

Green windows of opportunity? Latecomer development in the age of transformations towards sustainability

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Background Summary

- Special issue project - Industrial and Corporate Change (with Xiaolan Fu and Roberta Rabellotti)
- Key questions:
 - Do windows of opportunities for latecomer development arise with the green transformation?
 - Can they be exploited in different types of green sectors with different characteristics and related institutional support requirements?
 - What are the circumstances?
- Focus on renewables and emerging economies, China in particular
- Eight papers submitted for review in June. Next workshop November.
- This is work in progress!!!

Overview of papers

1. Introduction to SI by the editors
Rasmus Lema, Xiaolan Fu & Roberta Rabellotti

Sectoral Studies

2. Catch up, innovation and technological leadership under sectoral change: evidence from emerging market **wind turbine industries** – *Yixin Dai, Stine Haakonsson & Lars Oehler*
3. Windows of opportunity for catching-up in formative sectoral systems: the rise of China in the **Concentrated Solar Power sector** – *Jorrit Gosens, Alina Gilmanova, Ping Huang & Johan Lilliestam*
4. China's leadership in **hydropower** technology: comparing global knowledge positions for a green economy – *Zhou Yuan & Frauke Urban*
5. Is the window of technology opportunity a major factor for innovation in **solar PV industry** of China? – *Xielin Liu & Yutian Liu*
6. Windows of opportunity and changes in industrial leadership: the role of market demand location for latecomer catch-up in the **biomass industry** – *Ulrich*

Elmer Hansen & Teis Hansen

Cross cutting studies

7. When the “red dragon” turns into green: Towards a **history-friendly model** of Chinese catch-up in global green industries – *Fabio Landini, Rasmus Lema & Franco Malerba*
8. Green Windows of Opportunity: Insights from new **patent quality analysis** – *Daniel Hain and Roman Jurowetzki*
9. Catching-up in **global innovation systems** – A comparison of four Chinese cleantech industries – *Christian Binz, Jorrit Gosens, Xiaoshan Yap & Zhen Yu*

Comparative elements:

- Sector specific patterns: differences among mature and nascent technologies;
- China specific patterns in comparison with other emerging and incumbent countries.

Outline

1. Transformation and Green Windows of Opportunity
2. Conceptual framing and operationalisation
3. Preliminary insights and implications

1. Transformation and Green Windows of Opportunity

The green transformation

- Climate change and transgression of other planetary boundaries raise concerns about catastrophic and irreversible changes to global ecosystems
- The need to create a 'green economy' which drastically reduces the resources consumed in economic activities is becoming widely accepted
- Political will is mounting and is translating into institutional change
- Parts of our energy systems (power generation) are already transforming relatively fast – best example: Denmark raising the share of renewables from 22% to 63% in ten years (2006 to 2016)

A techno-economic paradigm shift

- Underlying hypothesis: the green transformation constitutes a set of significant regime changes in the techno-economic paradigm which includes changes in and across institutional, market and technological domains
- It will be a major disruption in the capitalist world economy, comparable with the changes involved in the industrial revolution of the nineteenth century (Perez 2015)
- These changes could open up opportunities for new models of latecomer development, where synergy can be created between environment-related and economic development strategies (?)
- Aim of this work: To show the *significance* of this proposition as well as the *limitations*

Green windows of opportunity

- GWOs are favourable but time-bound conditions for latecomer development arising from changes/disruptions in institutions, markets or technologies associated with the green transformation
- Idea is building theoretically on Perez and Soete (1988) who suggested that latecomers may find opportunities for leapfrogging in times of techno-economic paradigm transition.
- Lee and Malerba (2017) emphasised the distinction between windows based on technologies, markets and institutions – mainly evidenced catch-up facilitated by tech-disruptions (and new export opportunities)

The specificity of green technology sectors

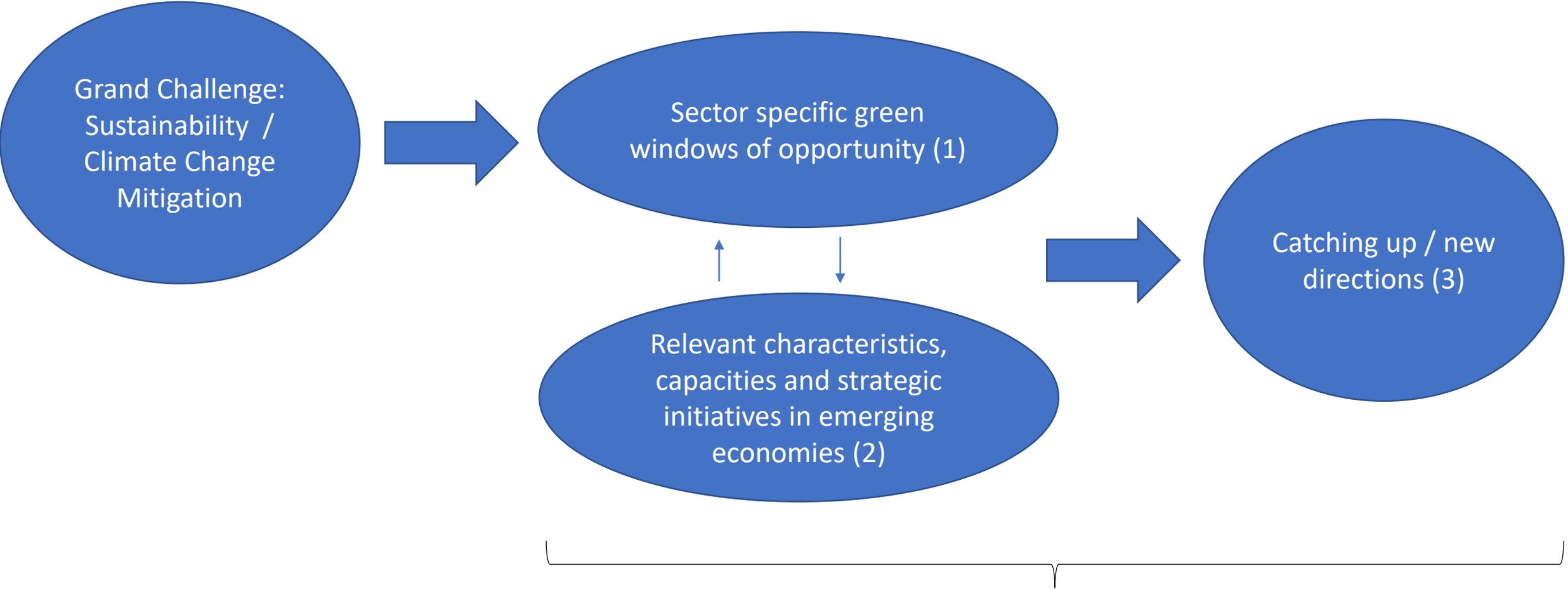
- Green technologies have a fundamental nature as public goods
- Environmental pressures and externalities means that there are local and global interests involved in their creation and diffusion
- Diverse set of technologies (transport, energy efficiency land-use etc) => Focus here is on (renewable) electricity generation:
 - Strong global agenda (e.g. Paris Agreement)
 - Nationally subject to energy and environment policy (highly regulated)
 - Public procurement, subsidies, quotas are accepted policy measures
 - Feed into value chains with professional users (intense user-producer interactions), highly systemic features and project modes of organisation
 - High degree of public R&D

Catching up and 'directionality'

- Catch-up is not a race along a fixed track, where only relative speed matters. Running in a new direction may be important.
- 'Directionality' may be particularly important when it comes to latecomer development in green technologies (the energy sector):
 - Limited scope for imitation (following the stylised pathways may end up in lock-in, asset stranding, irreversible damage)
 - Unlike prior techno-economic paradigms, development is not only driven by economic utility functions, but also by social ones (directed development / public choice)
 - Latecomer development led by green transformation is different by definition

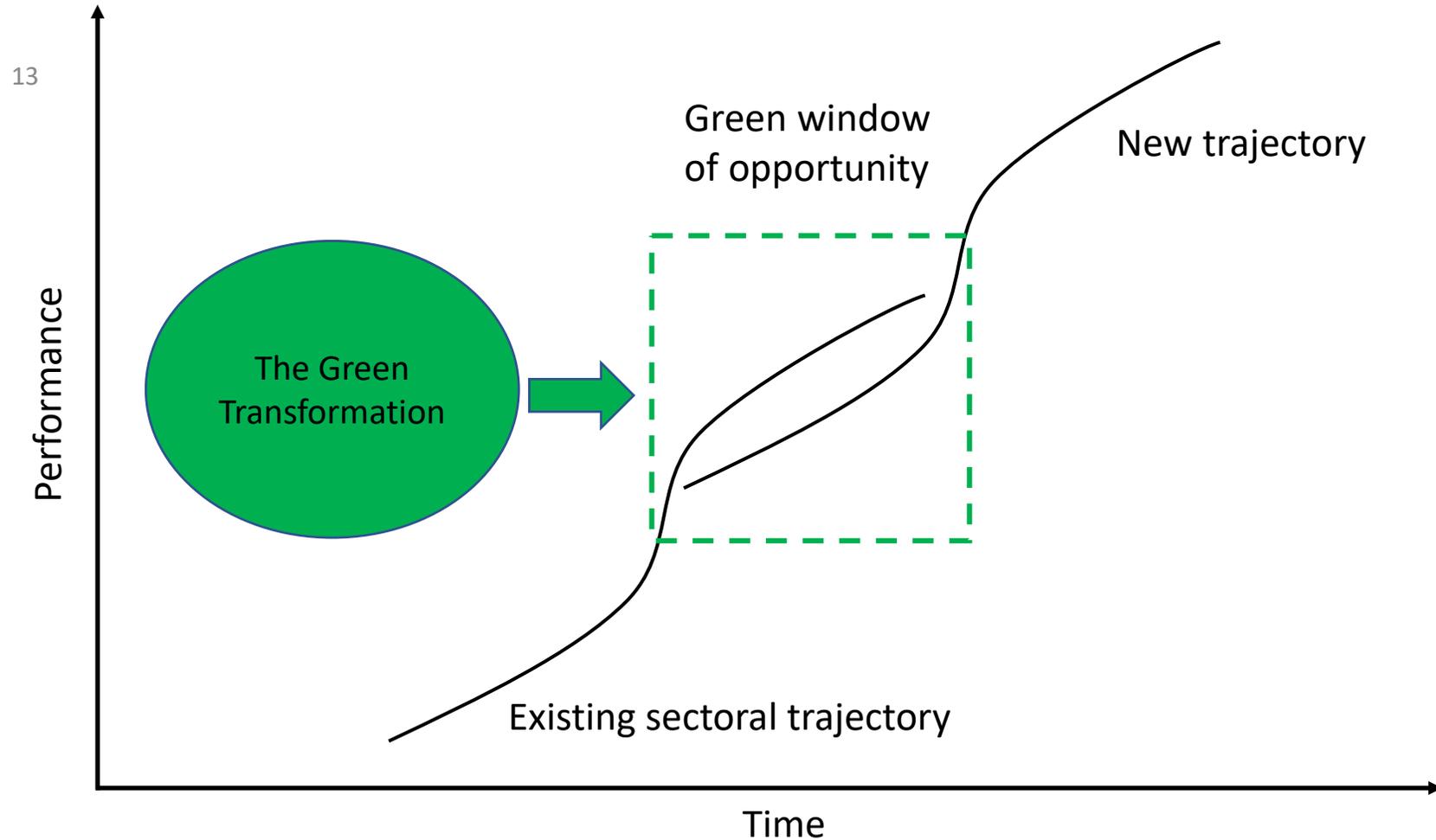
2. Conceptual framing and operationalisation

Conceptual Framework: The main building blocks

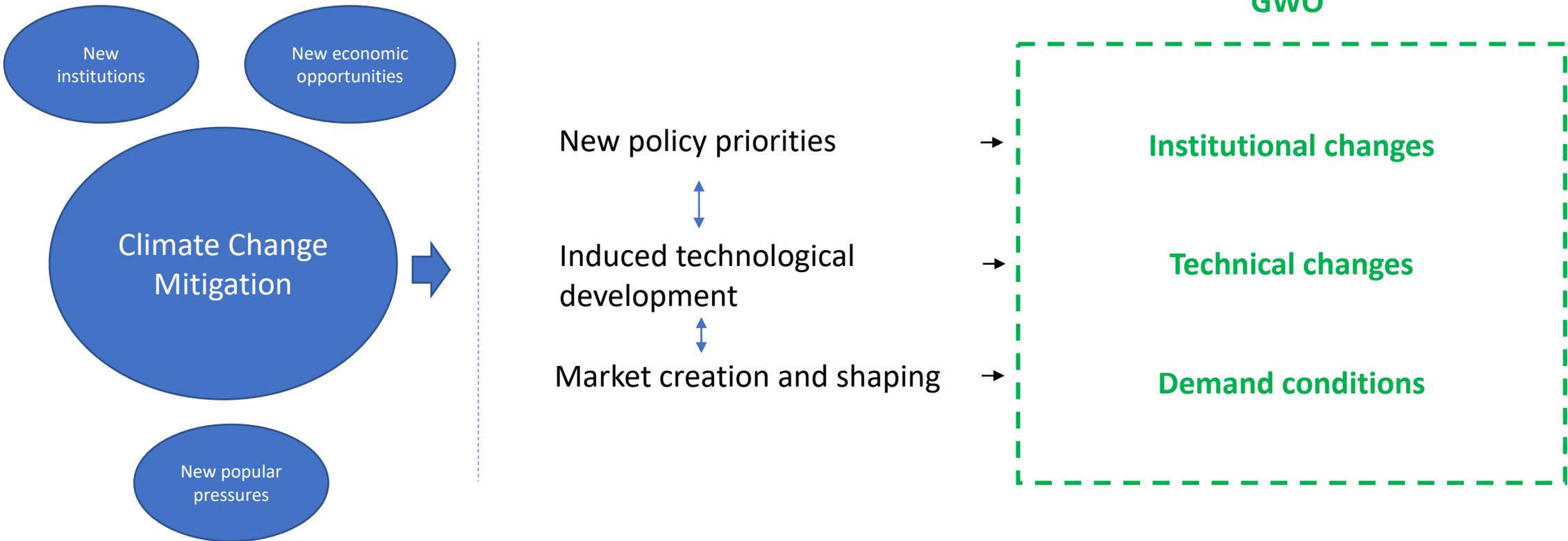


Empirical and analytical focus of the SI

(1) Green Windows of Opportunity (GWO)



Sector-specific GWOs: Creation and Shaping



Institutions:

- Major institutional changes at global or domestic level, e.g. climate change agreements by international organisations.
- Global initiatives such as the Technology Mechanism or other (UNFCCC) technology transfer mechanisms
- Local environmental standards or emission targets
- Technological standards and certification
- Renewable energy/sectoral deployment targets
- Demand side policies such as feed in tariffs in different forms in different sectors structuring the window.

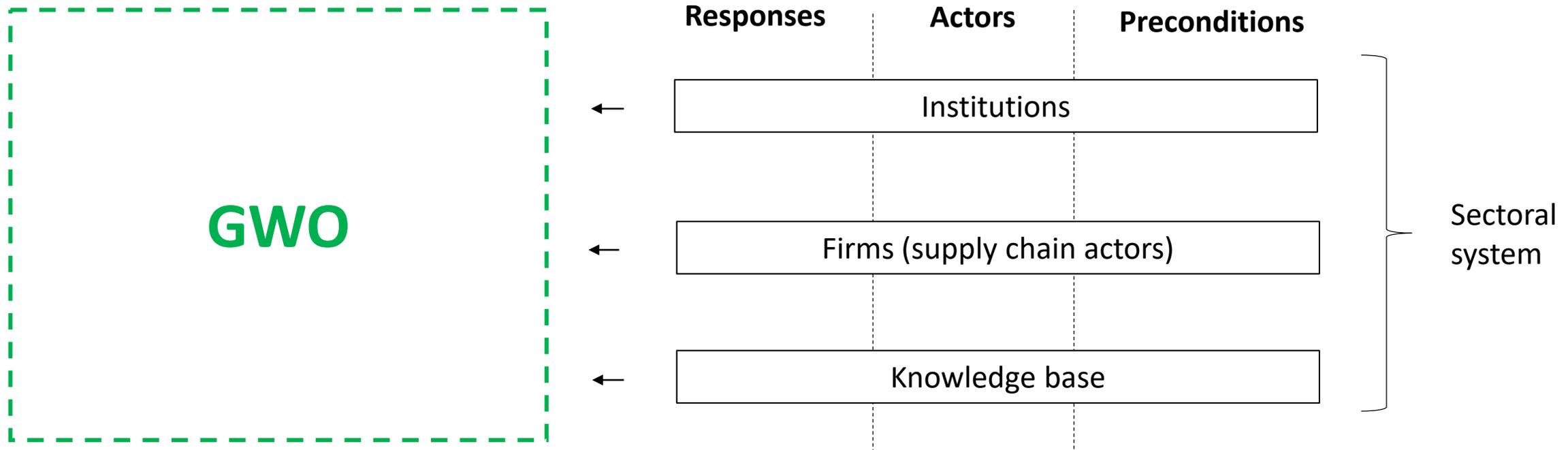
Markets

- Market opportunity in domestic markets or foreign markets.
- Opening of new markets, e.g. electrification initiatives low income countries
- Demand characteristics, e.g. quality and certification requirements in advanced markets, creating entry-barriers and limiting the scope of the window.
- Demand shifting to bigger or smaller solutions, e.g. small hydro or large wind.
- Demand shifting to more advanced or more simple solutions, depending on current needs or complementarities.

Technology:

- Generational shifts, e.g., comparable to quick succession of capacities in memory chips
- Breakthroughs in key basic research or engineering challenges
- Technological and logistic changes enabling shift new or more effective forms of deployment
- Knowledge base changes driving emergence of new dominant design
- New production methods leading to more effective mass production

(2) Relevant sectoral characteristics, capacities and strategic initiatives



2. 'Indicators' for sectoral system responses

Building Block	Who?	Types of responses (Indicators)
Enterprises (Supply chain 'actors')	<ul style="list-style-type: none"> - Electricity distributors - Professional users (utilities) - Independent power producers - Equipment manufacturers - Component supplier - R&D enterprises - Technology suppliers 	<ul style="list-style-type: none"> - Market entry and exit - Market re-orientation - Foreign direct investments - New product development - Supply chain creation or restructuring - Specialisation
Institutions	<ul style="list-style-type: none"> - Governments, national provincial - Energy regulators - Non-government organisations - Trade associations - Standard setting organisations - Banks and financial institutions 	<ul style="list-style-type: none"> - Local content rules - Trade associations lobbying for export promotion initiatives or reduction of component import duties - Investment incentives - FDI & OFDI policies
Knowledge base	<ul style="list-style-type: none"> - Universities - Research institutes - Training institutions 	<ul style="list-style-type: none"> - Research programs and projects - R&D Initiatives - Acquisition of technology (greenfield OFDI, brownfield OFDI, licenses, machinery imports) - Human capital acquisition and training

Sectoral systems compared: similarities and differences - TBD

	Wind	Solar PV	Hydro	Biomass	CSP
Maturity	<ul style="list-style-type: none"> High 	<ul style="list-style-type: none"> High 	<ul style="list-style-type: none"> Very high 	<ul style="list-style-type: none"> High 	<ul style="list-style-type: none"> Low
Industry structure	<ul style="list-style-type: none"> Large firms Low entry rates / relative stability in top segment 	<ul style="list-style-type: none"> High entry-rates 	<ul style="list-style-type: none"> Large firms Low entry rates 	<ul style="list-style-type: none"> One undisputed lead firm 20-30 followers 	<ul style="list-style-type: none"> Many small & few large firms Many entry/exits
Users	<ul style="list-style-type: none"> Professional (Utilities/IPPs) 	<ul style="list-style-type: none"> Professional Household 	<ul style="list-style-type: none"> Professional 	<ul style="list-style-type: none"> Professional 	<ul style="list-style-type: none"> Professional
Lead firms	<ul style="list-style-type: none"> Manufactures Power producers 	<ul style="list-style-type: none"> Manufactures 	<ul style="list-style-type: none"> Large EPC (system integrators) 	<ul style="list-style-type: none"> EPC Key component suppliers 	<ul style="list-style-type: none"> EPC Key component suppliers
Type of learning	<ul style="list-style-type: none"> Licensing Learning from (global) suppliers R&D 	<ul style="list-style-type: none"> Learning from exporting Machinery imports 	<ul style="list-style-type: none"> Project organised learning 	<ul style="list-style-type: none"> Licensing JV Suppliers learning from lead firms 	<ul style="list-style-type: none"> Learning by doing Machinery & complex component imports
Role of foreign knowledge	<ul style="list-style-type: none"> High but decreasing over time 	<ul style="list-style-type: none"> High but decreasing over time 	<ul style="list-style-type: none"> Only at vert early stages 	<ul style="list-style-type: none"> Mix of firms with high and low dependency 	<ul style="list-style-type: none"> Low
Universities and research	<ul style="list-style-type: none"> Limited demand for domestic R&D 	<ul style="list-style-type: none"> Important connections with foreign universities 	<ul style="list-style-type: none"> Limited but increasing, China moving to center 	<ul style="list-style-type: none"> Important connections with domestic universities 	<ul style="list-style-type: none"> Clear role for domestic R&D Spin-offs & cooperative development
Finance	<ul style="list-style-type: none"> SOE developer investment 	<ul style="list-style-type: none"> Stock listing abroad, other private funding 	<ul style="list-style-type: none"> China export-important bank 	<ul style="list-style-type: none"> SOE developer investment 	<ul style="list-style-type: none"> Mix of private & SOE, institutional lending
Standards	<ul style="list-style-type: none"> Technical an standards Safety standards 	<ul style="list-style-type: none"> GRID codes Monitoring 	<ul style="list-style-type: none"> Environmental an social sustainability measures 		<ul style="list-style-type: none"> Tower standards Participation in global IEC standard setting
Government Policy	<ul style="list-style-type: none"> FIT Local content 	<ul style="list-style-type: none"> FIT Supply-side support for technology 	<ul style="list-style-type: none"> FIT (below coal-fired price) 	<ul style="list-style-type: none"> FIT 	<ul style="list-style-type: none"> FIT

(3) Catching up patterns and cycles

- Catch up (production capacity and innovation capacity)
 - Measured as MW sold in the global (and domestic) market;
 - Technological capabilities (capability indicators), including creation of intangible assets
 - Position in global value chain
- Change in global leadership or closing the gap (... or failed attempts)
- Different catch up trajectories depending on GWO and responses
 - Path following
 - Path creating – new directions (new technologies, deployment models etc.)

3. Preliminary Insights and Implications

To what extent are we seeing catch-up / leadership?

- Some sector cases with very high global market shares, undisputed market leadership and global champions (hydro, solar PV).
- Some cases with rapidly developing sectors (catching up), but with some gap in capabilities and more focused on domestic market (wind and biomass).
- Questions arise about the connection between technology leadership and market leadership.
- In CSP, a newly emerging technology, China is leading a global scramble for defining the dominant design based on indigenous technology.

Are we seeing new pathways?

- Yes, at overall energy system level, to some extent, but not really detectible with a sub-sector lens
- No strong evidence of entirely new sector pathways – more path-following trajectories.
- Some evidence of ‘sub-stream trajectories’ (small wind, small hydro).
- Some differentiation in the organisation of production and role of financing power in external markets
- More novel pathways-in-the-making in India, SSA (distributed deployment – e.g. mini-grids; but less economic development potential).

What is the scope and nature of green windows of opportunity? (1)

- *Markets:*
 - Strong role of endogenous window creation. Domestic demand creation very strong in all cases (feed-in tariffs, commissioning)
 - Investment in demonstration projects (earlier in more mature technologies, now in CSP)
 - Differentiated role of external market (different patterns of sequencing, e.g. solar and wind)
- *Technologies:*
 - Only little evidence of technological windows (relatively stable/incremental technologies), except for Concentrated Solar Power (CSP).
 - New process-technologies more important than product innovations.
- *Institutions:*
 - Overall goals and targets
 - Mandatory purchasing arrangements
 - R&D programmes

What is the scope and nature of green windows of opportunity? (2)

- Green windows of opportunity different from those involved in catch-up in manufacturing industries (outsourcing)
- Green windows are much more dependent on *institutional disruptions* than on technological disruptions (contrast with Lee and Malerba 2017)
- They depend on endogenous window creation (not least markets)
- Multiple (co-occurring) and successive windows arise (e.g. solar PV industry)

Important determinants:

- Creation of synergy between environmental and industrial policy + massive government investments
- Policy fine-tuning: demand window sequencing, temporary protectionism e.g. local content requirements, raising of quality standards
- Markets for technologies (licenses, KIBS, acquisitions – e.g. biomass, solar PW)
- Entrepreneurial and business development action, e.g. making acquisition at the right moment.
- Experimentation and fine tuning of direction of search (investment in offshore and ‘post turbine technology’)

Implications

- For the green transformation:
 - Rapidly falling prices of renewables worldwide
 - New contenders and segmentations in the green economy
 - Formation of south-south linkages
 - East west-collaboration
- For catching-up
 - Latecomer-friendly models of 'green growth' are possible
 - But China's model may be difficult/impossible to replicate elsewhere (role of government, size of market, financing power).

Thank you!

	Wind	CSP	Hydro	Solar PV	Biomass
<u>GWO</u> M T I	M: Yes, domestic market creation. T: Located along three technology regimes. Two or three windows? Technology windows (R2: offshore + R3 :??)	I/M: In the form of demonstration projects. First window: R1? T: Era of ferment – a window in the making. Which design (standard) will win? Government role in standard facilitation?	M: First domestic market windows, then external market. T: Emerging specifications such as social sustainability, environmental sustainability. Reservoir management. Small hydro as GWO?	M: First, external market window (M1). Then internal window (M2). T: Production/process technology improving. Markets for process technology. Thin film regime? I: Supply side support (M1). Internal window creation for M2.	M: Domestic market creation. Mandatory purchase agreements (state). T: ??? Markets for technology I: Demand side initiatives. Co-emergence
<u>Responses / characteristics</u> F I K	F: ??? Role of SOEs? I: Government response to second regime (offshore) K: Experimentation with R3 technologies?	F: Different firms backing different designs. Limited role of external knowledge. K: Domestic knowledge sourcing? Related variability – integration of existing technologies components?	F: Chinese advantages in mature technology? What are they? E.g. Finance? Consortia formation. How do Chinese firm responses compare and differ with lead firms from Europe and N-S America.	M: Acquisitions Value chain development	M: Firm responses to policy. Acquisitions Spillovers. Flying geese model.
<u>Catch-up</u> P (MW sold) I (patents/indicator)	P: Yes, but only midsized turbines sold domestically. Very few exports Catch-up in capabilities? I: Yes, to a degree, A ‘mid-quality trap’?	P: ??? I: Yes, at par with ROW	P: Global market shares – high. I: Moving to the centre of of citation networks.	P: Yes, global market shares. I: ??? (exploration/exploitation)	P: Yes, market shares. I: ??? Sector-specific indicators (heat, pressers). VC: Yes, EPC

	Four cleantech industries	History models	FDI	Patent explorer
GWO	<p>Typology of windows? How does it differ from M-T-I?</p> <p>Finding patterns and typologising</p>	Demand window sequencing		<p>Method to identify the technological windows of opportunity</p> <p>Method to measure relative shortness of technology cycles.</p>
Respons	Firm strategies /govt respons (qualitative accounts)		FDI as key vehicle of of developing capabilities and catching up	Can show which geographies are strong.
Catch-up	<p>PI/I</p> <p>Yes, depends on techno-economic characteristics (learning mode and degree of customisation)</p>	Different performance I production and innovation catch-up		<p>Timing of catch-up in relation to WO</p> <p>Similarity to future / past</p>