment Partnerships, the EU's basic intention is to pool resources to develop new joint value chains for clean technologies with like-minded third countries. This starts with the sourcing of raw materials for industrial equipment and the supply of renewable energy. It also involves the development of manufacturing capacity for the production of equipment and skill creation through investment in training and reskilling. Finally, it goes beyond the pure supply chain approach and includes joint activities to strengthen the innovation capacity of clean technologies. The expected result is a diversification of existing supply channels.

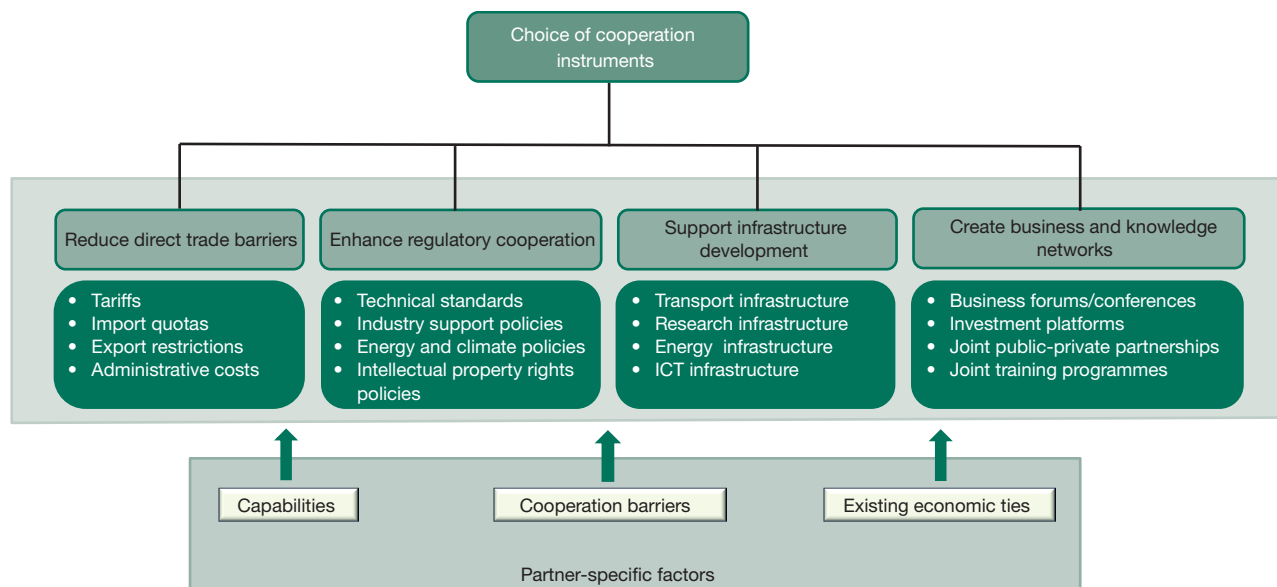
A key immediate objective of diversification efforts is to reduce supply risks. These can be of a direct economic nature, such as the risk of global supply shortages and associated price increases for critical raw materials or components. They can also be political in nature, in the form of the risk of export restrictions by supplier countries. Finally, they can be technical in nature, in the form of short-term capacity bottlenecks in production or failures

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Figure 1

Scheme of cooperation instruments in Clean Trade and Investment Partnerships

Source: Author's own illustration.

of cross-border transport infrastructure. Diversification of supply routes does not eliminate these risks, but it can reduce their overall impact on the security of supply.

The formation of partnerships also serves to raise productivity. By pooling capital to expand complementary production capacity, the partners aim to realise macroeconomic productivity gains from vertical specialisation. In the case of infant technologies, there is also the prospect of cost reductions through economies of scale (Ederington & McCalman, 2011). By jointly investing in the development of transport infrastructure (commodities, energy, data) for the formation of supply chains, the partners contribute to the reduction of overhead costs. By sharing existing knowledge, they increase the speed of adoption of new technologies (Foster & Rosenzweig, 2010). By building joint R&D capacities, they strengthen the innovative capacity of the partners involved.

In many cases, the promotion of joint value chains requires overcoming a multitude of regulatory, economic and technological obstacles. The first task in each cooperation consists of identifying the necessary bundle of measures to reduce partner-specific barriers (Figure 1), which are then implemented in a step-by-step manner.

In the absence of bilateral trade agreements, this is likely to involve measures to reduce direct trade barriers, i.e. barriers that make cross-border trade unnecessarily costly. Besides the reduction of tariffs, this can include

the dismantling of quantitative import or export restrictions as well as measures to reduce the administrative costs of customs clearance. These measures are supposed to improve the cost competitiveness of joint supply chains, both by eliminating direct cost burdens and by fostering specialisation among partners (Essaji, 2008).

Moreover, partnerships can go beyond reducing direct trade-related costs by addressing more fundamental barriers caused by differences in market regulation. Enhanced regulatory cooperation can help creating a fair joint market with partners through levelling the playing field for firms (Santeramo & Lamonaca, 2022). This does not only support potentially innovation-enhancing competition, but can also improve future policy designs by initiating knowledge exchange among regulatory bodies.

Reducing direct barriers to economic integration will in many cases not be enough to form competitive joint supply chains. Particularly in cooperation with developing or emerging economies, support for the development of trade-relevant infrastructure will have to be an integral part of the cooperation agenda. With the Global Gateway Initiative, the EU has developed a strategy for allocating funds to investments in the infrastructure of countries worldwide (Wolf & Poli, 2024).

Finally, cooperation policies can also support businesses in creating joint networks with stakeholders from partner countries. This can take forms of direct public engage-

ment like Public Private Partnerships (PPPs). On a lower level, it can consist of providing platforms for private economic exchange like regular business forums or dedicated market platforms.

Cooperation potentials

To identify country-specific cooperation potentials and barriers, we implement a multi-stage approach. The first step consists of analysing the specific strengths of potential partner countries in terms of their domestic resource potential. In line with the EU's value chain-centred Clean Industrial Deal approach (European Commission, 2025a), we conceptualise resources in a broad perspective as capabilities. First, this includes primary resources. Green technologies require sufficient access to renewable energy, but also to a range of critical minerals used as raw materials in production. We quantify the potential for renewable energy based on the climate-dependent generation potential of PV and wind electricity in a country. The potential in the field of critical minerals is assessed based on information about a country's geological raw material reserves. Our approach in identifying the list of critical minerals is to adopt the current list of strategic raw materials defined by the EU in its Critical Raw Materials Act (European Union, 2024a) and narrow it to those minerals for which international country-level data on reserves is available.

In addition, we identify the downstream manufacturing potential based on a country's industrial structure. One part of this potential is a country's ability to become a net exporter of renewable energy through its conversion into a form suitable for international transport. Current analyses identify hydrogen (and its derivatives) as a key technology for such export activities (IEA, 2019). By producing hydrogen through electrolysis of water, using electricity gained from renewables as an energy source, a renewable gas is obtained that can be directly shipped or processed into other derivatives like green methanol or ammonia. To identify these potentials, we account for national production capacities of hydrogen from electrolysis (both existing and currently constructed) (IEA, 2025a) as well as national capacities for capturing CO₂ (IEA, 2025b), a crucial input in processing hydrogen to derivatives like synthetic fuels.

The second part of the downstream potential considers capacities for producing the equipment and its components necessary for applying clean technologies. Our basis for this is the list of net-zero technologies identified by the EU in its Net-Zero Industry Act (European Union, 2024b). As is the case for most technologies, direct comparative data on manufacturing capacities is not

available, and we therefore proxy production potentials by export volumes in 2023.

Finally, we consider worker skills and innovation capacities as intangible resource potentials. Skill requirements are highly technology-specific. Skill supply for the wide range of existing clean technologies is thus difficult to quantify at country level. Yet, a commonality of complex (and partly still infant) clean technologies is the specific need for advanced engineering and natural science skills. We cover this in broad terms by considering the prevalence of tertiary education in the worker population and the share of graduates from STEM (science, technology, engineering, mathematics) fields in total graduates. Innovation capacity for clean technologies is measured in a more specific way by drawing on patent data differentiated by technology class. We consider both a quantity and a quality dimension in patenting, by including the number of patent applications with domestic inventors¹ and the average citation rates.

The different dimensions of resource potentials are highly complementary. Therefore, aggregating them to single indices is not sensible. Instead, we only aggregate single indicators within each resource category through Principal Component Analysis. The extracted first components of each category then undergo a cluster analysis, allowing for the identification of clusters of countries that offer similar specific resource potentials as future partners to the EU.

Data are taken from a range of renowned public databases (see Table 1). To ease the identification of cooperation patterns and focus on countries suitable for deepened partnerships, we limit the sample to those third countries that either already have bilateral trade agreements with the EU in place or are in the process of negotiating such agreements (European Commission, 2025c). Furthermore, we exclude very small countries with fewer than a million inhabitants. The countries analysed are: Albania, Algeria, Argentina, Armenia, Australia, Azerbaijan, Bosnia and Herzegovina, Botswana, Brazil, Canada, Chile, Colombia, Costa Rica, Cote d'Ivoire, the Dominican Republic, Ecuador, Egypt, El Salvador, Eswatini, Georgia, Ghana, Guatemala, Honduras, India, Indonesia, Israel, Japan, Jordan, Kazakhstan, Kenya, South Korea, Lebanon, Lesotho, Macedonia, Madagascar, Mexico, Moldova, Morocco, Mozambique, Namibia, New Zealand, Nica-

¹ For a country comparison, we must consider that often several people are registered as the inventors of a patent, who may be located in different countries. We account for this by applying an equal share for each inventor as a weighting factor. Then, we calculate the total innovation activity of a country in a field as the sum of the shares of inventors residing in the respective country (inventor counts).

Table 1
Indicators for measuring cooperation potentials

Category	Indicator	Measurement	Source
Mineral resources	Geological resources	Estimated geological reserves (tonnes) of 11 critical raw materials and raw material groups: bauxite, cobalt, copper, gallium, lithium, manganese, natural graphite, nickel, platinum, rare earth metals, titanium minerals	USGS (2025)
Renewable energy	Solar energy	Average specific PV output (kWh/kWp)	World Bank Group (2025)
	Wind energy	Average wind power density (W/m ²)	DTU (2025)
Skills	STEM graduates	Share of university graduates that graduated in STEM fields in 2023	UNESCO (2025)
	Tertiary education	Share of workers with tertiary education in 2023	World Bank (2025b)
Patents	Patent numbers	Number of patent families for energy technologies ¹ by country of residence of the inventor in 2013–2022	EPO (2025)
	Citations	Average size of patent families for energy technologies by country of residence of the inventor in 2013–2022	EPO (2025)
Hydrogen processing	H ₂ production capacity	Total capacity of electrolysis-based hydrogen production operational or under construction	IEA (2025a)
	CO ₂ capture capacity	Total carbon capture capacity operational or under construction	IEA (2025b)
Net-zero technology equipment	Batteries	Exports of lithium-ion batteries (HS code: 850650) in 2023	UN Comtrade (2025)
	Electrolysers	Exports of electrolysers (854330) in 2023	UN Comtrade (2025)
	Heat pumps	Exports of heat pumps (841961) in 2023	UN Comtrade (2025)
	Nuclear reactors	Exports of nuclear reactors (84110) in 2023	UN Comtrade (2025)
	PV modules	Exports of PV cells/modules (854142) in 2023	UN Comtrade (2025)
	Wind power	Exports of wind power generators (850231) in 2023	UN Comtrade (2025)

Notes: ¹The energy technologies were approximated by International Patent Classification classes in PATSTAT as follows: batteries: H01M; electrolysis: C25B; fusion reactors: G21B; heat pumps: F25B 30/00; solar cells: H01L; solar heat collectors: F24S; sustainable fuels: C10L 5/40; wind motors: F03D.

Source: Author's own representation.

ragua, Norway, Papua New Guinea, Paraguay, Peru, the Philippines, Serbia, Singapore, South Africa, Switzerland, Tunisia, Türkiye, Ukraine, the United Kingdom, Uruguay, Vietnam and Zimbabwe.²

The communalities between the different dimensions of countries' capabilities, as reflected in correlation coefficients, are almost consistently small and, in a few cases, even negative. In particular, bilateral correlations between capabilities reflecting natural resources (minerals, renewables) on the one hand and capabilities reflecting technological advancement (patents, net-zero tech production) on the other hand are very small, pointing at strong specialisation tendencies. This underlines the need for the EU to develop partner-specific cooperation strategies based on a partner's comparative advantages.

In order to cluster countries according to their specific strengths, the standard method of K-means clustering was applied, which assigns countries to a predetermined number of K different clusters on the basis of multidimensional proximity (Likas et al., 2003). To determine an appropriate number of clusters, the elbow method was used (Cui, 2020). It suggests the optimal number to be four.

Figure 2 illustrates the allocation of countries to these four clusters according to the K-means analysis. The result has some intuitive appeal. Cluster 1 consists of 24 countries. They share a high level of skill potential, while innovation and renewables potential are at a medium level. In addition to a few high-income countries, this group includes many emerging economies in North Africa and West Asia. Cluster 2 comprises only six countries. They share a high level of clean technology sophistication, reflected in high skills and innovation potential, and significant manufacturing capacity for both net-zero equipment and renewable fuels. Cluster 3 consists of only three countries. They exhibit high natural resource potentials for both minerals and renewable energy, while innovation and manufacturing capacities are at a medium level. Finally, Cluster 4 comprises the remaining 25 countries. They have a medium level of renewable energy potential, while innovation and manufacturing capacities are low.

In comparative advantage terms, Cluster 1 countries can be assessed to have their specific relative strengths in the field of skills, Cluster 2 countries in technologies (both development and manufacturing). Cluster 3 countries perform best in their mineral resource potentials, while comparative advantages of Cluster 4 countries lie in renewable energies.

² Detailed results for country-specific potentials are available from the author on request.

Figure 2
Composition of country clusters



Source: Author's own illustration.

Framework conditions

The barriers to establishing joint value chains in clean technologies are as diverse as the cooperation potentials. We deal with this fact by addressing and weighing different barriers to bilateral trade through a gravity regression approach. In doing so, we explain the volume of bilateral trade between EU member states and third countries by a range of explanatory factors. Besides standard variables controlling for size (GDP, population), geography (distance, common border) and historical relations (former colonial status), we consider a set of variables reflecting potential political barriers to trade. They include average tariff levels from UNCTAD (2025), the existence of bilateral trade agreements (Larch, 2023) and the Worldwide Governance Indicators (World Bank, 2025b).

The estimated coefficients (as far as they are statistically significant) obtained for the political barriers are used as weights in calculating the weighted sum of political barriers. The resulting aggregate measure is transformed into a dimensionless index by applying a standard max-min procedure.³ For each third country, this is done for both

³ Index = (value – min(value))/(max(value) – min(value))

export and import relations with each EU member state. Finally, the resulting indices are averaged over member states and trade direction (weighted by trade volumes). For each third country, this generates a single index with a scale from 0 to 1 measuring the overall extent of political barriers to trade with the EU. For our gravity analysis, we use panel data on trade volumes over a 20-year horizon (2004–2023) from UN Comtrade (2025). Control variables for the gravity regression are drawn from the World Development Indicators (World Bank, 2025b) and the database of the CEPII (2024).

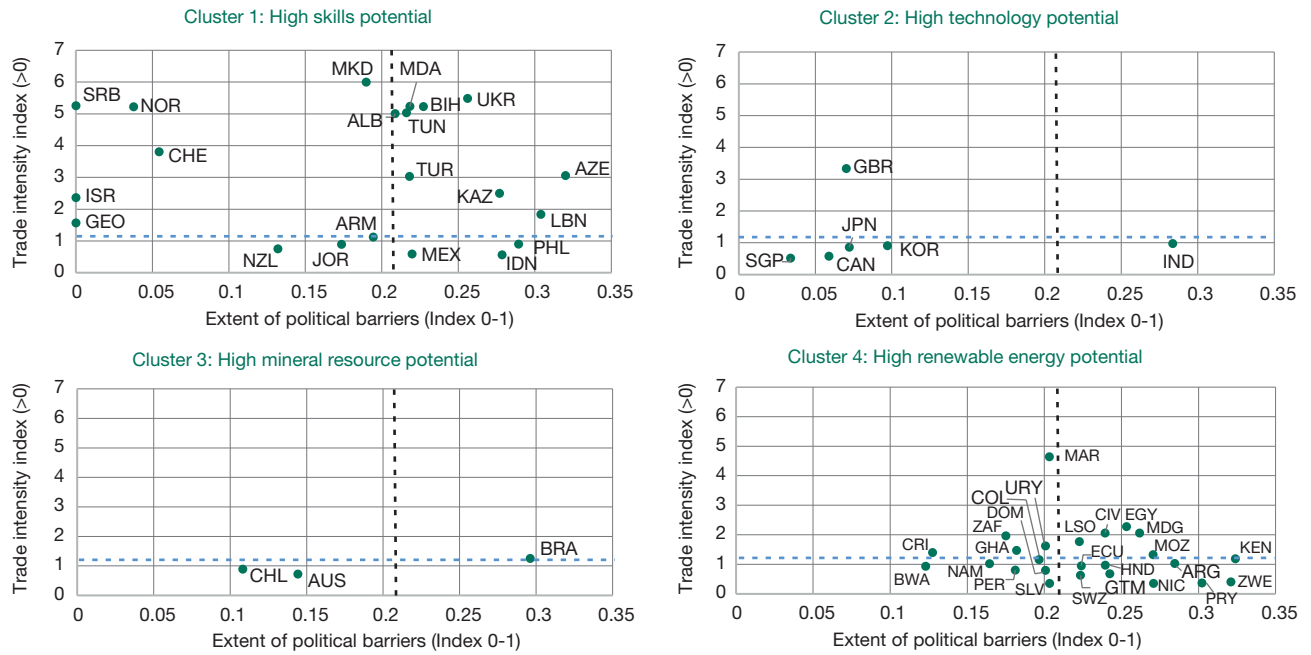
To measure the existing degree of economic cooperation between the EU and specific third countries, we apply the bilateral trade intensity index developed by the World Bank (WITS, 2025). It measures the relative level of bilateral trade volumes compared to the trading partners' overall trade volumes. To reflect the quality of trade-related infrastructure in a partner country, the subindex "infrastructure quality" from the most recent version (2023) of the World Bank Logistics Performance Index (LPI) (World Bank, 2025c) are used.

Figure 3 illustrates the results for the index of political trade barriers together with current trade intensities, measured for the most recent year (in most cases 2023). Cluster 1 (comparative advantage: high skills potential) includes a range of countries in the geographical vicinity of the EU, which already exhibit strong economic ties to the EU. The extent of institutional ties, however, differs considerably. Countries in Cluster 2 (comparative advantage: high technology potential) are mostly characterised by comparatively weak trade links with the EU. This is partly explicable by their geographical distance to the EU and their closer proximity to other economic superpowers (China, USA). With the exception of India, barriers at the political level are comparatively small, suggesting that cooperation is focused mostly on the promotion of joint business networks. Countries in Cluster 3 (comparative advantage: mineral resources) also exhibit a comparatively low intensity of merchandise trade with the EU, again plausibly explicable by spatial distance. Finally, Cluster 4 countries (comparative advantage: renewable resources) prove to be highly heterogeneous both in terms of their trade intensity and the extent of political trade barriers.

The identified country clusters also differ considerably in terms of infrastructure quality (see Figure 4). All countries in Clusters 2 and 3 score highly in terms of trade-related infrastructure. In contrast, the majority of countries in Cluster 4 score at the lower end of the scale. This highlights the fact that partnerships targeting different resources also require different cooperation instruments to overcome their specific obstacles.

Figure 3

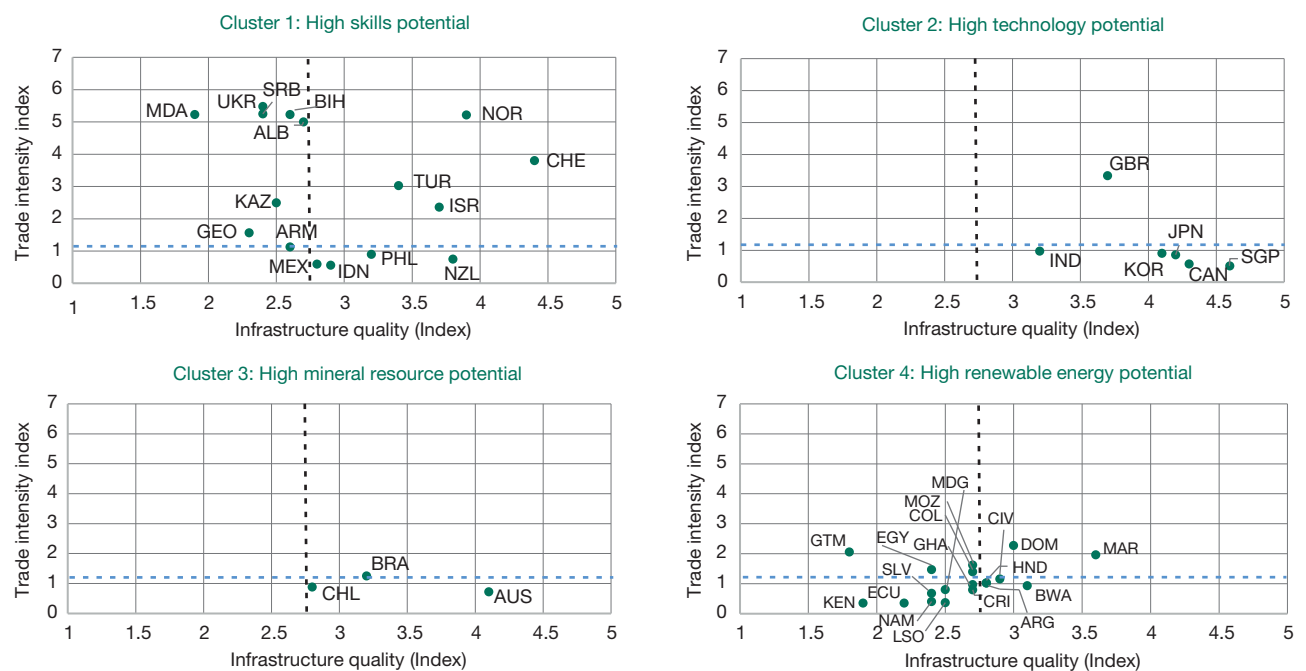
Comparison of political barriers and current strength of economic ties



Source: Author's own calculations. Light-blue dotted line: median level of trade intensity; black dotted line: median level of political barriers.

Figure 4

Comparison of infrastructure quality and current strength of economic ties



Source: Author's own calculations. Light-blue dotted line: median level of trade intensity; black dotted line: median level of infrastructure quality.

Finally, the general relationship between cooperation potentials and barriers becomes even clearer when examining the correlation between a country's supply of different capabilities and its framework conditions. The correlation coefficients are highly positive for infrastructure quality and highly negative for political barriers in relation to capabilities in net-zero equipment, skills and patents. Hence, partnerships to enhance cooperation in these areas do not usually require massive improvements in the partner country's enabling environment. In contrast, the correlation coefficients of mineral and renewable resources with both framework indicators are close to zero. In partnerships that mainly target natural resources, therefore, the EU will have to put a particular focus on obstacles related to infrastructure and institutional quality in partner countries.

Discussion

The preceding illustrative analysis points to some basic principles in forging new partnerships. This starts with the choice of partner countries for deepening cooperation. At the diplomatic level, it is important for the EU to signal that it is open to economic integration with any country that is interested in cooperation and shares at least some of the EU's core values. However, practical implementation involves up-front costs (setting up consultation platforms, negotiations, etc.) that require the EU to prioritise some partners over others. The EU should develop a strategic approach to building a portfolio of partners that best suits its needs.

Our analysis demonstrates that building new competitive green value chains requires a bundle of different resources, not all of which can be provided by individual partner countries. Potential partner countries differ greatly in their specific resource advantages. This is an argument for complementarity as a principle for partner selection. Countries with genuine comparative advantages should be prioritised when establishing new collaborations. Focusing on comparative rather than absolute advantages also promises efficiency gains in implementation, as cooperation instruments can be more specialised to the specific resource advantages of partners.

However, relying solely on complementary partners does not protect against the risk of long-term instability in partnerships. This speaks for applying the principle of substitutability, especially where the value chains concerned are of greater economic importance. It would be overly risky to base the future supply of rare earth metals, a key raw material for the low-carbon economy, solely on a strategic partnership with a single large supplier. To avoid this, the portfolio of partnerships needs a certain

Table 2

Decision matrix for prioritising cooperation instruments

		Weak economic ties with the EU	Strong economic ties with the EU
High infrastructure quality	Low political barriers	Create new business and knowledge networks: forums, conferences, standing committees	Maintain close political exchange
	High political barriers	Reduce direct trade barriers: lower tariffs, harmonise technical standards	Enhance regulatory cooperation: harmonise energy, climate and industrial policies
Low infrastructure quality	Low political barriers	Support infrastructure development: PPPs, development aid, investment platforms	Support infrastructure development: PPPs, development aid, investment platforms
	High political barriers	Support infrastructure development; reduce direct trade barriers	Support infrastructure development; enhance regulatory cooperation

Source: Author's own illustration.

degree of redundancy. Another advantage of substitutive partners is the prospect of positive synergy effects in cooperation. If certain specialised forms of cooperation (e.g. clean technology platform) are implemented with various partners, the EU can realise efficiency gains from consolidating bilateral formats into plurilateral clubs.

Therefore, the optimal mix of substitutability and complementarity among partners is crucial. This optimum cannot be determined on an aggregate level but is rather technology-specific. For clean technologies with especially high economy-wide significance, the idea of risk minimisation should be given greater priority. In the case of other technologies, the focus may be more on exploiting specialisation advantages by combining partners with different strengths and positions in future supply chains.

A strategic roadmap for deepening economic cooperation should start with the decision to prioritise specific capabilities of partner countries. On this basis, the next step is to identify appropriate instruments. Priority should be given to instruments that help to overcome the main cooperation obstacles. Table 2 presents a decision matrix based on the framework indicators we analysed. Accordingly, the selection considers both the physical and political environment as well as current economic linkages.

The specific design of each instrument will depend on the capabilities addressed. For example, enhanced regula-

tory cooperation with partner countries with potentials in renewable energy should focus on developing a common market design for cross-border trade of renewable hydrogen or biomethane. A similar specialisation is appropriate for infrastructure development. For countries with relatively high natural resource potential, programmes such as Global Gateway should initially focus on jointly promoting tangible upstream infrastructure. For countries with specific strengths in technological expertise, the creation of a common research infrastructure is more central.

In the medium term, the choice of cooperation instruments must also consider global competition with other countries' partnership strategies. China's extensive investment in resource-rich countries deserves particular attention (Kaplinsky & Morris, 2009). Countries face the choice of which economic clubs to join. An important competitive factor is the level of club-specific entry costs. For poor countries with relatively underdeveloped institutions, the focus will often be on the costs of political-regulatory adaptation.

In addition to these immediate costs, club membership may also entail additional long-term costs. For resource-rich countries, the main risk is economic lock-in. The establishment of joint value chains threatens to confine them permanently to the role of raw material supplier in international trade, with no prospect of participating in more value added-intensive downstream production stages. Strategic partnerships thus risk triggering a new form of the "resource curse", which has been the subject of empirical research for some time (Ploeg, 2011).

This makes it all the more important to keep the second component of access costs low for potential partners. One way to do this is to include binding steps to increase value-added contributions in roadmaps for future cooperation. Partner countries will be offered the prospect of expanding their role in joint value chains over time to include downstream processing steps, thereby advancing their industrial development while benefiting from knowledge spillovers.

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