FUTURE POTENTIALS OBSERVATORY

INNOVATION AND DESIGN HORIZONS

Historical and Economic Aspects of Innovation and Design Horizons in East-West Context

Working Paper

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Future Potentials Observatory

Historical and Economic Aspects of Innovation and Design Horizons in East-West Context – Working Paper

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Summary

Background and objectives

The main goal of the Innovation and Design Horizons research of the FPO is to provide insightful **decisions-making material for policymakers** by which they can **contribute to** previously defined areas[1] of **fundamental human goods**. Based on the expectable changes which are relevant to future potentials, this research focuses on different areas of innovation and design according to the key pillars of the future-potential-related strategic fields:

1. Ecological and geopolitical changes: **Eco- and energy** innovation and design
2. Technological changes: **Technological** innovation and design (non-eco and non-energy)
3. Socio-economic changes: **Social and business model** innovation and design
4. Cultural and spiritual changes: **Cultural** innovation and design, **design** innovation[2].

In the first phase, the scope of this working paper is the **historical and economic aspects** of innovation and design horizons in the East-West context. This working paper **analyses the relevant innovation and design areas** based on Eastern and Western research and **establishes the theoretical foundation** for the mapping in the second phase, which will be followed by recommendations in the third phase. Accordingly, this work does not aim to provide an exhaustive and overarching literature review on every pre-defined innovation and design area. Instead, the main objectives are to **confirm or reject the relevance of the pre-defined innovation areas**; moreover, to **explore and (re-)interpret the influential topics** and thoughts from Western and Eastern research in these innovation areas from the perspective of governing future strategic changes.

Research questions are answered by systematic literature review (SLR) methodology and results are discussed from two key theoretical perspectives of strategic change and innovation which complement each other: **transdisciplinary research**[3] and **dynamic capabilities**[4].

[1] Peace and safety, attachment, care, and balance (Szántó, et al., 2020)
[2] In a cultural sense
[3] In line with the practical goal of the study and the (future) real-world problems to solve
[4] In line with the turbulent and uncertain environment of the present and the future

Main results

Based on quantitative and qualitative SLR data, **the pre-defined innovation areas are relevant, but to varying extents**. The focal innovation areas can belong to heterogenous research fields (there were 44 related fields even in case of the top 100 reviews), but the main fields are Business and Management, Economics, Engineering, Environmental and Sustainable Science. Based on the top 100 highly cited reviews of the focal areas, the following conclusions can be made:

1. Eco-innovation and technological innovation are the main areas where authors of Western and Eastern institutes work together, while social and business model innovation did not induce such influential collaborative works until now.
2. **Western research seems to be more influential** in every innovation area (based on the number of highly cited works).
3. Technological innovation, eco-innovation, social innovation, and business model innovation are the most influential topics of the international literature, regarding both Eastern and Western research. **The dominance of technological innovation is present in Eastern and Western research** as well. In contrast, energy innovation, design innovation, and mainly **cultural innovation are similarly underrepresented topics**.

Based on the in-depth qualitative analysis of the **most relevant[5] reviews**, the following topics and thoughts are widely discussed in the focal innovation areas[6]:

1. The historical parts of **eco-innovation** studies often mention the **Brundtland report from 1987** and the rapidly increasing scientific, social, and industrial attention toward environmental sustainability. Regarding economic aspects, **circular economy development** is considered to be the main driver of eco-innovation, regardless of the affiliation countries. Eco-design is also unequivocally mentioned as a tool for eco-innovation.
2. Eastern and Western works approach technological innovation in different ways. While Western research clearly focuses on **how to produce technological innovations** in a business context (e.g., strategic ambidexterity), **technological specifics** are more emphasized among the most-cited Eastern review papers (e.g., artificial intelligence).
3. The Eastern **business model innovation studies** emphasize **internal factors** (e.g., knowledge management or organizational inertia), while the most influential Western review follows

[5] Highly or most cited works which meet the thematic inclusion criteria
[6] Again, these conclusions are related to most relevant reviews according to the scope of this working paper and do not generally describe Eastern and Western research.

rather an **external approach** (sustainable business model building). Regarding social innovation, the most relevant reviews were written by authors of Western institutions.

4. **Highly cited Eastern and Western reviews mostly disregard the topic of cultural innovation compared to the other focal innovation areas**, however, there are at least a few studies which are more or less relevant in case of Western research. Eastern and Western research are similar in terms of the **rareness of relevant design innovation reviews** (in a cultural sense).

Three influential thoughts might be unexpected but universally relevant for decision-makers:

1. Sustainability-oriented innovations for circular economy development[7], cleaner production or eco-efficiency[8] need **not only eco-design but sustainability-rooted organizational behavior**. However, **this behavior cannot be based on a simple "switch"** of the business model but on reaching **different phases**.
   Policymakers can provide activating and motivating external stimulus to change the *resistant* state into *reactive* and *anticipatory*, moreover, support capability building to reach the *innovation-based* and *sustainability-rooted* state.
   (Klewitz & Hansen, 2014)
2. In contrast to the frequent industrial and institutional practice which emphasizes operational efficiency and productivity efforts for decades and still nowadays, **process management can be even counterproductive and build resistance to change in a technologically complex context.**
   When incremental innovation is not enough, and radical innovation would be needed, limiting process management could be important to accelerate exploration instead of exploitation.
   (Benner & Tushman, 2003)
3. **Ecological and technological aspects** should not be argued only separately, but **with an integrative approach based on business models**, as it must go beyond the value proposition. For this purpose, technology-based sustainable business model archetypes can drive the transformation of organizations (e.g., creating value from waste or minimizing material use).
   (Bocken, et al., 2014)

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[7] By maintaining, reusing, recycling (Saidani, et al., 2019)
[8] For lower environmental impact or economic gains (Klewitz & Hansen, 2014)

Directions for the next phases

Based on the theoretical iteration, **transdisciplinary research and development, and the dynamic capabilities framework are both relevant approaches for governing innovation and design-related strategic change**. In the focal innovation and design areas, possible directions of the recommendations (in the last phase) could include, for example,

1. on the organizational level: Aligning business strategy with an impact vision, **reconfiguration of business models** following sustainable business model archetypes, leveraging external resources by **open innovation** and managing continuously evolving networks, initiating organizational changes, improving knowledge management practices.
2. on policy level: **Ecosystem building**, developing shared meanings and taxonomies, **transition management** with broad societal discourse, inclusivity, co-production of solutions, according to broad techno-economic and societal aspects, encouraging the establishment of social enterprises for supporting local and regional development.

As **cultural innovation and design innovation** seem to be truly overlooked based on the results of this working paper, a **deeper analysis** of this area might be practical and also theoretically contributing during the next phases.

The in-depth analysis revealed more similarities than differences regarding the historical and economic aspects in the East-West context. It could be because of the nature of this meta-review, i.e., review papers usually merge thoughts from all over the world and try to provide a general understanding, so slight differences might emerge based on only the specific sub-topic selection. Consequently, **the next phase could focus on certain countries as "frontiers" of innovation and design horizons** from the perspective of Hungary, V4, and the Carpathian basin, with a more specific approach, building on the theoretical foundations of this first work. Accordingly, besides the most "Western" and "Eastern" countries, USA and China, other **economically prospering but culturally distinctive countries** are worth focusing on, for example, **Israel, Japan, South Korea, and India**.

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1. Introduction

1.1. Project overview

This working paper is based on the mission of the FUTURE Potential Observatory which aims to investigate, analyze, and present

a) the future potential of social entities, such as families, organizations, cities, countries,
b) geopolitical frontiers, and
c) innovation and design horizons

in an East-West context, with a special focus on Hungary. These points represent thematically interconnected but separate research projects.

Accordingly, three working papers focus on the innovation and design horizons, as separate parts of the project. The structure of the research process is the following:

1. ***Historical/Economic aspects of innovation and design horizons in East-West context research (the scope of this working paper)***
   Highlighting key characteristics based on a systematic literature review of historical and economic aspects of innovation and design horizons in the East-West context, highlighting the role of Hungary, the Carpathian basin and V4 countries
2. **Innovation and Design Horizons Map research**
   Associating key drivers of innovation and design horizons to key historical and economic characteristics in the East-West context, creating a map of these drivers across geopolitical, industry and policy dimensions
3. **Forecasting new Innovation and Design Horizons**
   Forecasting new innovation and design trends based on the innovation and design horizons map, as well as additional relevant international scientific literature. Highlighting the role of Hungary, the Carpathian basin and V4 countries.

The main goal of the Innovation and Design Horizons research and its three phases is to provide insightful decisions preparation material for policymakers by which they can contribute to previously defined areas[9] of fundamental human goods.

While this working paper, as the first part of this research, focuses on review papers (i.e., providing a meta-review for initial understanding, orienting next tasks), the second part covers original research

[9] Peace and safety, attachment, care, and balance (Szántó, et al., 2020)

articles through mapping (i.e., trends and opportunities), and the third part will provide detailed recommendations, mainly for Hungary.

This document is structured as follows. In the remaining parts of the Introduction, the background of the research, objectives, and research questions will be elaborated. Section 2 argues the research framework with the theoretical perspectives which orient the discussion of the results, and the followed methodology. After that, results of the historical and economic aspects of innovation and design areas are presented and discussed. Finally, research questions are answered, moreover, limitations and directions for the next phase are highlighted.

1.2. Research background

1.2.1. Strategic aspects of future potentials, innovation, and design

Future potentials research is based on its antecedent research concept, i.e., social futuring which is a multidisciplinary concept related to several fields, such as philosophy or sociology (Szántó, et al., 2019). As detailed in one of the key works of this research area, *"social futuring is the very feature of an arbitrarily chosen social entity that expresses its potential, ability and competence (1) to interpret, envisage, influence, and generate future changes, and (2) to prepare for their strategic treatment – that is, await the challenges that stem from any changes (be they limits/ opportunities or threats) in a state of full preparedness"* (Szántó, 2018, p. 6).

Social futuring has also a normative frame, i.e., a good, fulfilled life, and integrates strategic elements from other concepts, such as resilience, future orientation, and. future proofing. These strategic elements include, for example, existence-sustainability, active behavior, a vision, future scenarios, or planning strategic actions (Aczél, 2018). From this strategic perspective, there are three basic forms of social futuring:

1. Proactive: Strategic creativity
2. Active: Strategic resiliency
3. Reactive: Strategic adaptivity. (Szántó, 2018)

These strategic orientations are also emphasized in the holistic concept of future potentials, approaching *"the strategic management of future change"* as a tool to reach the fundamental goals, i.e., to preserve a good life in a unity of order (Szántó, et al., 2023, p. 8).

Based on the above, "strategy" and "change" seem to be two of the main keywords of future potentials, and these are also closely related to the scope of this work. Specifically, the field of strategic management and change management is rich in scientific studies on renewal which affect innovation and design activities and vice versa. First, it is because innovation is mostly associated with novelty, change, learning, development and value creation (Baregheh, et al., 2009). Second, on the one hand, the design of a product, a system, or an institution is usually oriented by strategic aspects (e.g., organizational/societal vision and end-user/societal needs), but on the other hand, there is a growing importance of design in strategic-decisions making, for example, through design thinking; and strategic management is sometimes considered to be an "art" (Knight, et al., 2020).

The integrated strategic management of innovation and design is also deeply elaborated by Le Masson et al. (2010). Following a business and economic perspective, the authors argue that

a) one should talk about "intensive innovation" which is systematic, repeated, and oriented (i.e., not random and episodic);
b) this intensive innovation is a major driving force of contemporary capitalism and affects international economic competition in the future;
c) intensive innovation requires a transition from research and development (R&D) to research, innovative design, and development (RID), which generates change within organizations and its economic, social, and ecological impacts (Le Masson, et al., 2010).

Based on the above, this research follows a strategic management approach, i.e., considering external and internal factors before a strategic recommendation; and looks at innovation and design integratively, as a future source of sustainable competitive advantage at organizational, national or regional level (Table 1).

	External trends, critical success factors	**Valuable internal capabilities, differentiation opportunities**
Analyses and discussions	Similarities and differences of certain types of innovation and design activities in the Eastern (e.g., China, India) and the Western (e.g., USA, EU) worlds / cultures	Unique resources and opportunities in Hungary, the Carpathian basin and V4 countries in certain types of innovation and design activities
Recommendations	Strategic change directions for facilitating innovation and design in the focal region: Policy, institutional, research, and corporate actions	

Table 1. Strategic approach to the research

Source: authors

1.2.2. Focal areas and research questions of the project

Based on the expectable changes and pillars which are relevant to future potentials (Szántó, et al., 2023) , this research focuses on different areas of innovation and design according to the key pillars of the future-potential-related strategic fields, as detailed in Table 2. While these innovation areas can be analyzed separately, multiple interconnections could be also relevant in the literature, for example, green transformation (Csedő & Zavarkó, 2020; Magyari, et al., 2022), artificial intelligence (Mariani, et al., 2023; Di Vaio, et al., 2020), or digitalization and ICT in different sectors for positive economic (Csedő, et al., 2019a) or social impacts (Pörzse, 2008; Pörzse, 2011; Sára, et al., 2013).

The definitions of the specific innovation areas (e.g., eco-innovation) are in the scope of the systematic literature review (see Section 3.2).

Content of expectable changes (Szántó, 2018)	Innovation and design area
Ecological – (geo)political	Eco- and energy- innovation and design
Technological	Technological innovation and design (non-eco and non-energy)
Socio-economic	Social and business model innovation and design
Cultural – spiritual	Cultural innovation and design; design innovation

Table 2. Focal innovation areas of the research

Source: authors

Based on the three-phase structure of the research and the four innovation areas, a matrix is developed with twelve questions (Table 3).

Approach		Research questions and sub-questions (SQ)			#
History and current economic development	**Fundamental external factors**	What similarities and differences could be identified regarding the dominant	ecological and energy	innovation and design research?	1
			technological		2
			social and business model		3
			cultural		4
	Mapping & Internal factors (change drivers)	What are the unique resources and opportunities for	ecological and energy	innovation and design activities?	5
			technological		6
			social and business model		7
			cultural		8
Recommen-dations	**Governance actions**	What policy, institutional, research, and corporate actions could facilitate	ecological and energy	innovation and design?	9
			technological		10
			social and business model		11
			cultural		12

Table 3. Research questions of the project

Source: authors

1.2.3. Self-reflection by the list of key definitions

Most of the underlying definitions of this work derive from the field of business and management, more specifically, the resource-based view of the firm (See Section 2.1.2 for details and justification). This approach brings significant novelty into socio-economic research of this area, due to the small extensions which enable to use the definitions in a broader context.

In this work, the following definitions shaped the analysis and the discussion:

a) *Innovation* is "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD, 2005, p. 46).
b) *Design*, from an innovation perspective, covers "thought processes, such as intuition, analysis, framing, abductive reasoning generative sensing, and mental simulation" which interact with strategic purposes, culture, and externalized understandings (of the market) (Knight, et al., 2020, p. 36).
c) *Strategic change* is the "change in the fundamental pattern of present and planned resource deployments" (Hoppmann, et al., 2019, p. 437)

d) *Strategic management* "typically involves the formulation and execution of plans relating to the establishment and deployment of assets[10]" to "match its capabilities to its ever-changing environment if it is to attain its best performance" (Teece, 1984, p. 87).

e) *Innovation management* covers tasks related to "innovation strategy, external intelligence[11], idea management, product portfolio management, technology portfolio management, development and launch, post-launch activities (e.g., project learning), resource and competence management" (Tidd & Thuriaux-Alemán, 2016, p. 1024).

f) *Change management* aims "to become more effective at achieving the goals[12] in the face of internal and external opportunities and threats" […] by finding the proper "response at individual, group or system level, although these levels cannot be seen in isolation from each other". (Burnes, 2017, p. 29)

g) *Governance* means "leadership systems, control protocols, property rights, decision rights, and other practices that give their authority and mandates for action"[13] (Tihanyi, et al., 2014, p. 1535).

1.3. Scope of this working paper

1.3.1. Objectives and scope

This working paper analyses the relevant innovation and design areas based on Eastern and Western research and establishes the theoretical foundation for the mapping in the second phase, which will be followed by recommendations in the third phase.

The relevant innovation areas are defined based on the previous lessons of social futuring research and the new future potentials index. The main assumption of this working paper is that the four innovation areas indeed appear in the international scientific literature.

Objectives of this working paper are the following:

1. Confirm or reject the main assumption regarding the relevance of the innovation areas
2. Explore the most influential topics and thoughts from Western and Eastern research in these innovation areas
3. Re-interpet them from the theoretical perspectives (detailed in Section 2.1).

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[10] In the original text: „…of a **firm's** assets"
[11] In the original text: „…external **business** intelligence…"
[12] In the original text: "…the goals of the **organization…"**
[13] In the original text: „...**managerial** control protocols…" and „...give **organizations** their…"

1.3.2. Objectives out of scope

In line with the objectives listed above, first, this working paper does not aim to explore concrete innovation and design activities, nor general similarities and differences of historical and/or current Eastern and Western innovation and economic subjects, but instead, focuses on influential Western and Eastern thought patterns which might help decision-makers to identify the directions of the ever-changing internal and external environment, manage threats, and seize opportunities to increase the volume of human goods.

Second, as this is only the first part of the research process with time and volume constraints, this work does not aim to provide an exhaustive and overarching literature review on every pre-defined innovation and design area. Instead, it aims to provide a brief overview of the key topics, moreover, explore and (re-)interpret the most influential (i.e., some of the most cited and also thematically relevant) theories and thoughts to accelerate further analyses for policymaking.

Third, given the practical purpose of the working paper (supporting future policymaking on institutional and corporate levels), it does not aim to be value-neutral regarding the fundamental goals (contributing to human goods), nor the research approach (future potentials and governing strategic change in the future). Instead, this work uses scientifically established theoretical concepts and methodologies to support practical goals and reflects on its own assumptions, in line with the requirements of qualitative research. Outlining and fulfilling relevant scientific research gaps, and providing theoretical contributions, however, will be important in case of another research outcome.

1.3.3. Research questions of this working paper

Based on these objectives, there are three main questions (MQ) of this working paper:

MQ I: Are the pre-defined innovation areas indeed relevant based on the literature?

MQ II: What similarities and differences could be identified in the East-West dichotomy regarding the dominant research in the focal innovation and design areas?

Sub-questions (see Table 3):

SQ1: What similarities and differences could be identified regarding the dominant *ecological and energy* innovation and design research?

SQ2: What similarities and differences could be identified regarding the dominant *technological* innovation and design research?

SQ3: What similarities and differences could be identified regarding the dominant *social and business model* innovation and design research?

SQ4: What similarities and differences could be identified regarding the dominant *cultural* innovation and design research?

MQ III: How can one (re-)interpret the influential thoughts of these innovation and design areas from key theoretical perspectives of strategic change to support policymaking?

2. Research framework

2.1. Theoretical perspectives

2.1.1. Perspective for innovation and design – Transdisciplinarity

To solve real-world problems, involving stakeholders and facilitating collaborative research and development of new solutions are increasingly emphasized within the transdisciplinary view. Transdisciplinary research principles are related to previously elaborated Mode 2 research (e.g., knowledge production for practical and contextual application for managerial problem-solving (MacLean, et al., 2002)), or more recently, sustainability science (Belcher, et al., 2019). Consequently, the transdisciplinary approach is inherently relevant in case of multiple pre-defined innovation areas (e.g., ecological innovation for environmental sustainability, social innovation and cultural innovation for social sustainability, business model innovation and technological innovation for economic sustainability). Lang et al. (2012) developed a framework (Table 4) for an ideal-typical transdisciplinary research process based on prior research, and the following definition:

"Transdisciplinarity is a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge." (Lang, et al., 2012, pp. 26-27)

Social practice	Transdisciplinary research process	Scientific practice
Societal problems (actor-specific, relevant)	**Phase A** "Collaboratively framing the problem and building a collaborative research team" 🡻	**Scientific problems** (e.g., lack of methods)
🡹 **Actor specific societal discourse** (e.g., institutions)	**Phase B** "Co-producing solution-oriented and transferable knowledge through collaborative research" 🡻	🡹 **Scientific discourse** (e.g., industrial research)
II **Results useful for societal practice** (e.g., prototypes)	**Phase C** 🡸 🡺 "(Re-)integrating and applying the produced knowledge in both scientific and societal practice"	II **Results relevant for scientific practice** (e.g., new research questions)

Table 4. Conceptual model of transdisciplinary research

Source: re-created based on Lang et al., 2012, p. 26-27

Given the research-focused nature of the transdisciplinary nature, this perspective might be more applicable for innovation and design-related policymaking and operative levels. Consequently, the next section presents a theoretical perspective for driving change from a strategic and organizational perspective.

2.1.2. Perspective for governing strategic change – Dynamic capabilities

There is a broad consensus in the strategic management literature that in a rapidly changing environment, the ability to innovate and change is a critical success factor for organizational survival or competitive advantage (Csedő & Zavarkó, 2019a). This statement is even more relevant in an era of rapid technological and geopolitical change. The literature has also shown that innovation and change are interrelated, and organizations need to not only operate effectively in their current business areas but focus on exploration and new opportunities (Duncan, 1976; March, 1991). The balance between exploitation and exploration is critical mainly because of the adaptation paradox (Csedő, et al., 2019b), i.e., the more an organization adapts its current environment, the less it will able to adapt to the changes of the future (Burgelman, 1991), i.e., although routines and practices for strong optimization are useful for the present, they might threaten the adaptation capability for the future. One key challenge for this strategic ambidexterity is that exploitation and exploration compete for the same resources and also require opposing practices (e.g. efficiency requires strict regulation, while exploration requires agility and flexibility) (Gibson & Birkinshaw, 2004). Moreover, path dependency makes it difficult for organizations to deviate from the well-known path, in which they have invested a lot of resources (Sydow, et al., 2009). Consequently, strategic (exploitation and exploration), structural (stability and flexibility), and capabilitiy-based dilemmas (leveraging existing capabilities and developing new ones) determine the context of change management (Csedő & Zavarkó, 2019b).

Nevertheless, enabling renewal continuously or from time to time is a critical task in a turbulent and uncertain future environment (cf.: future potential). The appropriate strategic approach could be the resource-based view (RBV). According to the historical aspects of RBV, resource position barriers also exist besides entry barriers (Wernelfelt, 1984), and sustained competitive advantage could be built on valuable resources rather than (only) market positioning (Barney, 1991). While one part of the literature explored the opportunities of tangible and intangible resources in gaining a sustainable advantage in a turbulent environment (Grant, 1996), other studies oriented the attention to precisely differentiate resources from capabilities (Helfat & Peteraf, 2003). Furthermore, separating operational and dynamic capabilities (Teece, et al., 1997) gave additional emphasis on environmental adaptation (Guesalaga, et al., 2018). In contrast to the Porterian strategic approach, the RBV suggest that in a turbulent environment, using and developing valuable, resources could mean a more stable basis for strategy formulation than only market positioning (Barney, 1991). Moreover, the relationship between the organization (as an open system) and the external environment is bilateral, i.e., organization performance (e.g., an innovation) could impact the external conditions (Teece, 2007).

According to the most dominant approach of the RBV, the dynamic capabilities framework, organizations need capabilities for sensing, seizing, and transforming (Teece, et al., 1997). Table 5 presents the theoretical and practical aspects of this framework.

Capability	Core element	Main factors (examples)
Sensing	Analytical systems and individual capabilities to learn, detect, filter and shape opportunities	Selection of internal R&D processes and technologies Identifying complementary skills and innovations of partners and suppliers Monitoring changes in consumer behaviour and market needs Monitoring external technological and scientific results
Seizing	Organizational structure, processes, incentives	Business modelling Decision bias, avoiding errors, identifying complementary capabilities Resource development, specialization (matching complementary skills to increase their combined value) Increasing commitment, leadership, culture shaping
Transforming, reconfiguring, continuous renewal	Co-specialization and recombination of resources	Knowledge management, knowledge transfer, know-how integration Corporate governance: align incentives, minimize agency costs, strategically responsible management, conscious use of profits (to invest in the future) Decentralization, promoting open innovation, developing integration and coordination capabilities Control the strategic fit (value creation) of resource combinations

Table 5. The dynamic capabilities framework

Source: Csedő & Zavarkó, 2021, based on Teece, 2007

As the Table shows, governance could have an impact on building dynamic capabilities. Empirical research has also shown that dynamic capabilities contribute to the development of performance differences between firms. It was also found that the adaptive capacity of organisations is strongly influenced by corporate governance structure, resource allocation process and management incentive system. (Pisano, 2017)

Finally, it is also worth noting that not only the organisation but also the governance system itself must be dynamic enough to adapt to changes in the environment and the company at its own level (e.g., more decision-makers may be needed as the organization grows, more intensive committee work may be needed in turbulent environments). Dynamic governance, therefore, could mean not only ensuring that the organization adapts to the environment but also that the governance system itself (e.g., the functioning of the boards) adapts to changing environmental circumstances (Hoppmann, et al., 2019; Csedő & Zavarkó, 2021).

2.1.3. Framework synthesis

Based on the above, transdisciplinarity and the dynamic capabilities framework could offer insightful theoretical perspectives and a basis for practical suggestions with different focus points and levels. Table 6 compares the two perspectives which complement each other.

	Transdisciplinarity	Dynamic capabilities
Focus	Designing and implementing research, development, and innovation by participation, stakeholder engagement, collaborations, for societal goods	Sensing and seizing opportunities, managing threats, transforming the organizational / institutional system according to new conditions, for sustained competitive advantage / survival
Dominant approach	Outside-in (e.g., finding and solving real-world problems)	Inside-out (e.g., building and using valuable capabilities)
Dominant change direction	Bottom-up (e.g., emphasizing stakeholder involvement)	Top-down (e.g.., the role of leadership in sensing changes and re-allocating resources)
Levels of problems and solutions	Operative / Micro (e.g., concrete social and scientific problems)	Strategic / Macro (e.g., the threat of environmental misfit)
The main area for practical suggestions	Institutional policymaking	Corporate decision-making

Table 6. Theoretical perspectives of this work to analyze innovation, design, and strategic change

Source: authors

2.2. Methodology

The research is based on a Systematic Literature Review (SLR). During SLR, a research question is answered or a hypothesis is confirmed/rejected by collecting relevant previous studies on the specific field that meets the pre-defined inclusion criteria (Snyder, 2019) SLR methods are often used in management research, as well (Hiebl, 2021). Based on the recommendations in the literature (Okoli, 2015; Fisch & Block, 2018; Thomé, et al., 2016), the SLR process was the following:

1. Developing a research protocol: fixing the research focus points (innovation areas)
    a. Searching literature in electronic database: Web of Science (WoS)
    b. Looking for and reviewing articles, as they might contain historical and economic perspectives, i.e., presenting a meta-review
2. Assign search keywords for the focal areas[14] as the topic[15] of potentially relevant studies
    a. Ecological and energy innovation
        i. "eco-innovation"
        ii. "ecological innovation"
        iii. "energy innovation"
    b. Technological innovation (non-eco and non-energy)
        i. "technological innovation"
        ii. Filtering out the eco- and energy-related research categories, such as Environmental Sciences, Energy Fuels, Environmental Studies, Green Sustainable Science Technology
    c. Social and business model innovation
        i. "social innovation"
        ii. "business model innovation"
    d. Cultural and design[16] innovation
        i. "cultural innovation"
        ii. "design innovation"
3. Categorizing relevant articles by the authors' affiliation: East / West / Other[17] / Global[18]

[14] In line with the theoretical background, the SLR method approaches *design* as part of the broader *innovation* process (e.g., as shown by Tidd & Thuriaux-Alemán (2016) who concerns "development and launch" as an innovation management practice)
[15] In case of WoS, the Topic-focused search covers the title, the keywords, and the abstract
[16] The „design innovation" was added because of (1) the very low number of studies, the topic of which was related to „cultural innovation" and (2) the frequent interconnection between design and culture terms (Knight, et al., 2020)
[17] "Other" countries are not unquestionably related to the "Western world" or the "Eastern world" according to the work of Huntington (1991) – E.g., Latin America or the Orthodox World
[18] The co-authors of certain articles are affiliated with Eastern and/or Western and/or Other countries

4. High-level quantitative analyses
5. Citation-based prioritizing, i.e., finding the most influential studies which might shape the present and future thoughts on innovation and design
6. Content-based filtering by title and abstract, focusing on
    a. Design aspects (“design”) AND/OR
    b. Economic aspects (“econom*)[19]
    c. Relevance (i.e., disregarding too narrow technical topics, including studies which (can) have interconnections with future potentials, innovation and design, or strategic change)
7. In-depth qualitative analysis according to the following aspects: History, economy, design, strategic change
8. Interpretation of the results from the aspect of the research questions

[19] Historical aspects are implicitly considered in review articles

3. Results and discussion

3.1. Overview of the results

Based on the WoS database, there are almost 30.000 studies which are related at least to one of the four innovation areas. Table 7 shows that there are only ca. 12.000 studies which could be relevant based on the inclusion criteria.

	Search keywords and innovation areas	TOTAL	Since 2000 & Tech. filter: non-eco&energy-related fields
I/1.	Ecological innovation	171	50
I/2.	Eco-innovation	2 371	1 016
I/3.	Energy innovation	456	145
I.	**Eco- and energy innovation area**	**2 998**	**1 211**
II/1.	Technological innovation	18 173	812
II.	**Technological innovation area**	**18 173**	**7 812**
III/1.	Social innovation	3 851	1 332
III/2.	Business model innovation	2 231	1 502
III.	**Social and business model innovation area**	**6 082**	**2 834**
IV/1.	Cultural innovation	384	58
IV/2.	Design innovation	931	288
IV.	**Cultural and design innovation area**	**1 315**	**346**
	Total	**28 568**	**12 203**

Table 7. Potentially relevant studies in the focal areas, including original research and review papers as well

Source: authors

The overview of the search results provides an initial insight about the more dominant and less dominant topics:

a) Technological innovation is the most dominant area while cultural and design innovation is underrepresented.
b) In case of the first area, eco-innovation is more apparent than energy innovation.
c) In the third area, social innovation and business model innovation seems to be similarly important.
d) In the fourth area, cultural innovation studies are rare, while design innovation is more frequent.

These initial findings also shape the relevance-based filtering for the in-depth analyses of review studies (e.g., ecological versus energy innovation).

Nevertheless, from ca. 12.000 studies, only ca. 900 studies were review papers. As the research focuses on the most influential Eastern and Western articles, the 100 top-cited reviews were analyzed according to the affiliation countries and research fields. Figure 1 shows the distribution of the top 100 reviews according to the East-West categorization. A detailed list of the studies and the categorization can be found in the Appendix. The Figure shows that 77% of these articles were written by authors of Western research institutions, while 10%-10% were Eastern and Global (co-authorship from heterogenous countries), and 3% was Other countries' research (e.g., Chile).

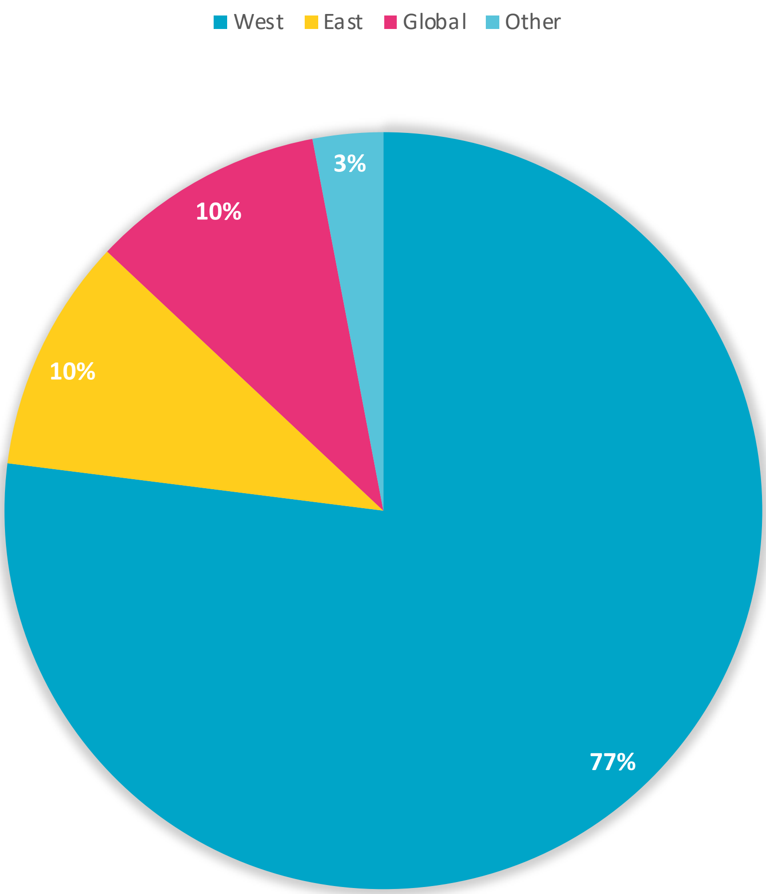

Figure 1. Distribution of the most cited review papers according to the affiliation countries

Source: authors

Based on the number of authors in case of the top-cited review papers in the focal innovation areas, Figure 2 shows that the most influential countries are USA and England.

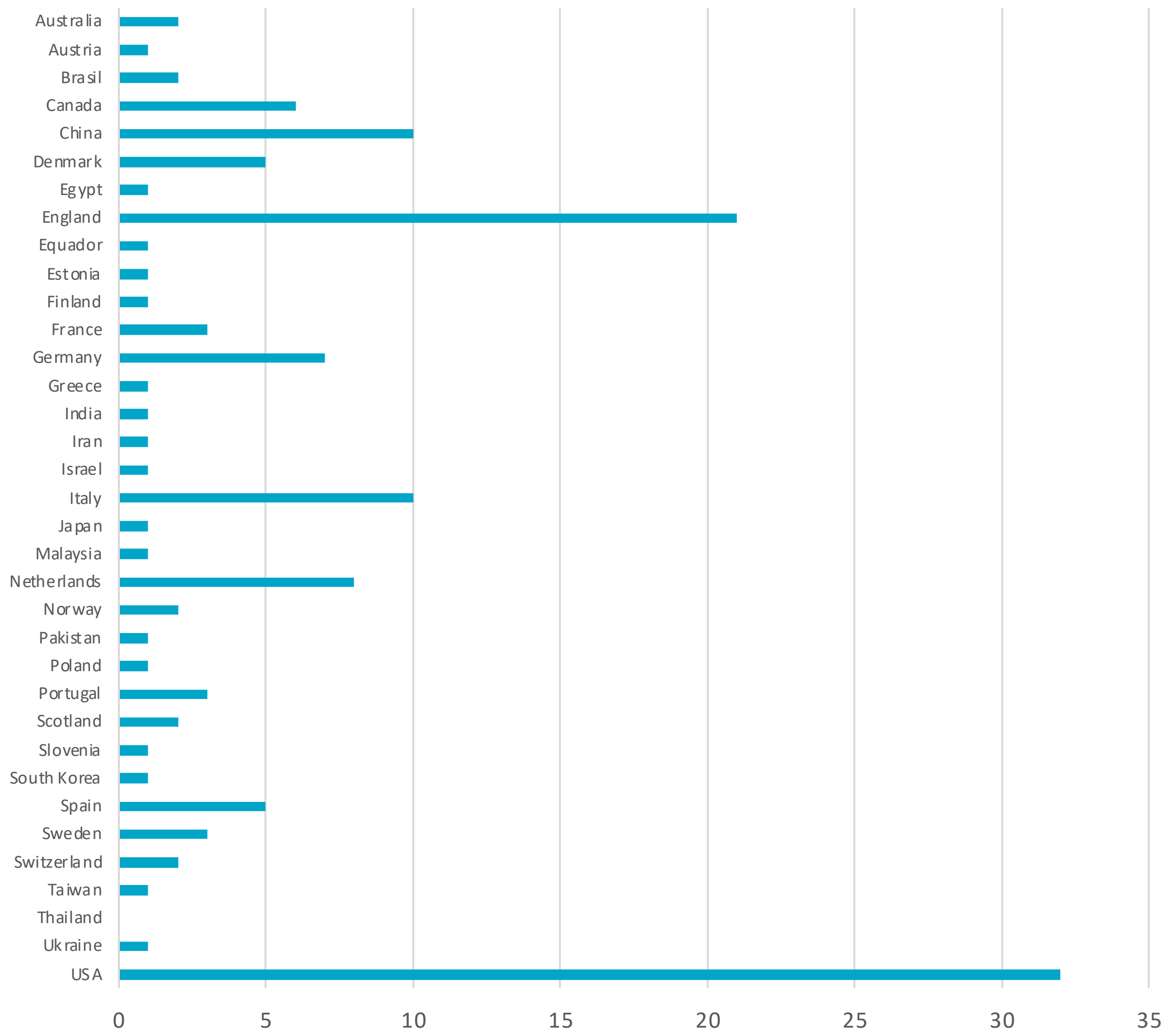

Figure 2. The most influential countries in the focal innovation areas, according to the affiliation countries of 100 top-cited review papers

(the total number is higher than 100 (140) because of co-authorships)

Source: authors

Regarding the innovation areas, the most dominant area is technological innovation (59%), even by filtering out the eco- and energy-related fields from its list. Another important finding is that only 3 papers belong to the cultural or design innovation topic from the top 100 reviews (Figure 3), which is in line with their underrepresented nature in the total number of studies.

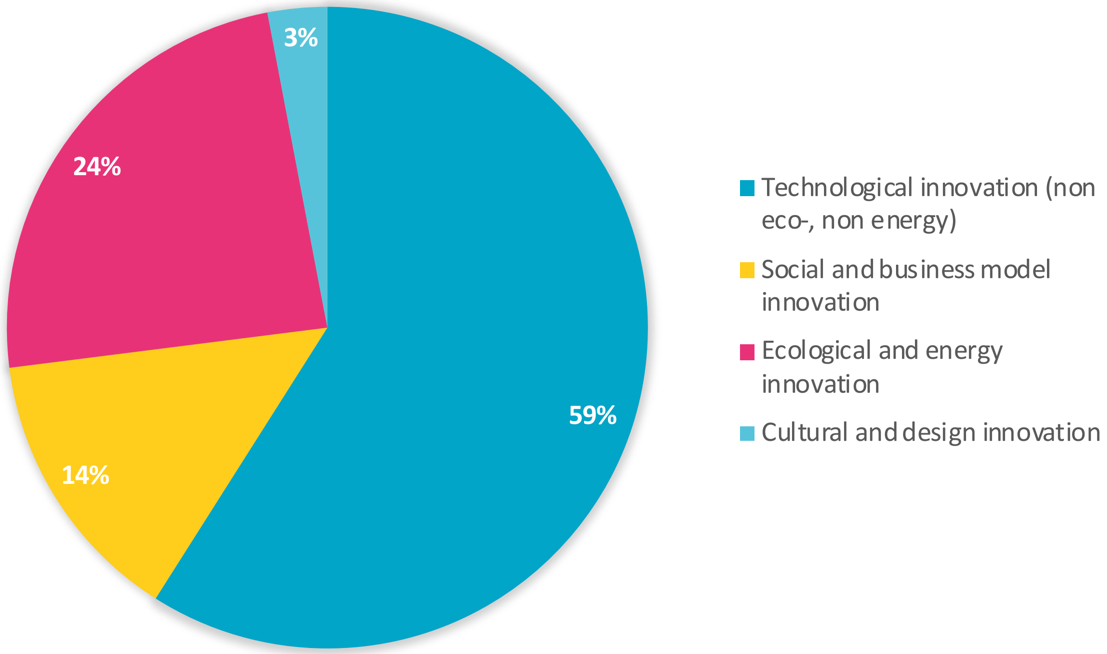

Figure 3. Distribution of the 100 top-cited review papers according to their innovation area

Source: authors

Based on the matrix of the East-West categorization and the innovation areas, Figure 4 shows that Western research institutions are more influential than other parts of the world.

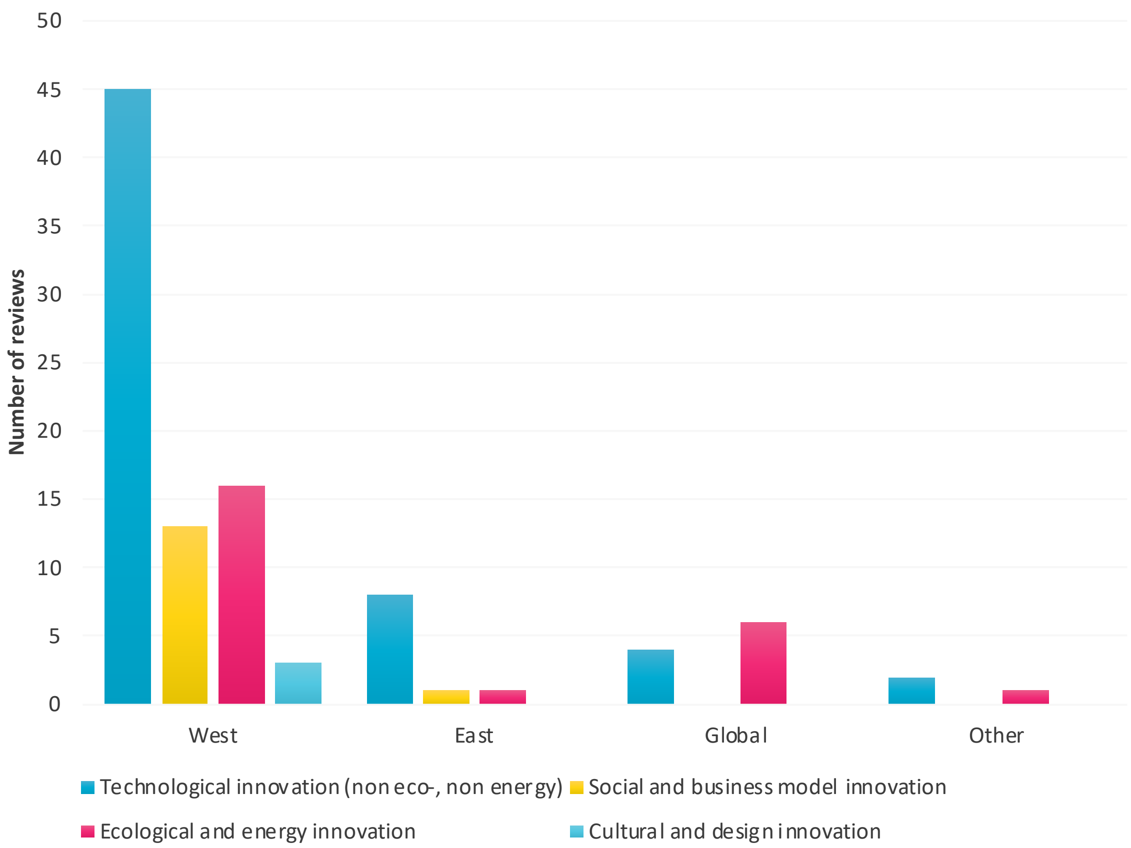

Figure 4. Distribution of the top-cited reviews according to innovation areas and East-West categorization

Source: authors

Nevertheless, more specific insights can be gained based on research fields (i.e., WoS categories). Figure 5 shows that 44 different research fields are relevant in case of the top 100 reviews, from which Business, Economics, Engineering, Engineering-Environmental, Environmental Sciences, Geography, Green & Sustainable Science & Technology, Industrial, Management, and Transportation appeared in case of the 10 top-cited reviews.

Business	Agronomy	Argiculture, Multi-disciplinary	Behavioral Sciences
Biochemistry & Molecular Biology	Biology	Chemical	Chemistry, Multi-disciplinary
Chemistry, Physical	Communication	Computer Science, Artificial Intelligence	Construction & Building Technology
Developmental Biology	Economics	Energy & Fuels	Engineering
Engineering, Civil	Engineering, Electrical & Electronic	Engineering, Environmental	Engineering, Multi-disciplinary
Environmental Sciences	Food Science & Technology	Genetics & Heredity	Geography
Geosciences, Multi-disciplinary	Green & Sustainable Science & Technology	Industrial	Information Systems
Management	Materials Science, Biomaterials	Materials Science, Multi-disciplinary	Nanoscience & Nanotechnology
Neurosciences	Operations Research & Management Science	Pharmacology & Pharmacy	Polymer Science
Psychology, Applied	Psychology, Experimental	Public Administration	Regional & Urban Planning
Reproductive Biology	Social Sciences, Interdisciplinary	Telecommunications	Transportation

Figure 5. Relevant research fields of the focal innovation areas

(research fields of the top 10 reviews with blue background)

Source: authors

3.2. Innovation definitions and viewpoints

Table 8 presents a list of the definitions or viewpoints of the focal areas and related search terms, i.e., ecological (or eco-)innovation, energy innovation, technological innovation, social innovation, business model innovation, cultural innovation, and design innovation.

Innovation and design area	Definition / Viewpoint	Source
Ecological innovation & Energy innovation	"Eco-innovations represent new or enhanced processes, organizational forms, as well as products or technologies that are beneficial to the environment in that they reduce or avoid negative environmental impacts"	(Klewitz & Hansen, 2014, p. 58)
	"EI is defined as a process realized by a number of "actors", "actions" and "audiences" which takes into consideration that there are multiple stakeholders involved, including the government, public, media, environmental organizations, shareholders, suppliers, customers, employees, etc."	(He, et al., 2018, p. 504)
	"With increasing competitiveness of renewable and clean energy, there is growing opportunity to leverage clean energy innovation as a step towards a low carbon future."	(Jordaan, et al., 2017, p. 1406)
Technological innovation	"Technological innovation is the central engine of organizational adaptation."	(Benner & Tushman, 2003, p. 242)
	"Following the Oslo Manual's lead, we defined innovation as 'implemented technologically new products and processes and significant technological improvements in products and processes.' (1997: 31)"	(Becheikh, et al., 2006)
	"The technological innovation of *Chinese* firms has become one of the critical engines driving this [rapid economic] development."	(Yang, et al., 2012, p. 820)

Cont.

Innovation and design area	Definition / Viewpoint	Source
Social innovation & Business model innovation	"The focus of policy is towards creating options and exploring paths of societal development, social innovation, as it were, rather than planning and then implementation."	(Voß, et al., 2009, p. 281)
	"The term is used as synonymous for intended and unintended social change, while it is used as a synonym for intangible innovations as well"	(Lubberink, et al., 2017, p. 5)
	"Business model innovation offers a potential approach to deliver the required change through re-conceptualising the purpose of the firm and the value creating logic, and rethinking perceptions of value."	(Bocken, et al., 2014, p. 43)
	"Business model innovation is seen as a new source of innovation which is different from the product, process and organizational innovation."	(Bashir & Farooq, 2018, p. 363)
Cultural innovation & Design innovation	"Cumulative culture describes the capacity to accumulate cultural innovations in successive generations, with each new generation learning from and adding to the previous generations' cultural knowledge"	(Mesoudi & Whiten, 2008, p. 3494)
	"The exchange of cultural information between divergent groups may have facilitated the emergence of cultural innovation."	(Ackermann, et al., 2016, p. 1)
	"Design innovation is a key driver to success in the current competitive market by substantially improving product design and features to delight customers' expectations."	(Suhariyanto, et al., 2017, p. 678)

Table 8. Definitions or viewpoints of the focal innovation areas from the literature

Source: authors

3.3. In-depth analysis of strategic and change aspects

3.3.1. Ecological and energy innovation and design

The starting point of Klewitz and Hansen's highly cited work (2014) is that the term sustainable development was first mentioned in 1972 at the United Nations Conference on the Human Environment, while innovation for sustainability has gotten increasing attention since the publication of the Brundtland report in 1987. This report was focusing on creating, redesigning, adapting and diffusing environmentally beneficial technologies by firms. This emerging trend, first, was concerned about mainly environmental (i.e., ecological) aspects, which brought eco-design into the scope of product innovators, moreover, "environmental issues were recognized as sources of strategic change" (p. 57). Later, however, sustainability-oriented innovations (SOIs) appeared which cover not only environmental, but social and economic dimensions. Accordingly, the suggested strategic behaviour of small and medium-sized enterprises is to follow a sustainability-rooted strategy which integrates economic, environmental, and social aspects in their core business, with the goal of market transformation and radical innovations, enabled by the strong interaction with external actors. Nevertheless, according to the authors, this requires the transition of the behaviour from a resistant, reactive, anticipatory, or innovation-based state (Figure 6) (Klewitz & Hansen, 2014).

From a strategic change perspective, this would involve sensing the entrepreneurial opportunity, organizing the capacity building and transforming the organization according to a new business model.

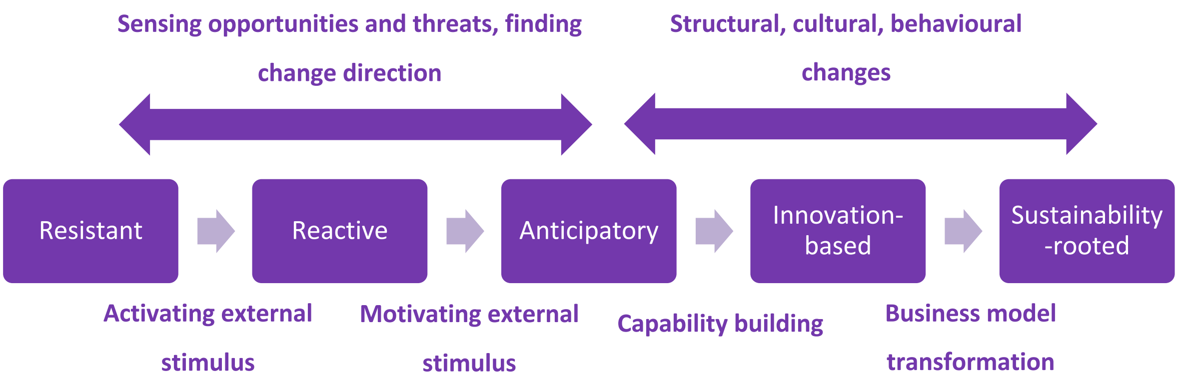

Figure 6. Interpretation of the strategic sustainability behaviour development from a change management perspective

Source: authors, based on Klewitz & Hansen, 2014, extended

Regarding industrial aspects, the food industry is an important area of eco-innovation, as Mirabella et al. (2014) argue that food waste is relevant in developed countries through the total food life cycle, i.e., agriculture, food-manufacturing, food retail and household consumption. The highest percentage of food waste production is in the case of households (42%) and during manufacturing and processing (39%). In the latter case, eco-innovation must focus to support the development of a circular or a zero-waste economy and society. This goal could be achieved by new production systems, e.g., biorefineries and industrial symbiosis "in which the goal is to use wastes from one sector as an input for other sectors" (Mirabella, et al., 2014, p. 29). The authors highlight that mainstream sectors, such as the pharmaceutical industry could be the potential area of waste recovery. Nevertheless, further processing is needed before using food waste in another sector, which induces costly research and development. Consequently, mostly high-value-added products could be economically feasible, but the involvement of several stakeholders (e.g., producers, technology developers / intermediaries, and end-users) is also needed.

Based on the above, food waste recovery-aimed eco-innovation might require an innovation *eco(-)system* of interested parties which must go beyond not only organizations but sectors for industrial symbiosis. Innovation ecosystem building, however, needs ecosystem builder organizations the directors of which engage boards of other organizations to collaborate based on a promising opportunity (Figure 7).

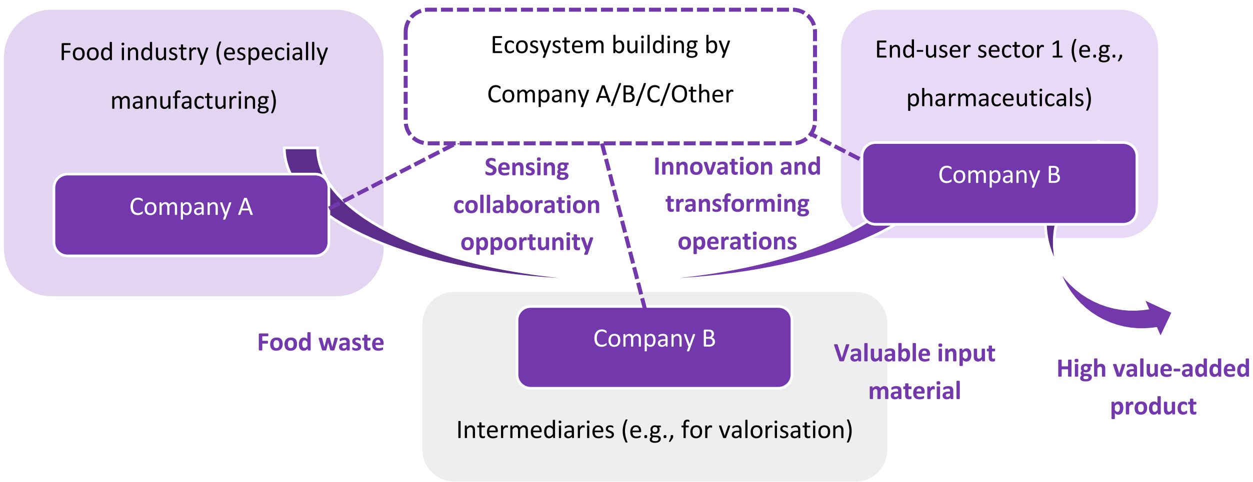

Figure 7. Eco-innovation by innovation ecosystem building for food waste recovery and industrial symbiosis

Source: authors, based on Mirabella et al., 2014, extended

Regarding the development of the circular economy (CE), Saidani et al. (2019) reviewed the existing CE indicators and suggested a taxonomy which might accelerate a common understanding among stakeholders, including academia and industry as well. Their taxonomy for the CE indicators includes 10 categories, which also illustrate what aspects were concerned during indicator set development to date (n=55):

1. Level: micro, meso, macro
2. Loops: maintain, reuse, recycle
3. Performance: intrinsic, impacts
4. Perspective: actual, potential
5. Usages: improvement, benchmarking, communication, etc.
6. Transversality: generic, sector-specific
7. Dimension: single, multiple
8. Units: quantitative, qualitative
9. Format: web-based tool, Excel, formulas. (Saidani, et al., 2019)

Nevertheless, from a practical perspective, the authors also argue that even though an appropriate CE taxonomy could foster CE development as it provides a new basis for measurement, the implementation of CE models "relies on the synergy between key building blocks including product design, new business models, reverse logistics, enablers and systems conditions" (Saidani, et al., 2019, p. 556). Furthermore, CE strategies would affect the organizational models, technologies, shared knowledge, and product innovation directions, which are all related to change management (Figure 8).

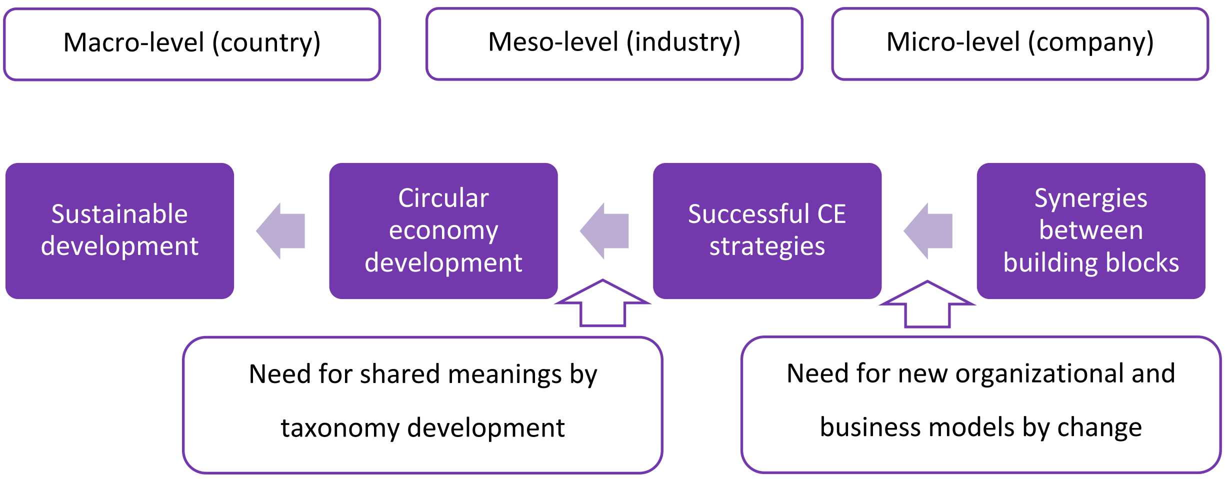

Figure 8. Structure and tools of CE development

Source: authors, based on Saidani et al., 2019, extended

The work of Choudhary and Srivastava (2019) approaches energy innovation from the aspect of sustainability, in which the chronology of sustainability was also highlighted with key events and dates, e.g., Brundtland Commission report (1987), Earth Summit in Brazil (1992), UN Framework Convention on Climate Change, Kyoto protocol (2000-). According to the authors, the first decade of renewable energy development was between 2004 and 2014. The review of the authors identifies prior review themes in the area of PV research, for example:

a) emission liability, carbon capture
b) renewable energy and investments, instant change of technology (e.g., energy return on investment or scalability)
c) integrated approach (e.g., hybrid solutions with biomass-PV), harvesting techniques
d) power electronics, power optimization
e) software, artificial intelligence
f) grid integration, role of microgrid
g) low-carbon economy, energy policy, innovative public thoughts
h) weather and optimization, nature-inspired aspects, space solar, climate factor
i) manufacturing optimization, forecasting for stability, material aspects, and energy baseline. (Choudhary & Srivastava, 2019)

The authors argue that there are several innovation areas that need to be explored to enable further growth based on PV-based clean energy, such as the efficient manufacturing of solar cells, innovative power electronics, energy-water-environment nexus of mitigation policies, renewable hybrid models for cost-effectiveness, energy storage, regenerative systems. Moreover, it is highlighted that "renewable energy system must incorporate business for the social environment and deliver inclusive functionality rather than only ownership" (Choudhary & Srivastava, 2019, p. 607) which would inherently require a change in current thought patterns of business.

One of the key studies of Eastern eco-innovation (EI) research was written He et al. (2018) who focused on the corporate background of EI. Their review showed that the main research themes were the following between 2006 and 2015: stakeholder influence; product-service systems; eco-design; drivers; environmental management systems; green supply chain management; EI systems or networks; new product development; performance & SMEs” (He, et al., 2018, p. 512). Based on their findings and further theoretical iteration, the authors developed a driver-source-position-performance framework which could be used to accelerate eco-innovation.

Table 9 shows how the EI process could be interpreted from the aspect of a single organization and how dynamic capabilities aspects could be interpreted in the outlined EI dimensions. Nevertheless, the authors highlight that collaborative knowledge management, global networking, and knowledge institutions are key for EI. Partnerships seem to be crucial for radical innovation, which usually leads to better performance compared to incremental innovation – nevertheless, financial and environmental outcomes are not always unequivocal, as they depend on the specific adoption of EI activities at certain companies (He, et al., 2018).

Framework	Typology	Examples / Realization	Dynamic capabilities aspects
Driver	External	Government, customers, stakeholders	Sensing changing needs, new trends, new threats and opportunities
	Internal	Efficiency, environmental management concerns	
Source / Strategy	Reactive	Incremental innovation	Seizing opportunities, managing threats by innovation, building partnerships for radical innovation
	Proactive	Radical innovation	
Position / Implementation	Eco-product	Eco-design, new product developments, product services	
	Eco-process	End-of-pipe and cleaner production technologies	Initiating organizational changes, transforming the organization
	Eco-organization	Environmental management system	
Performance / Evaluation	Market-based	Financial indicators	Continuous control and reconfiguring if needed
	Accounting-based	Overall profitability	
	Operation-based	Operation efficiency	

Table 9. EI process, specificities and related governance tasks

Source: authors, based on He et al., 2018, extended

The history of EI technologies in corporate contexts was explored by Kuo and Smith (2018) who presented a four-stage evolution diagram about moving towards sustainability. According to their discussion, between 1990 and 2000, the focus was on green or sustainable product development because of the extended producer responsibility concept. Nevertheless, as enterprises faced challenges of autonomous product development, supply chain members started to collaborate in stage 2 (2000-2010) which resulted in (1) closed-loop supply chains, and later (2) innovative business models to optimize the supply chain and manage risks. The problem with this approach was that collaboration partners forget to involve customers, i.e., customers did not like the end-products, thus, design for sustainable consumption is becoming more and more important since 2010 in stage 3. Additionally, to ensure a closed loop, recycling and waste management became more emphasized. At stage 4 (nowadays), enterprises should focus on the construction and the optimization of hybrid models to turn new technologies into eco-innovations. However, all the dimensions of development remain relevant in stage four. During this process “the organizational theories can help explain organizational behavior, designs, or structures (R52)[…] and the design and management of a sustainable business model should be eco-innovative (R51)” (Kuo & Smith, 2018, p. 212). Table 10 presents the list of the identified areas of supporting EI technologies and the relevance of strategic change.

Dimension / Stage	**Green/Sustainable product development**	**Business model integration**	**Green marketing and consumption**	**Hybrid model building**
Start date	1990	2000	2010	2020
Development areas	Product strategies Design innovation Lean/green manufacturing and management Value co-creation Impact measurement	Development of a closed-loop supply chain Supplier management of sustainable supply chain Supply chain risk evaluation, optimization, sustainability measurement	Green marketing strategies Green marketing development Waste resource management Decision-making for waste management	Integrating design, evaluation, operation methodologies, modelling techniques
Key areas of strategic change	Dynamics for sustainable transition (culture, behaviour, interests)	Corporate social responsibility as a driver	Design for remanufacturing	Design and management of sustainable business models

Table 10. EI technology development dimensions

Source: authors, based on Kuo and Smith, 2018, extended

Table 11 presents the historical and economic insights of the above-presented research in the ecological and energy innovation and design area, and highlights related strategic and change aspects.

Western Ecological and Energy Innovation Research			Perspectives of analysis (examples for insights)			
Authors and aff. country	***Scope of the research***	***Main finding(s) / suggestion(s)***	***History***	***Economy***	***Design***	***Strategy and change***
(Klewitz & Hansen, 2014) Germany	Sustainability-oriented innovation (SOI) of SMEs	Interaction with external actors to increase SOI performance and root the whole business model in sustainability	The term sustainable development is used since 1972, SOI has got increasing attention since 1987 (p. 57)	While the concept of cleaner production focuses on environmental impact, eco-efficiency emphasizes economic gain (p. 66)	Eco-design as a tool for sustainability-oriented product innovation (p. 67)	Business model transformation for SOI (p. 70)
(Mirabella, et al., 2014) Italy	Reusing food waste in industrial symbiosis	Industrial symbiosis would be possible, but stakeholder involvement is required	Food waste is an important topic since the 1990s (p. 28)	Industrial ecology, circular economy, and zero waste economy are the leading principles for eco-innovation (p. 28)	Designing novel beverages from by-products (p. 34)	Involvement of stakeholders, inter-organizational collaboration (p. 39)
(Saidani, et al., 2019) France, USA	Circular economy (CE) indicators	A new taxonomy with 10 categories is developed	Since 1987, sustainable development becomes a more and more important scientific and industrial topic, for the goals of which CE could function as "toolbox" (p. 543); eco-design tools emerged in the 1990s (p. 547)	Circular economy objectives (reduce, reuse, recycle) are different from the traditional linear economy, i.e., new measurement methods are needed (p. 543)	Sustainable development indicators, eco-design tools, and circular economy indicators have several taxonomies in the literature (p. 547)	CE strategies require new organizational and business models (p. 556)

Cont.

Eastern Ecological and Energy Innovation Research			Perspectives of analysis (examples for insights)			
Authors	*Scope of the research*	*Main finding(s) / suggestion(s)*	*History*	*Economy*	*Design*	*Strategy and change*
(Choudhary & Srivastava, 2019) India	Photovoltaic trends and growth	Need for innovative policies, energy cost reduction, social acceptance, capacity building and collaborations	The history of sustainability since 1987 has led to the first decade of development in renewable energy between 2004-2014 (p. 591)	Renewable energy is a better option for a sustainable future and global economic contribution compared to other technologies (p. 591)	The intermittent nature of PV capacities is challenging for energy management design (p. 606), the design of digital controllers/ converters (p. 602)	Reconfiguring business activities for the social environment (p. 608)
(He, et al., 2018) China, Hong Kong	Corporate eco-innovation (EI)	Using the driver-source-position-performance framework could lead to competitive advantage by EI	Brundtland report in 1987 emphasized environmentally sound technologies, and since 2000, EI diffused as a corporate practice and in supply chain networks (p. 503)	Climate changes, environmental pollution and resource scarcity mean a growing pressure for companies to follow both economic and environmental goals (p. 503)	Eco-design is one of the nine main areas of eco-innovation (research) (p. 511)	Seizing opportunities by eco-product development transforming with eco-processes and eco-organization systems (p. 512)
(Kuo & Smith, 2018) Taiwan	Eco-innovation technologies	New technologies are needed for business model integration, green marketing and consumption, and hybrid models	Stage 1 of enterprise evolution towards sustainability was between 1990 and 2000 with green product development (p. 209)	Circular economy development is a key future direction of EI technology development (p. 216)	Design for the bottom of the pyramid (BOP) to reduce poverty (p. 216), and value-added design for economical ecological and social enhancements (p. 217)	Changing culture, behaviour, interests and designing sustainable business models (p. 211)

Table 11. Historical and economic aspects of ecological and energy innovation and design research

Source: authors

3.3.2. Technological innovation (non-eco and non-energy)

One of the most influential studies concerning technological innovation was written by Brenner and Tushman (2003), in which they argue that even though there are increasing institutional pressures to improve process management, which is expected to positively affect operational efficiency, it is known for several decades that productivity efforts are not enough to maintain the firm's ability to remain competitive in the long run. Accordingly, this needs dynamic capabilities through which exploiting existing markets and exploring new ones would be possible. Regarding technological innovation, the authors present that exploitation can be associated with incremental technological innovation for current customer sets, while exploration would be realized through architectural or radical innovation which is aimed at emergent customer sets. The choice between the nature of technological innovation (and product innovation) must be based on the environment, i.e., technological cycles with incremental and non-incremental changes. According to their model (Figure 9), process management, exploitative and explorative technological innovation, and the stable or turbulent environment affect the adaptation of organizations, in terms of performance (e.g., financial) and responsiveness (to technological transitions) (Benner & Tushman, 2003). From a change management perspective, it means that managers must find (ambidextrous) organizational forms based on the nature of the environment and the appropriate innovation goals, moreover, to limit the emphasis on process management if needed.

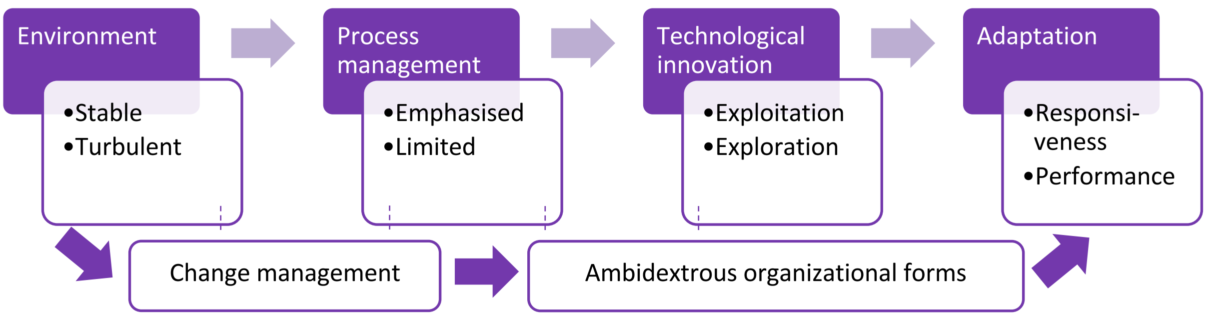

Figure 9. Technological innovation from the aspect of strategic ambidexterity

Source: authors, based on Benner & Tushman, 2003, extended

Besides strategic ambidexterity, another important direction of technological innovation research is open innovation. In the review of West and Bogers (2014), the introduction highlights that open innovation is a new paradigm which is in contrast to the dominant innovation approach of the 20th century which was about producing technological innovations through corporate R&D and using the outputs by the vertically integrated commercialization infrastructure. Instead, external and internal ideas and capabilities can be combined to increase technological innovation performance. An important aspect of open innovation is how firms leverage external sources of innovation, regarding which the authors argue that it usually follows a three-phase linear process: obtaining, integrating, and commercializing; and this can be combined with the interaction among collaborators. Table 12 presents the phases and research topics of leveraging external sources of innovation, combined with the relevant strategic change management and governance tasks.

Phases	Steps	Topics	Governance
Obtaining	Searching	Sourcing, Technology scouts, Limits	Inter-organizational network building
	Enabling / Filtering	Brokerage, Contests, Intermediaries, Toolkits, Platforms, Gatekeepers	
	Acquiring	Incentives to share, Contracting, Nature of the innovation,	
Integrating		Absorptive capacity, Culture and "Not invented here", Incentives to cooperate, Competencies	Initiating organizational changes focusing on open culture, long-term-focused incentives and competency development
Commercializing		Commercialization process, Value creation, Value capture	Reconfiguring business models
Interaction	Feedback	R&D Feedback, Customer/market feedback	Partner and other stakeholder management
	Reciprocal	Cocreation, Communities, Value networks	

Table 12. Phases, steps, topics and governance tasks of leveraging external resources for open innovation

Source: authors, based on West and Bogers, 2014, extended

Technological innovation is crucial in certain sectors, for example, in the manufacturing sector, as Becheikh et al. (2006) discussed in their review about determinants of innovation. Based on empirical studies published between 1993 and 2003, the authors found that many internal factors determine innovation in manufacturing firms, such as

1. the firms' general characteristics (e.g., size and age)
2. strategies (e.g., diversification, internalization, differentiation)
3. structure (e.g., formal structure or flexibility, centralization, interactions)
4. control (e.g., financial or strategic)
5. culture (e.g., resistance to change)
6. leadership (e.g., CEO characteristics, management experience)
7. functional operation (e.g., R&D assets, HR qualification, financial autonomy).

Nevertheless, there are contextual factors which influence technological innovation performance, such as the industry, the region, the inter-organizational networks, knowledge or technology acquisition opportunities, government policies, or surrounding culture (Becheikh, et al., 2006). The authors concluded that managers and policymakers have opportunities to foster innovation in the manufacturing sector (i.e., initiate change, as detailed in Table 13).

Subject of changes	Managers (firm level)	Policymakers (country level)
Goals	Clear definition of the strategies Specialization built on distinctive competencies, differentiation Internalization and patenting Monitoring competitors Increasing or decreasing firm size	Developing and communicating clear policies Promote certain sectors which are relevant for innovation Strategically planning university locations and research centres
Realization	Flexible structure Interaction between units Qualified employees, training and development Empowerment of employees Innovation culture with total quality management and continuous improvement principles	Encourage competition by reducing entry barriers Providing financial support by subsidies, preferential rates, loans, tax credits Establishing institutions to support the internalization of firms Creating meeting places where entities can collaborate and ideate Promoting clusters

Table 13. Change directions to foster technological innovation

Source: authors, based on Becheikh, et al., 2006

Compared to Western research, highly cited Eastern review papers which are related to technological innovation were focusing less on abstract technological innovation and more on concrete technologies and sectors. For example, Tao et al. (2021) focused on using machine learning (ML) in perovskite materials discovery and design, which "have attracted much attention in many scientific fields for the composition diversity, easily available synthetic conditions and a variety of attractive properties" (p. 1). According to their study, the traditional material development was mainly based on trial and error, and continuous improvement, which needed a long-time. After that, simulation methods, such as Density Functional Theory (DFT), Monte Carlo simulation and molecular dynamics were explored and used, however, computational simulation methods were also challenging because of the need for professional skills and high computational costs. Recently, machine learning has emerged, which drives artificial intelligence in analyzing data and structures, and could provide a new workflow for materials discovery and research Based on the review of the authors, the application of ML will increase materials research, however, important tasks must be realized to proceed to a more mature phase, such as:

a) the combination of ML and experiments or simulations
b) new ML algorithms for smaller samples
c) ML computing platform development
d) enabling the interpretation of the statistical ML black box. (Tao, et al., 2021)

Regarding task a), Figure 10 shows that this combination would enable significant advancements in research and development.

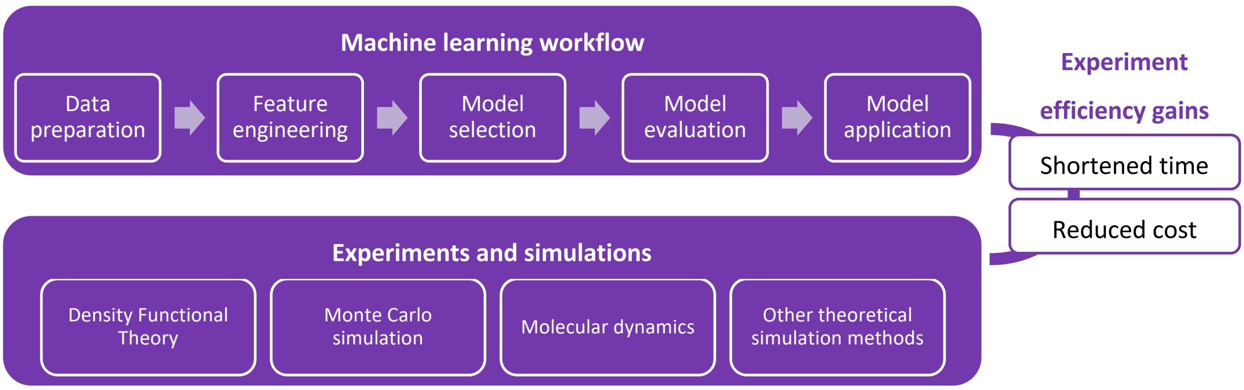

Figure 10. Perspectives of Machine Learning in materials research

Source: authors, based Tao et al., 2021

Besides machine learning, artificial intelligence (AI) is also a key topic in the area of technological innovation, which was analyzed concerning the education sector by Chen et al (2020). The authors mention that the development of personal computers since the 1970s and the programmed instructions since the 1990s enabled to use computers in different departments of the education sector After that, the higher computational and data processing performance, and the emergence of the worldwide web and task-oriented programs further increased the presence of computers and affected the interactions among students and teachers. As information communication technologies are being developed further, the authors argue that AI can help to reach higher quality in

- teaching, e.g., through increased efficiency in reviewing students' assignment
- learning, e.g., through a customized curriculum which reflects the students' different needs. (Chen, et al., 2020)

Furthermore, the authors discuss what future scenarios of AI implementation could be relevant in the education sector. Table 14 presents these scenarios with additional operational changes which could be relevant during AI-based transformation.

Scenarios	AI-related technological innovations	Operational changes (examples) by new technologies
Assessment of students and schools	Adaptive learning method and personalized learning approach, academic analytics	Performing administrative tasks instead of instructors
Grading and evaluation of papers and exams	Image recognition, computer-vision, prediction system	Grading exams, provide feedback, assist the decision-making of instructors
Personalized intelligent teaching	Data mining or Bayesian knowledge interference, intelligent teaching systems, learning analytics	Uncovering learning shortcomings, identifying learning styles and preferences of students
Smart school	Face recognition, speech recognition, virtual labs, Augmenter Reality, Virtual Reality, hearing and sensing technologies	Allowing instruction beyond the classroom, supporting collaboration
Online and mobile remote education	Edge computing, virtual personalized assistants, real-time analysis	Helping to build personalized learning plans, detecting learning states and apply intelligent adaptive intervention

Table 14. AI scenarios in education and potential operational changes by technological innovation

Source: authors, based on Chen, et al., 2020, extended

The most relevant review (based on citation number) which discusses technological innovation with a more abstract approach was written by Yang et al. (2012) who analyzed the past, present and future of technological innovation in China. Regarding the past, the authors argue that even though technological innovation was important in the growth of the Chinese economy in the last decades, "the financial crises in the late 1990s and in 2008 have made it clear to the Chinese government that the nation's sustainable growth in the global economy will depend on the further development of the science and technology system and on the competence of its technological innovation" (Yang, et al., 2012, p. 820). Along with this recognition, the previously central-plan-based economy became a market-based economy, which was facilitated and controlled by the government. Nevertheless, based on the literature review, the authors identified another important external factor which influenced the technological innovation of Chinese firms, i.e., the uncertain environment in the transition economy. In case of the internal factors, scholars highlighted more topics, such as market orientation, entrepreneurship, top management teams, organizational control, and organizational learning. While general strategic management would only consider these two factors (internal and external) the authors also argue the importance of interfirm cooperation, i.e., alliances, networks and managerial ties, and cluster cooperation (Yang, et al., 2012). Based on the framework of the authors for future research, Figure 11 presents how certain factors influence innovation performance, and what dynamic governance tasks must be realized to accelerate innovation performance.

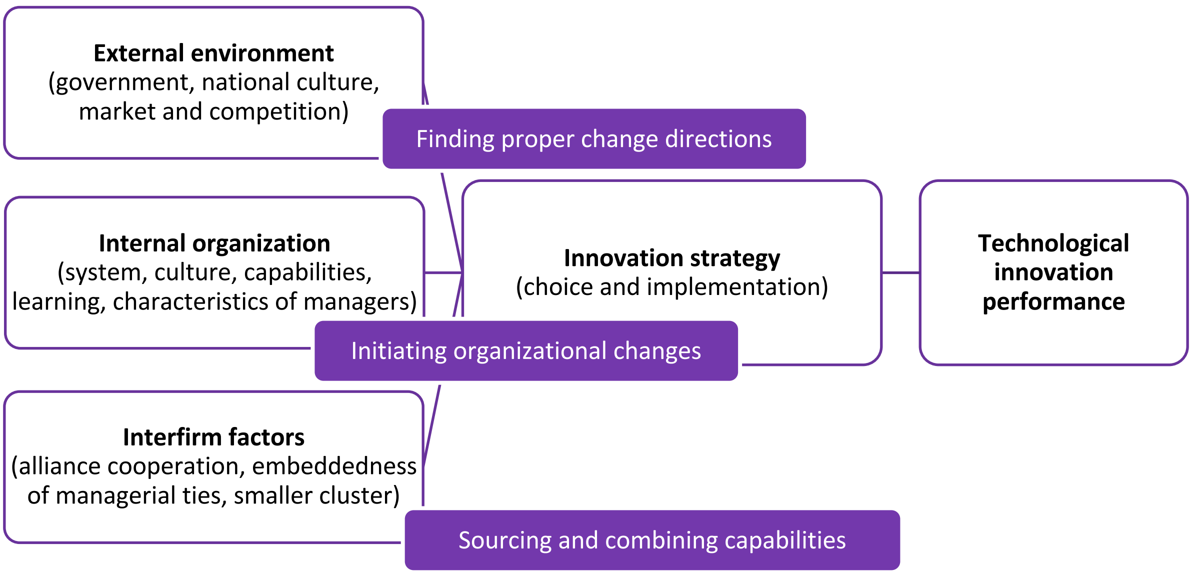

Figure 11. Factors behind technological innovation performance and related governance tasks

Source: authors, based on Yang et al., 2012, extended

Table 15 presents the historical and economic insights of the above-presented research in the technological innovation and design area, and highlights related strategic and change aspects.

Western Technological Innovation Research			Perspectives of analysis (examples for insights)			
Authors and aff. country	*Scope of the research*	*Main finding(s) / suggestion(s)*	*History*	*Economy*	*Design*	*Strategy and change*
(Benner & Tushman, 2003) USA	Ambidexterity and process management	Process management can be counterproductive in technologically complex contexts where incremental innovation is not enough	Since 1978, it is discussed that productivity gains and efficiency focus might hamper long-term competitiveness, however, institutional pressures orient managerial attention to process management in the 2000s (p. 238)	Technological cycles affect organization environments with the emergence of a dominant technological framework – and after product innovation, process innovation and incremental refinements come, ended by a new discontinuity (p. 248)	Products can be designed for existing needs (exploitation) or emergent markets (exploration) (p. 243)	In a stable environment, process management could contribute to effectiveness, thus building resistance to change in a turbulent context (p. 252)
(West & Bogers, 2014) USA, Denmark	Open innovation and leveraging external sources	Business models are often ignored in research despite their role in open innovation	The dominant innovation approach of the 20th century was to produce technological innovations through corporate R&D and vertically integrated commercialization infrastructure (p. 814)	External sourcing could be relevant because of (1) the economies of scale or (2) access to innovations or innovation-producing capabilities (p. 815)	External and internal ideas are combined in the open innovation paradigm (p. 815)	Cultural changes might be needed to utilize external innovation and/or collaborate (p. 821)
(Becheikh, et al., 2006) Canada	Innovation in the manufacturing sector	Managers and policymakers have many options or duties to support technological innovation	According to Schumpeter (1934), innovation drives economic development, and since then, innovation affects the (international) competitiveness of companies and countries (p. 644)	Policymakers can foster innovation by reducing entry barriers from economic sectors, supporting geographical clusters, helping internalization, etc. (p. 658)	Improvement only in product design and package are not innovations (p. 645)	Innovation might need a change in corporate strategy, structure, culture, marketing or firm size (p. 659)

Cont.

Eastern Technological Innovation Research			Perspectives of analysis (examples for insights)			
Authors and aff. country	***Scope of the research***	***Main finding(s) / suggestion(s)***	***History***	***Economy***	***Design***	***Strategy and change***
(Tao, et al., 2021) China	**Machine learning (ML) in (perovskite) materials discovery and design**	The application of ML will increase materials research which supports technological innovation	Traditional material development was mainly based on trial and error, which was followed by simulated methods, and since the 1980s ML emerged which can accelerate the process (p. 1)	The development of materials drives technological innovation and scientific progress (p. 1)	ML is a useful tool to support materials design and screen different materials (p. 1)	ML in materials research is early-phase but must be promoted to increase experiment efficiency (p. 14)
(Chen, et al., 2020) China	**Artificial intelligence (AI) in Education**	AI can help to reach higher quality in teaching and learning	Personal computers (1970s-), programmed instructions (1990s-), later computer-aided instruction and learning (CAI/L) and recently the internet, increased processing, and software packages are useful for education (p. 75265)	Computer-related technological innovations encouraged AI development which affects many industries (p. 75276)	AI development brings together system designers, data scientists, product designers, statisticians, linguists, and other experts (p. 75267)	Change in the education system by AI is feasible based on different scenarios, such as, “personalized teaching” or “smart school” (p. 75268)
(Yang, et al., 2012) China	**Technological innovation in China**	Future research should focus on the choice and implementation of an innovation strategy	Technological innovation was a key driver of the rapid development of China’s economy in the past decades (p. 820)	The central-plan-based economy became a market-based economy, pushed and controlled by the government (p. 822)	Market orientation can enhance competitiveness and new product performance (p. 824)	External, internal, and interfirm factors affect the innovation performance (p. 832)

Table 15. Historical and economic aspects of technological (non-eco-, non-energy) innovation and design research

Source: authors

3.3.3. Social and business model innovation

From a policy perspective, Voß et al. (2009) was focusing on the relationship between long-term policy design and transition management. The authors argue that long-range policy design has become less influential after the 1970s, but recent long-term policy design concepts seem to be more reflexive with the recognition of limits. The concept of transition management, however, combines the vision of sustainable development with short-term experimental learning with a time horizon of 25-50 years. It aims to realize substantive goals (e.g., increasing resource efficiency) with the core "idea to modulate co-evolutionary dynamics that already drive socio-technical change, and to bend them in ways that facilitate transformative innovation" (Voß, et al., 2009, p. 277), and nurturing and growing approach (instead of planning and controlling change). Accordingly, transition management supports policies for social learning, and finding ways of social innovation. Nevertheless, to follow this approach in practice, transition management would need redesigning, according to the authors (Table 16). (Voß, et al., 2009)

Policy design aspect of sustainable development	Transition management approach
Transition in socio-technical systems	Broad societal discourse, challenging the legitimacy of existing systems
Innovators and stakeholders	New principles and guidelines for participant selection and interactions among actors who co-produce new solutions
Change visions	Construction by participants according to feasibility, creative and normative aspects
Experimentation	Procedures to select and design experimentation
Evaluation and learning	According to broad techno-economic and societal aspects, and alternative pathways, learning from experiments and the overall process
Legitimacy	Inclusivity, participation, transparency
Approach	Policy design as an innovation process, continuous design

Table 16. Transition management as a tool for sustainable development and long-term policy design

Source: authors, based on Voß, et al., 2009

Social innovation is sometimes mentioned together with sustainable innovation and responsible innovation (RI), for example in the work of Lubbering et al. (2017) which was focused on the implementation of RI in a business context. The authors highlight that social innovation "is a commonly but not consistently used term by scientists as it is conceptualized and defined in different ways by different streams of scholars" (Lubberink, et al., 2017, p. 5). Different interpretations include intended and unintended social change, intangible innovations, creation of social value, driving positive social change, or meeting social needs and improving human and environmental well-being (Lubberink, et al., 2017). In contrast, RI is more about innovating with and for society, within four dimensions (Table 17), which can require changes within the organizations as well.

	Main idea	Examples of RI-supportive practices in a business context	Driving internal change
Anticipation	Systematic thinking about the desirable futures and the potential benefits and also problems and alternatives of the innovation	Understanding the innovation context (e.g., trends, technologies, legislation) and the social problem, risk assessment of the innovation,	Roadmap development to increase the positive impact Aligning business strategy with impact vision
Reflexivity	Exploring underlying values and beliefs to ensure wider moral responsibility	Formal evaluations of the actions and responsibilities Knowledge assessment Prioritizing certain values and motivations	Cultural change for employee empowerment and self-reflection
Inclusion and deliberation	Frequent or continuous engagement of stakeholders, negotiations, discussing concerns and bias	Involvement of wider public, supply-chain actors, end-users, experts, governmental agencies Formal process for collecting information, organizing dialogues and evaluation	Resource allocation to enable networking, involvement and reorganization of work with stakeholders
Responsiveness	Shaping innovation direction based on stakeholder values	Addressing grand environmental, social, and economic challenges Addressing local problems	Preventing or overcoming organizational inertia

Table 17. Responsible innovation principles, practices and change drivers within organizations

Source: authors, based on Lubberink, et al., 2017

Sustainability is also a key topic in case of business model innovation, not only social innovation. For example, Bocken, et al. (2014) focused on the relationship between sustainability and business model innovation by identifying nine different sustainable business model archetypes which firms can follow to support sustainable development and shape their transformation. The authors argue that business model innovation in line with these archetypes can be a tool to change the common phenomenon that businesses disregard the value of natural assets and ecological systems despite their well-known importance for human well-being. It is because, "in a sustainable business, the value proposition would provide measurable ecological and/or social value in concert with economic value" (Bocken, et al., 2014, p. 43). Nevertheless, business modelling must go beyond the value proposition. Accordingly, the authors described the nine archetypes according to three dimensions, i.e., value proposition, value creation and delivery (key activities, resources, channels, partners, technology), value capture (cost structure and revenue streams) in three groupings (technological, social, and organizational) (Figure 12). (Bocken, et al., 2014)

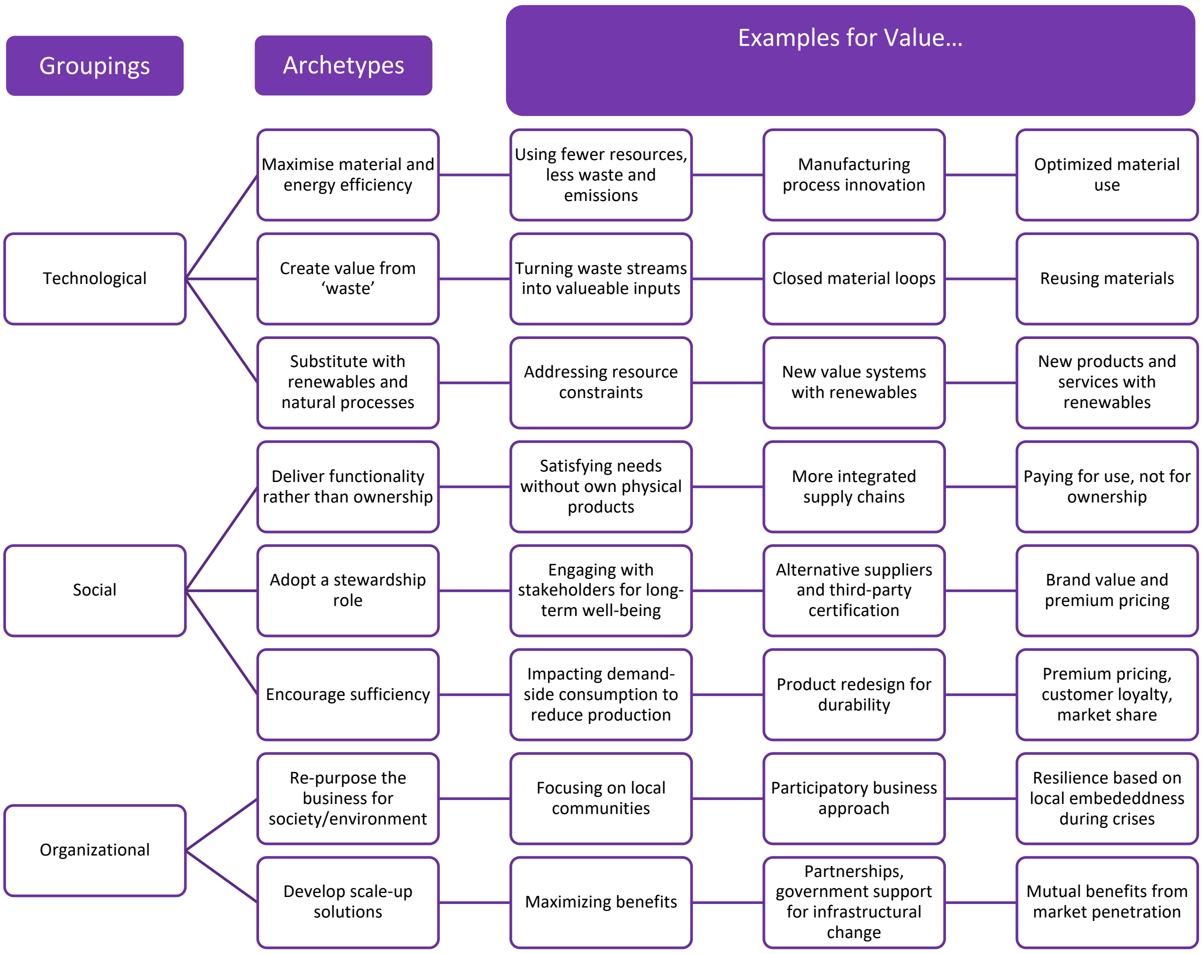

Figure 12. Sustainable business model archetypes and examples

Source: authors, based on Bocken, et al., 2014

Regarding the Eastern social and business model innovation (BMI) research, Bashir & Verma (2019) was focusing on the internal factors and consequences. According to the authors, researching business models became important in the early 1990s with the dot com bubble, and prior research tends to emphasize that technological developments could drive BMI. The authors highlight that in low labour economies, such as in China or India, companies can imitate product or service innovations more easily, which increases the importance of BMI which is a more complex subject and that is why it can lead to a more sustained competitive advantage. Based on their findings, structure, culture, inertia, leadership, and technology are found to be the antecedents of BMI, BMI is moderated by firm size and inexperience, and BMI can affect strategic flexibility, competitiveness, and competitive advantage. Figure 13 shows that organizational inertia is a key reason why incumbents are worse at BMI compared to new entrants, however, if they are successful, better economies of scale, advanced control of key resources and better bargaining power enable to improve competitiveness through BMI in a larger pace (i.e., firm size positively moderates the relationship between BMI and firm competitiveness) (Bashir & Verma, 2019, p. 274).

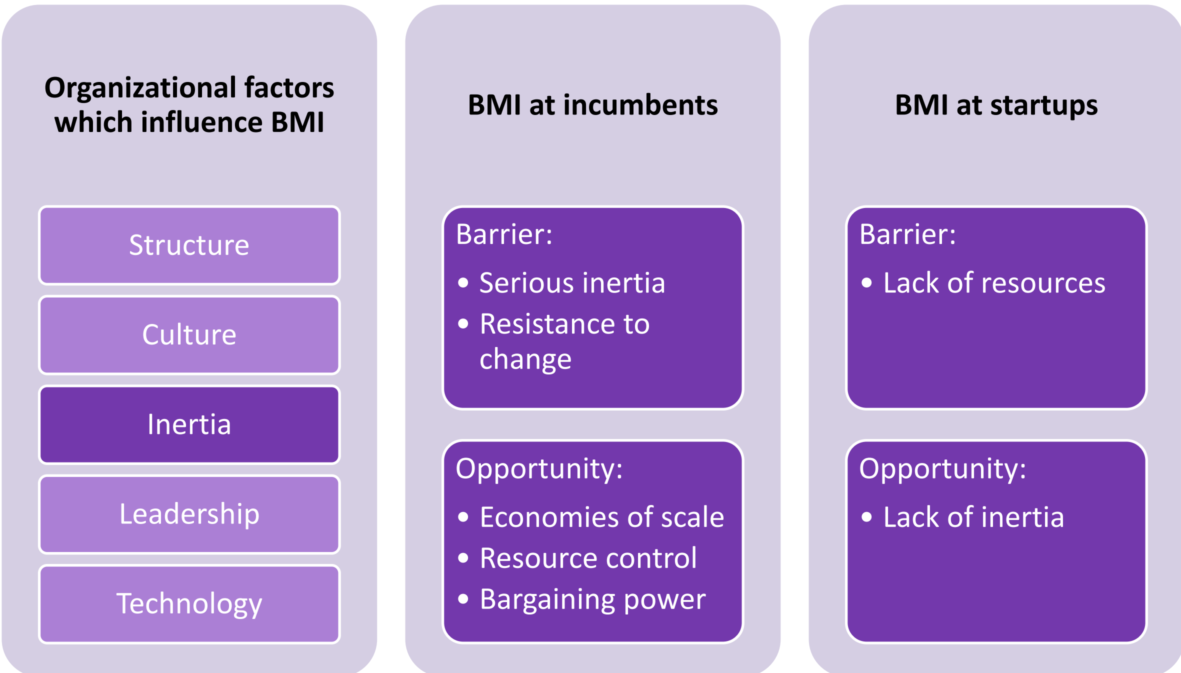

Figure 13. General and firm-size specific factors of business model innovation

Source: authors, based on Bashir & Verma, 2019

BMI was also interconnected with knowledge management (KM) which has been acknowledged to be important for BMI in the early 2000s when it became "the mantra for survival, competence, and success of pure-play net enterprises, as well as relatively traditional brick-and-mortar enterprises faced with the challenge of transforming their business models into, and beyond, brick-and-mortar companies" (Bashir & Farooq, 2018, p. 363). Accordingly, Bashir & Farooq (2018) developed a conceptual model which links KM, BM and firm competence based on their underlying factors:

1. KM with knowledge acquisition, conversion, dissemination, application, and reuse;
2. BMI with, value proposition, assets and capabilities, revenues and cost architecture, and actors in business networks.

Based on their review, the main idea of the conceptual model is that companies must integrate KM and BMI to gain a sustainable competitive advantage. Their argument is supported by prior influential theories, such as the resource-based view (RBV), which suggest that knowledge is a key resource to be developed and used for BMI, and the knowledge-based view (KBV), according to which competitive advantage derives from KM activities. The logic of these influences within the organization and the consequent role of Chief Knowledge Officers are illustrated in Figure 14. (Bashir & Farooq, 2018)

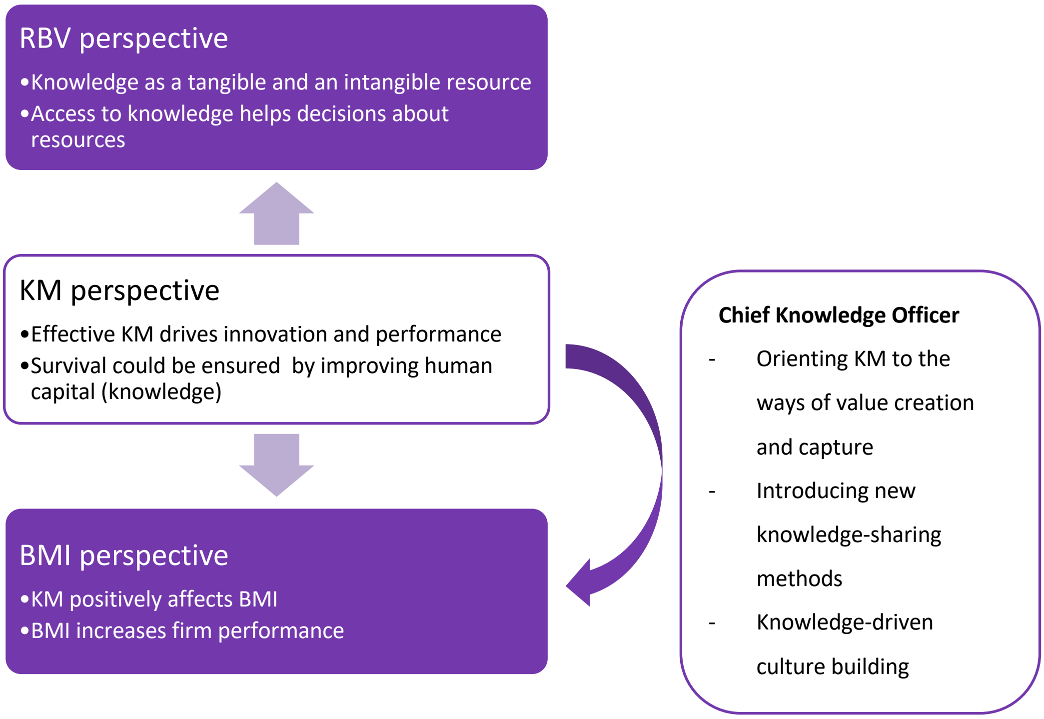

Figure 14. Knowledge management for business model innovation

Source: authors, based on Bashir & Farooq, 2018

In case of social innovation, Kim and Lim emphasize the role of social enterprises, framed by the social economy theory (Kim & Lim, 2017). Accordingly, the social enterprise is a type of organization which realizes social activities as a member of an independent third sector between the market and the state.

Regarding this nature, social enterprises are like non-profit organizations, voluntary groups or non-governmental organizations, however, they are different due to the emphasis on social innovation processes, social entrepreneurship, and the dual goal of gaining social and economic benefits (Kim & Lim, 2017). The authors argue that previously, local and regional development (LRD) was primarily market-centred with various efforts on export-oriented industrialization, public investment, realizing comparative advantages or land reform, but more recently, broader considerations emerged, such as environmental protection. Sustainable LRD, however, has serious obstacles:

1. lack of participation (e.g., by civil communities)
2. lack of will (e.g., in economic organizations)
3. conflictual definitions of sustainable development (e.g., between government organizations and economic organizations)
4. lack of resources and capacities (e.g., of state administrations or companies)
5. lack of cooperation (e.g., between civil society and business). (Kim & Lim, 2017)

Nevertheless, social enterprises could play a beneficial role in solving these problems, mainly based on cooperation and stakeholder engagement, as detailed in Figure 15.

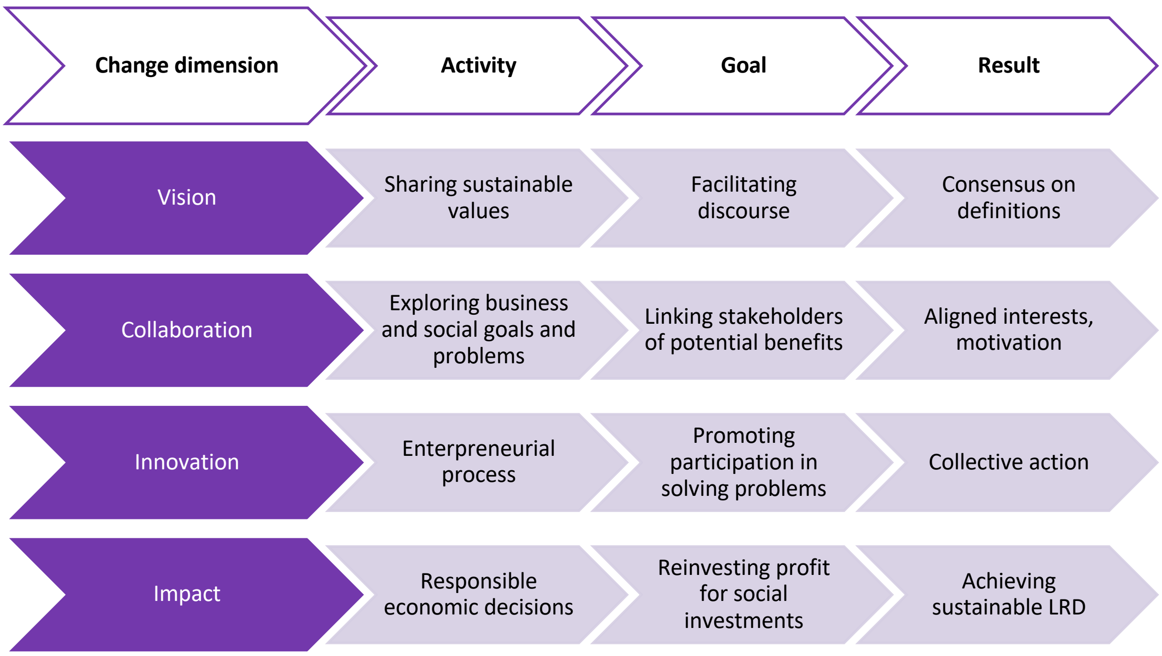

Figure 15. The role of social enterprises in sustainable, local and regional development

Source: authors, based on Kim & Lim, 2017

Table 18 presents the historical and economic insights of the above-presented research in the social and business model innovation and design area, and highlights related strategic and change aspects.

Western Social / Business Model Innovation Research			Perspectives of innovation analysis (examples for insights)			
Authors and aff. country	*Scope of the research*	*Main finding(s) / suggestion(s)*	*History*	*Economy*	*Design*	*Strategy and change*
(Voß, et al., 2009) Germany, UK, Netherlands	**Long-term policy design and transition management**	Policy design and transition management can be a governance or social innovation	After the 1970s, long-term policies became less dominant, but the transition towards sustainable development might induce the return to long-range policy design (p. 276)	In transition management, policy design must not be evaluated only according to narrow techno-economic criteria but broad societal implications (p. 295)	"Design as a process", i.e., policy design is an open-ended process of social innovation (p. 278)	Redesigning transition management is needed according to sustainable development goals (p. 295)
(Lubberink, et al., 2017) Netherlands	**Responsible innovation (RI) in the business context**	Anticipation, reflexivity, inclusion, deliberation, responsiveness and knowledge management are key to RI	Private industry is increasingly seen not only as part of societal problems but the potential developers of solutions (p. 1)	RI must have not only social and environmental impact, but economic as well (p. 2)	Responsiveness for RI could include tailoring products for local needs (p. 16)	Changes in the external environment induce responsive innovation strategies (p. 16)
(Bocken, et al., 2014) UK	**Sustainability and business model innovation**	There are certain sustainable business model archetypes which help to develop a common language for sustainable development	While valuing ecological systems and natural capital is well-known for decades, businesses often disregard the value of natural assets (p. 42)	Western economic models must change fundamentally with a radical reduction in consumption to enable a sustainable future (p. 52)	Design for maximized product life a potential value proposition (p. 46)	Firms can use a sustainable business model archetype to shape their transformation (p. 54)

Cont.

Eastern Social / Business Model Innovation Research			Perspectives of innovation analysis (examples for insights)			
Authors and aff. country	***Scope of the research***	***Main finding(s) / suggestion(s)***	***History***	***Economy***	***Design***	***Strategy and change***
(Bashir & Verma, 2019) India	**Internal factors and consequences of business model innovation (BMI)**	BMI could enhance firm performance and strategic flexibility	BM became an important topic in the early 1990s with the dot com bubble (p. 262)	Low labour economies, such as China or India make vulnerable product and service development to imitation (p. 273), but imitating a new BMI is more difficult	BMI is an alternative to product (or service or process) innovation (p. 274)	Organizational inertia can prevent firms from modifying their BM (p. 269)
(Bashir & Farooq, 2018) India	**Knowledge management (KM) and BMI**	Knowledge sharing between departments, and Chief Knowledge Officers (CKO) could drive BMI	KM is acknowledged to be important for BMI since the success of e-commerce and the transformation challenge of “traditional” brick-and-mortar companies in the early 2000s (p. 363)	Knowledge creation and sharing is the key to sustainable competitive advantage in the knowledge economy (p. 366)	BM is different from product innovation (p. 363); procedures, structures of KM and value capture of BM can be redesigned (p. 365, 366, 370)	BMs need to be reshaped because of a dynamic environment, and not the sensing but the implementation is the most challenging part (p. 375)
(Kim & Lim, 2017) Korea	**Social enterprise and development**	Social enterprises can play a role in social innovation processes, and local and regional development (LRD)	Historically, LRD was focusing on market-driven strategies, emphasizing employment, income, or productivity (p. 1)	Social economy can be seen as a third and independent sector between the market and the state, where social enterprises pursue profit and socio-environmental benefits simultaneously (p. 2-3)	New products derive from social entrepreneurs to solve social problems (p. 3)	The social innovation process can be facilitated by social enterprises through relational assets and collaboration (p. 9-10)

Table 18. Historical and economic aspects of social and business model innovation and design research

Source: authors

3.3.4. Cultural innovation and design

Studies mentioning cultural and/or design innovation are less connected to the higher level economic and transdisciplinary change framework than the studies focusing on the previous innovation areas. Based on the WoS database, there are less than 30 articles on the topic that concern "cultural innovation" or "design innovation". A short overview of the most relevant studies is presented below.

The most cited work in the area of cultural and design innovation is written by Hills et al. (2015). The authors focus on the exploration-exploitation trade-off, but instead of interpreting this dynamic in a business context, they point out its significance in the cognitive search process. They highlight that this tradeoff can be interpreted at individual, group, and social levels, and affects science and cultural innovation as well. From an adaptation perspective, the authors made a similar abstract statement than business scholars often do: "maladaptive states of both individual and group search lie at the extremes of too much exploitation (compulsiveness, perseveration, and groupthink) or too much exploration (impulsiveness, inattentiveness, and failure to leverage social information)" (Hills, et al., 2015, p. 52).

Another approach to cultural innovation is possible by understanding cultural transmissions. Mesoudi and Whiten (2008) focus on three methods used in cultural transmission experiments. The first is the transmission chain method, in which information goes through (and maybe changes) a linear chain of participants. The second is the replacement method, in which participants are gradually moved in and out of groups. The third is the closed-group method, in which group learning is realized without replacement to explore whom people learn from individually or when cultural (collective) learning is present instead of individual learning. (Mesoudi & Whiten, 2008)

The most relevant study from this area is about designing innovation networks. Smart et al. (2007) that inter-organizational innovation networks are useful for technological innovation, as they enable the exploitation of complementary resources. The authors introduce a concept of technological rules about design-oriented knowledge which help effective network building:

1. Design for lifecycle: Concerning the entire product lifecycle during the strategy formulation of a new product development
2. Design for proactive management: Establishment of formal structures and coordinating processes
3. Design for emergence: Encouraging creativity and informal channels
4. Design for diversity: Ensuring heterogeneous experience, skills, and disciplines to cope with development complexity

5. Design for high involvement: Relationship management and connecting people
6. Design for diffusion: Creating practice-based learning opportunities for knowledge transfer
7. Design for strategic innovation portfolio: Coordinating several networks with different purposes. (Smart, et al., 2007)

In case of Eastern research, while "cultural innovation" seems to be a disregarded term, "design innovation" appears in a few cases. Most of these studies, however, rather concern the technical and technological aspects of design innovation instead of product or business development perspectives. For example, Wang et al. (2018) mention design innovation in the context of battery thermal management and safety issues. A similarly narrow-focused mention belongs to the work of Amran et al. (2020), in which the authors review the design aspects of using structural insulated panels for building construction.

The most relevant study, which involves design innovation in its topic, is related to the multi-life cycle (MLC) assessment of sustainable products. Suhariyanto et al. (2017) argue that traditional Life Cycle Assessment (LCA) guidelines are inappropriate for products with multiple life cycles, enabled by new design approaches and/or technologies. Accordingly, MLC products can be developed by design innovation or technological innovation. Table 19 shows how design innovation and technological innovation can contribute to MLC product development.

Phase	First life cycle	New life cycle by design innovation	New product generation by technological innovation
1	Raw material extraction	***Recycling and material processing***	***New technology for recovered materials***
2	Manufacturing	***Remanufacturing***	Manufacturing
3	Distribution	Distribution	Distribution
4	Use	Use	Use
5	End-of-life / New life cycle	End-of-life / New life cycle	End-of-life / New life cycle

Table 19. Design innovation and technological innovation of multi-life-cycle products

Source: authors, based on Suhariyanto et al., 2017

Table 20 presents the historical and economic insights of the above-presented research in the social and business model innovation and design area, and highlights related strategic and change aspects.

Western Cultural and Design Innovation Research			Perspectives of innovation analysis (examples for insights)			
Authors and aff. country	*Scope of the research*	*Main finding(s) / suggestion(s)*	*History*	*Economy*	*Design*	*Strategy and change*
(Hills, et al., 2015) UK, USA, Germany	**Exploration and exploitation in cognitive search processes**	Search problems and solutions affect problem-solving, memory, scientific and cultural innovation	The trade-off between exploitation and exploration has been reflected in numerous research fields, e.g., using existing knowledge versus seeking new knowledge in social learning (p. 47)	Cognitive systems and the exploitation-exploration trade-off can be relevant in case of social innovation (p. 46)	Exploitation and exploration patterns can be differentiated in case of visual search as well (p. 47) which can affect product design (p. 46)	Too much exploitation or exploration can lead to inadequate responses in a given environment (p. 52)
(Mesoudi & Whiten, 2008) UK	**Cultural transmission methods**	The replacement method is applicable to studying cultural innovation	Accumulating cultural innovations in successive generations means learning and adding new cultural knowledge by each generation (p. 3494)	In an economic game, generating stable behavioural conventions are rather possible through verbal or written instructions compared to observation (p. 3497)	Design activities might be affected by social learning mechanisms (learning, teaching, language) (p. 3489)	Cultural transmission could be more important compared to individual learning and genetic evolution when changes in the environment are too rapid (p. 3490)
(Smart, et al., 2007) UK	**Designing innovation networks**	Certain technological rules based on design-based knowledge allow forming efficient networks	Traditionally, the resource-based view of the firm assumed that the source innovation should be searched within the boundary of a single firm (p. 1071)	Hypercompetitive and global business environments force(d) companies to develop critical capabilities for product/service renewal (p. 1070)	The discipline of management is a "design science", thus design-oriented knowledge is needed, which is grounded, field-tested, and actionable (p. 1072)	Networks are continuously evolving, and could pursue both incremental and discontinuous change (p. 1077)

Cont.

Eastern Cultural and Design Innovation Research			Perspectives of innovation analysis (examples for insights)			
Authors and aff. country	***Scope of the research***	***Main finding(s) / suggestion(s)***	***History***	***Economy***	***Design***	***Strategy and change***
(Wang, et al., 2018) China	**Battery thermal management (BTM) and safety**	BTM system research should focus on enhanced safety and optimal working temperature range	Green energy vehicles with batteries become more and more important as countries announce deadlines for fossil-fuelled vehicles (p. 4009)	BTM safety is critical to avoid socioeconomic loss (e.g., because of damages from fire or explosion) (p. 4022)	Thermo-safe design innovation of batteries is needed concerning cells, modules, packs, and related systems and controls (p. 4008, 4009)	Technological innovation is challenged by the goal of preventing and mitigating environmental harms (in the automobile industry) (p. 4008)
(Amran, et al., 2020) Saudi Arabia, Malaysia, India, Russia	**Structural insulated panels for construction (SIP)**	Fabrication of SIPs has been developed recently and performed well over the years	SIPs were developed during the 1930s to design and fabricate sandwich panels (p. 1358)	Insulation systems of buildings must be in line with not only technical aspects (e.g., thermal insulation) but environmental and economic aspects (p. 1365)	Design efficiency and thermal performance can be increased in case of current SIP applications (p. 1359)	From a local idea (SIP in the UK), the solution was increasingly manufactured by designers and builders, with novel elements over time (p. 1375)
(Suhariyanto, et al., 2017) Malaysia	**Multi-Life Cycle Assessment (MLCA) for sustainable products**	MLCA perspectives should be explored in case of products with multiple possible life cycles	The rate and direction of technological changes are traditionally seen as an influential factor in environmental impacts (p. 679)	Design for Sustainability can contribute to environmental, social and also economic advantages as companies could increase profits through material reductions and attracting a new customer base (p. 678)	Design innovation is one tool to generate multiple life cycle products, by reusing, remanufacturing, and recycling without disassembly, redesigning, or upgrading (p. 678)	The MLC product system would mean cradle-to-cradle design, encourage multi-generation products, and change the broader environmental performance (p. 694)

Table 20. Historical and economic aspects of cultural innovation and design research

Source: authors

4. Conclusions

4.1. MQ I: The relevance of the focal innovation and design areas

The first main research question was the following:

> Are the pre-defined innovation areas indeed relevant based on the literature?

Based on quantitative and qualitative SLR data, the pre-defined innovation areas are relevant, but to varying extents. The focal innovation areas can belong to heterogenous research fields (there were 44 related fields even in case of the top 100 reviews), but the main fields are Business and Management, Economics, Engineering, Environmental and Sustainable Science. Based on the top 100 highly-cited reviews of the focal areas, eco-innovation and technological innovation is the main areas where Western and Eastern institutes work together, while social and business model innovation did not induce such influential collaborative works until now.

4.2. MQ II: Similarities and differences in East/West context

The second main research question was the following:

> What similarities and differences could be identified in the East-West dichotomy regarding the dominant research in the focal innovation and design areas?

Western research seems to be overrepresented in every innovation area, based on the 100 most-cited review papers. Technological innovation, eco-innovation, social innovation, and business model innovation are the most dominant topics of the international literature, regarding both Eastern and Western research. The dominance of technological innovation is present in Eastern and Western research as well. In contrast, energy innovation, design innovation, and mainly cultural innovation are similarly underrepresented topics. Regarding the differences, Western eco-innovation reviews are more influential than Western social and business model innovation reviews, while Eastern research is uniformly less influential in these areas.

Detailed answers are presented based on the sub-questions.

4.2.1. SQ 1: Ecological and energy innovation

The first sub-question was the following:

> What similarities and differences could be identified regarding the dominant ecological and energy innovation and design research?

The most relevant Eastern and Western reviews are similar regarding the historical aspects, as they often mention the Brundtland report from 1987 and the gradually increasing scientific, social and industrial attention toward environmental sustainability. Regarding economic aspects, circular economy development is clearly considered to be the main driver of eco-innovation, regardless of the affiliation countries. Eco-design is also unequivocally mentioned as a tool for eco-innovation. No significant differences are apparent in this innovation area.

4.2.2. SQ 2: Technological innovation

The second sub-question was the following:

> What similarities and differences could be identified regarding the dominant technological innovation and design research?

In terms of the significance of technological innovation, the most relevant Eastern and Western reviews seem to be in line with each other (i.e., a tool for environmental adaptation and economic development). There is a difference, however, about how the most-cited works approach this topic. While most relevant Western reviews clearly focus on how to produce technological innovations in a business context (e.g., strategic ambidexterity, limiting process management, facilitating open innovations, introducing supporting policies), there are more technological specifics among the most-cited Eastern review papers (e.g., machine learning (ML), artificial intelligence (AI)). Accordingly, the historical and economic aspects of these topics are different. For example, Western general business and management studies highlight technological cycles, entry barriers or even to Schumpeter's thoughts from 1934, while Eastern ML and AI research reach back to the diffusion of personal computers to the 1970s-1980s.

4.2.3. SQ 3: Social and business model innovation

The third sub-question was the following:

> What similarities and differences could be identified regarding the dominant social and business model innovation and design research?

The most relevant reviews are similar in the meaning of business model innovation and social innovation, however, and there are also similarities regarding the key topics of this area (e.g., the role of policymaking in case of transition management or local and regional planning). Nevertheless, while the most relevant Eastern studies interconnect business model innovation with internal factors (e.g., knowledge management or organizational inertia), the most relevant Western review follows rather an external approach (sustainable business models). Regarding social innovation, the most cited reviews were written by authors of Western institutions.

4.2.4. SQ 4: Cultural innovation

The fourth sub-question was the following:

> What similarities and differences could be identified regarding the dominant cultural innovation and design research?

Highly cited Eastern and Western reviews mostly disregard the topic of cultural innovation compared to other focal innovation areas, however, there are at least a few studies which are more or less relevant in case of Western research. These are focusing on cognitive search processes and cultural transmission. In case of the design innovation, Eastern and Western research are similar in terms of the rareness of relevant design innovation reviews. The selected Western review approaches design-based knowledge from the business and management field (i.e., innovation networks), while the Eastern one would like to encourage sustainable product development (by a multi-life-cycle analysis method).

4.3. MQ III: Initial directions of recommendations from the transdisciplinary and the dynamic capabilities perspective

The third main research question was the following:

> How can one (re-)interpret the influential thoughts of these innovation and design areas from key theoretical perspectives of strategy and change to support policymaking?

Based on the (re-)interpretation of the literature, transdisciplinary research and development, and dynamic capabilities are both relevant approaches to innovation and design-related strategic change.

Details of the (re-)interpretation opportunities of studies are presented in Table 21.

Area	Transdisciplinarity	Dynamic capabilities
Ecological innovation and design	- Eco-innovation by innovation ecosystem building - Developing shared meanings by taxonomy development, involving stakeholders - Building partnerships for radical innovation and eco-design	- Developing strategic sustainability behaviour - Reconfiguration of business models in line with the circular economy strategies - Introducing eco-processes, e.g., by cleaner production technologies, and eco-organization development, e.g., by an environmental management system
Techno-logical innovation and design	- Leveraging external resources through open innovation - Developing and communicating clear policies, promoting certain sectors and clusters - Combining interfirm capabilities by alliances, managerial ties, clusters	- Managing strategic ambidexterity by emphasized or limited process management - Enabling flexible structure, interacting between units, empowerment, organizational culture development - Initiating organizational changes focusing on systems, culture, capabilities, learning, managerial attitudes
Social and business model innovation and design	- Transition management with broad societal discourse, inclusivity, and co-production of solutions, according to broad techno-economic and societal aspects - Responsible innovation based on stakeholder values, continuous engagement and negotiations	- Aligning business strategy with impact vision, cultural change for employee empowerment, resource allocation to enable networking, preventing organizational inertia - Establishing social enterprises for supporting local and regional development
	- Building sustainable business models according to technological, social, or organizational archetypes	- Business model innovation by improved knowledge management and reducing organizational inertia
Cultural innovation and design; design innovation	- Balancing exploitative and explorative search patterns to increase the efficiency of problem-solving - Driving cultural transmission, i.e., information exchange between generations when individual learning is too slow compared to the pace of environmental changes	- Managing continuously evolving networks to pursue incremental and discontinuous change - Introducing a multi-life-cycle product system with cradle-to-cradle design and multi-generation products

Table 21. Suggestions based on the literature for strategic change in the focal innovation areas, from the transdisciplinary and the dynamic capabilities perspectives

Source: authors

Besides, three influential thoughts could be highlighted which can be unexpected but universally relevant for decision-makers:

1. Sustainability-oriented innovations for circular economy development[20], cleaner production or eco-efficiency[21] need not only eco-design but sustainability-rooted organizational behavior. However, this behavior cannot be based on a simple "switch" of the business model but on reaching different phases. Policymakers can provide activating and motivating external stimulus to change the *resistant* state into *reactive* and *anticipatory*, moreover, support capability building to reach the *innovation-based* and *sustainability-rooted* state. (Klewitz & Hansen, 2014)
2. In contrast to the frequent industrial and institutional practice which emphasizes operational efficiency and productivity efforts for decades and still nowadays, process management can be even counterproductive and build resistance to change in a technologically complex context. When incremental innovation is not enough, and radical innovation would be needed, limiting process management could be important to accelerate exploration instead of exploitation. (Benner & Tushman, 2003)
3. Ecological and technological aspects, should not be argued only separately, but with an integrative approach based on business models, as it must go beyond the value proposition. For this purpose, technology-based sustainable business model archetypes can drive the transformation of organizations (e.g., creating value from waste or minimizing material use). (Bocken, et al., 2014)

4.4. Limitations and next phase

Based on the results and the conclusion, the following limitations must be highlighted which can orient the next phase:

1. This work aimed to explore what Eastern and Western topics and thoughts might be influential in the focal innovation areas *globally as a theoretical foundation*, and *not* what research topics are the most popular *in concrete Eastern and Western contexts*. The latter task belongs to the next phase, i.e., identifying change drivers and mapping.
2. Based on the appearance and relevance of innovation sub-areas, the categorization of the innovation areas might be fine-tuned. For example, given the importance of social innovation

[20] By maintaining, reusing, recycling (Saidani, et al., 2019)
[21] For lower economic impact or economic gains (Klewitz & Hansen, 2014)

and business model innovation (both deriving from the socio-economic pillar of future potentials), they could be discussed separately or combine social innovation with ecological innovation within a “sustainable-oriented innovation” category which can cover ecological and social aspects as well. Another opportunity is to develop a matrix of pillars and innovation areas in the next phase, instead of pairing them.

3. As cultural innovation and design innovation (in a cultural sense) seem to be truly overlooked in case of innovation and design research, a deeper analysis of this area might be practical and also theoretically contributing, e.g., it could be the main topic of the scientific article.
4. Even though differences could be also outlined in the East-West context, the in-depth analysis revealed more similarities. It could be because of the nature of this meta-review, i.e., review papers are likely to provide more general understandings, and slight differences might emerge based on the specific sub-topic selection. Consequently, the next phase could focus on certain countries as “frontiers” of innovation and design horizons from the perspective of Hungary, V4, and the Carpathian basin. Accordingly, besides the most “Western” and “Eastern” countries, USA and China, other economically prospering but culturally distinctive countries are worth focusing on, for example, Israel, Japan, South Korea, and India.

5. Appendix

Top 100 highly-cited reviews in the four focal innovation and design areas from 2000, with East-West categorization based on the affiliation countries, ordered according to the number of citations

Authors	Article Title	Times Cited, WoS	Year	Search Category	Author Country	East/ West
Benner, MJ; Tushman, ML	Exploitation, exploration, and process management: The productivity dilemma revisited	2189	2003	Technological innovation	USA	West
Bocken, NMP; Short, SW; Rana, P; Evans, S	A literature and practice review to develop sustainable business model archetypes	1489	2014	Social and business model innovation	England	West
Crossan, MM; Apaydin, M	A Multi-Dimensional Framework of Organizational Innovation: A Systematic Review of the Literature	1403	2010	Technological innovation	England; Egypt	Global
West, J; Bogers, M	Leveraging External Sources of Innovation: A Review of Research on Open Innovation	928	2014	Technological innovation	Denmark	West
Klewitz, J; Hansen, EG	Sustainability-oriented innovation of SMEs: a systematic review	621	2014	Ecological and energy innovation	Germany	West
Chapman, L	Transport and climate change: a review	603	2007	Technological innovation	England	West
Mirabella, N; Castellani, V; Sala, S	Current options for the valorization of food manufacturing waste: a review	572	2014	Ecological and energy innovation	Italy	West
Agarwal, R; Echambadi, R; Franco, AM; Sarkar, MB	Knowledge transfer through inheritance: Spinout generation, development, and survival	535	2004	Technological innovation	USA	West
Becheikh, N; Landry, R; Amara, N	Lessons from innovation empirical studies in the manufacturing sector: A systematic review of the literature from 1993-2003	511	2006	Technological innovation	Canada	West
Cardinal, LB	Technological innovation in the pharmaceutical industry: The use of organizational control in managing research and development	491	2001	Technological innovation	USA	West
McEvily, SK; Chakravarthy, B	The persistence of knowledge-based advantage: An empirical test for product performance and technological knowledge	440	2002	Technological innovation	USA; Switzerland	West
Qu, XL; Brame, J; Li, QL; Alvarez, PJJ	Nanotechnology for a Safe and Sustainable Water Supply: Enabling Integrated Water Treatment and Reuse	399	2013	Technological innovation	USA	West
Ghobakhloo, M	Industry 4.0, digitization, and opportunities for sustainability	389	2020	Social and business model innovation	Iran	East
Winans, K; Kendall, A; Deng, H	The history and current applications of the circular economy concept	384	2017	Social and business model innovation	USA	West

Geissdoerfer, M; Vladimirova, D; Evans, S	Sustainable business model innovation: A review	382	2018	Social and business model innovation	England; USA	West
Boyjoo, Y; Sun, HQ; Liu, J; Pareek, VK; Wang, SB	A review on photocatalysis for air treatment: From catalyst development to reactor design	351	2017	Ecological and energy innovation	Australia	West
Sheremata, WA	Centrifugal and centripetal forces in radical new product development under time pressure	332	2000	Technological innovation	USA	West
Avlonitis, GJ; Papastathopoulou, PG; Gounaris, SP	An empirically-based typology of product innovativeness for new financial services: Success and failure scenarios	329	2001	Technological innovation	Greece	West
Pieroni, MPP; McAloone, TC; Pigosso, DCA	Business model innovation for circular economy and sustainability: A review of approaches	329	2019	Social and business model innovation	Denmark	West
Saidani, M; Yannou, B; Leroy, Y; Cluzel, F; Kendall, A	A taxonomy of circular economy indicators	321	2019	Ecological and energy innovation	USA	West
de Medeiros, JF; Ribeiro, JLD; Cortimiglia, MN	Success factors for environmentally sustainable product innovation: a systematic literature review	308	2014	Ecological and energy innovation	Brasil	Other
Prajogo, DI; Ahmed, PK	Relationships between innovation stimulus, innovation capacity, and innovation performance	307	2006	Technological innovation	England	West
Hojnik, J; Ruzzier, M	What drives eco-innovation? A review of an emerging literature	304	2016	Ecological and energy innovation	Slovenia	West
Janssen, S; van Ittersum, MK	Assessing farm innovations and responses to policies: A review of bio-economic farm models	294	2007	Technological innovation	Netherlands	West
Bossle, MB; de Barcellos, MD; Vieira, LM; Sauvee, L	The drivers for adoption of eco-innovation	285	2016	Ecological and energy innovation	Brazi; France	Global
Voss, JP; Smith, A; Grin, J	Designing long-term policy: rethinking transition management	267	2009	Social and business model innovation	Germany; England; Netherlands	West
Galli, P; Vecellio, G	Technology: driving force behind innovation and growth of polyolefins	264	2001	Technological innovation	Italy	West
Hills, TT; Todd, PM; Lazer, D; Redish, AD; Couzin, ID	Exploration versus exploitation in space, mind, and society	242	2015	Cultural and design innovation	England; USA; Germany	West
Chauhan, BS; Mahajan, G; Sardana, V; Timsina, J; Jat, ML	PRODUCTIVITY AND SUSTAINABILITY OF THE RICE-WHEAT CROPPING SYSTEM IN THE INDO-GANGETIC PLAINS OF THE INDIAN SUBCONTINENT: PROBLEMS, OPPORTUNITIES, AND STRATEGIES	234	2012	Technological innovation	India	East
Bercovitz, JEL; Feldman, MP	Fishing upstream: Firm innovation strategy and university research alliances	222	2007	Technological innovation	USA	West

Diaz-Garcia, C; Gonzalez-Moreno, A; Saez-Martinez, FJ	Eco-innovation: insights from a literature review	222	2015	Ecological and energy innovation	Spain	West
Kyriakopoulos, K; Moorman, C	Tradeoffs in marketing exploitation and exploration strategies: The overlooked role of market orientation	218	2004	Technological innovation	Netherlands; USA	West
Colombo, MG; Grilli, L; Piva, E	In search of complementary assets: The determinants of alliance formation of high-tech start-ups	217	2006	Technological innovation	Italy	West
Mesoudi, A; Whiten, A	The multiple roles of cultural transmission experiments in understanding human cultural evolution	200	2008	Cultural and design innovation	England; Scotland	West
Qi, GY; Zeng, SX; Tam, CM; Yin, HT; Zou, HL	Stakeholders' Influences on Corporate Green Innovation Strategy: A Case Study of Manufacturing Firms in China	199	2013	Ecological and energy innovation	China	East
Wiggins, RR; Ruefli, TW	Sustained competitive advantage: Temporal dynamics and the incidence and persistence of superior economic performance	198	2002	Technological innovation	USA	West
Calabro, A; Vecchiarini, M; Gast, J; Campopiano, G; De Massis, A; Kraus, S	Innovation in Family Firms: A Systematic Literature Review and Guidance for Future Research	191	2019	Technological innovation	France; Germany; Italy; England	West
Khan, F; Ahmad, SR	Polysaccharides and Their Derivatives for Versatile Tissue Engineering Application	181	2013	Technological innovation	Scotland; England	West
Dushnitsky, G; Shaver, JM	LIMITATIONS TO INTERORGANIZATIONAL KNOWLEDGE ACQUISITION: THE PARADOX OF CORPORATE VENTURE CAPITAL	180	2009	Technological innovation	USA	West
Zhang, ZY; Dong, YJ; Li, F; Zhang, ZM; Wang, HT; Huang, XJ; Li, H; Liu, B; Wu, XX; Wang, H; Diao, XZ; Zhang, HQ; Wang, JH	The Shandong Shidao Bay 200 MWe High-Temperature Gas-Cooled Reactor Pebble-Bed Module (HTR-PM) Demonstration Power Plant: An Engineering and Technological Innovation	170	2016	Technological innovation	China	East
Tarrant, MK; Cole, PA	The Chemical Biology of Protein Phosphorylation	169	2009	Technological innovation	USA	West
Ali, S; Champagne, DL; Spaink, HP; Richardson, MK	Zebrafish Embryos and Larvae: A New Generation of Disease Models and Drug Screens	165	2011	Technological innovation	Netherlands	West
Sudakaran, S; Kost, C; Kaltenpoth, M	Symbiont Acquisition and Replacement as a Source of Ecological Innovation	163	2017	Ecological and energy innovation	Germany; USA	West
Surrs, RAA; Hekkert, MP	Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands	161	2009	Technological innovation	Netherlands	West
King, DR; Slotegraaf, RJ; Kesner, I	Performance implications of firm resource interactions in the acquisition of R&D-intensive firms	156	2008	Technological innovation	USA	West

Hienerth, C	The commercialization of user innovations: the development of the rodeo kayak industry	156	2006	Technological innovation	Austria	West
Bogers, M; West, J	Managing Distributed Innovation: Strategic Utilization of Open and User Innovation	153	2012	Technological innovation	Denmark	West
Hudry, E; Vandenberghe, LH	Therapeutic AAV Gene Transfer to the Nervous System: A Clinical Reality	151	2019	Technological innovation	USA	West
del Rio, P; Penasco, C; Romero-Jordan, D	What drives eco-innovators? A critical review of the empirical literature based on econometric methods	150	2016	Ecological and energy innovation	Spain	West
Nussholz, JLK	Circular Business Models: Defining a Concept and Framing an Emerging Research Field	149	2017	Social and business model innovation	Sweden	West
Gallagher, KS; Grubler, A; Kuhl, L; Nemet, G; Wilson, C	The Energy Technology Innovation System	146	2012	Ecological and energy innovation	USA; England	West
Xu, LZ; Shyu, TC; Kotov, NA	Origami and Kirigami Nanocomposites	144	2017	Technological innovation	USA	West
von Keyserlingk, MAG; Martin, NP; Kebreab, E; Knowlton, KF; Grant, RJ; Stephenson, M; Sniffen, CJ; Harner, JR; Wright, AD; Smith, SI	Invited review: Sustainability of the US dairy industry	144	2013	Technological innovation	Canada; USA	West
Karakaya, E; Hidalgo, A; Nuur, C	Diffusion of eco-innovations: A review	144	2014	Ecological and energy innovation	Spain; Sweden	West
Li, X; Wu, P; Shen, GQP; Wang, XY; Teng, Y	Mapping the knowledge domains of Building Information Modeling (BIM): A bibliometric approach	143	2017	Technological innovation	China; Australia	Global
de Jesus, A; Antunes, P; Santos, R; Mendonca, S	Eco-innovation in the transition to a circular economy: An analytical literature review	140	2018	Ecological and energy innovation	Portugal; England	West
Swink, M; Nair, A	Capturing the competitive advantages of AMT: Design-manufacturing integration as a complementary asset	137	2007	Technological innovation	USA; Columbia	Global
Cillo, V; Petruzzelli, AM; Ardito, L; Del Giudice, M	Understanding sustainable innovation: A systematic literature review	137	2019	Social and business model innovation	Italy	West
Sheth, RU; Cabral, V; Chen, SP; Wang, HH	Manipulating Bacterial Communities by in situ Microbiome Engineering	135	2016	Technological innovation	USA	West
Graf, BL; Rojas-Silva, P; Rojo, LE; Delatorre-Herrera, J; Baldeon, ME; Raskin, I	Innovations in Health Value and Functional Food Development of Quinoa (Chenopodium quinoa Willd.)	135	2015	Technological innovation	USA; Chile; Equador	Global
Capaldo, A; Petruzzelli, AM	Partner Geographic and Organizational Proximity and the Innovative Performance of Knowledge-Creating Alliances	134	2014	Technological innovation	Italy	West

Macia, E	Exploiting aperiodic designs in nanophotonic devices	132	2012	Technological innovation	Spain	West
Geissdoerfer, M; Pieroni, MPP; Pigosso, DCA; Soufani, K	Circular business models: A review	132	2020	Social and business model innovation	England; Denmark	West
Blackman, S; Matlo, C; Bobrovitskiy, C; Waldoch, A; Fang, ML; Jackson, P; Mihailidis, A; Nygard, L; Astell, A; Sixsmith, A	Ambient Assisted Living Technologies for Aging Well: A Scoping Review	129	2016	Technological innovation	Canada; Sweden; England	West
Barbieri, N; Ghisetti, C; Gilli, M; Marin, G; Nicolli, F	A SURVEY OF THE LITERATURE ON ENVIRONMENTAL INNOVATION BASED ON MAIN PATH ANALYSIS	129	2016	Ecological and energy innovation	Italy; France	West
Mangaroska, K; Giannakos, M	Learning Analytics for Learning Design: A Systematic Literature Review of Analytics-Driven Design to Enhance Learning	128	2019	Technological innovation	Norway	West
Mueller, V; Rosenbusch, N; Bausch, A	Success Patterns of Exploratory and Exploitative Innovation: A Meta-Analysis of the Influence of Institutional Factors	128	2013	Technological innovation	Germany; Canada	West
Limb, CJ; Roy, AT	Technological, biological, and acoustical constraints to music perception in cochlear implant users	128	2014	Technological innovation	USA	West
Lubberink, R; Blok, V; van Ophem, J; Omta, O	Lessons for Responsible Innovation in the Business Context: A Systematic Literature Review of Responsible, Social and Sustainable Innovation Practices	128	2017	Social and business model innovation	Netherlands	West
Schmid, O; Padel, S; Levidow, L	The Bio-Economy Concept and Knowledge Base in a Public Goods and Farmer Perspective	128	2012	Social and business model innovation	England	West
Lubberink, R; Blok, V; van Ophem, J; Omta, O	Lessons for Responsible Innovation in the Business Context: A Systematic Literature Review of Responsible, Social and Sustainable Innovation Practices	128	2017	Ecological and energy innovation	Netherlands	West
Jordaan, SM; Romo-Rabago, E; McLeary, R; Reidy, L; Nazari, J; Herremans, IM	The role of energy technology innovation in reducing greenhouse gas emissions: A case study of Canada	127	2017	Ecological and energy innovation	USA; Canada	West
Zhao, DX; He, BJ; Johnson, C; Mou, B	Social problems of green buildings: From the humanistic needs to social acceptance	127	2015	Ecological and energy innovation	China; Japan	Global
Smol, M; Kulczycka, J; Avdiushchenko, A	Circular economy indicators in relation to eco-innovation in European regions	127	2017	Ecological and energy innovation	Poland; Ukraine	Global
Ketata, I; Sofka, W; Grimpe, C	The role of internal capabilities and firms' environment for sustainable innovation: evidence for Germany	124	2015	Ecological and energy innovation	USA; Denmark	West
Pacheco, DAD; ten Caten, CS; Jung, CF; Ribeiro, JLD; Navas, HVG; Cruz-Machado, VA	Eco-innovation determinants in manufacturing SMEs: Systematic review and research directions	123	2017	Ecological and energy innovation	Brasil; Portugal	Global

Luca, F; Perry, GH; Di Rienzo, A	Evolutionary Adaptations to Dietary Changes	120	2010	Cultural and design innovation	USA	West
Edwards-Schachter, ME; Matti, CE; Alcantara, E	Fostering Quality of Life through Social Innovation: A Living Lab Methodology Study Case	119	2012	Social and business model innovation	Spain	West
Choi, SB; Park, BI; Hong, P	Does Ownership Structure Matter for Firm Technological Innovation Performance? The Case of Korean Firms	118	2012	Technological innovation	South Korea	Other
MacVaugh, J; Schiavone, F	Limits to the diffusion of innovation A literature review and integrative model	118	2010	Technological innovation	England; Italy	West
Li, FGN; Trutnevyte, E; Strachan, N	A review of socio-technical energy transition (STET) models	117	2015	Technological innovation	England; Switzerland	West
Tariq, A; Badir, YF; Tariq, W; Bhutta, US	Drivers and consequences of green product and process innovation: A systematic review, conceptual framework, and future outlook	116	2017	Technological innovation	Thailand; Pakistan, China	East
Hossain, M; Leminen, S; Westerlund, M	A systematic review of living lab literature	116	2019	Social and business model innovation	England; Finland; Canada	West
Polzin, F	Mobilizing private finance for low-carbon innovation - A systematic review of barriers and solutions	116	2017	Ecological and energy innovation	Netherlands	West
Shane, SA; Ulrich, KT	Technological innovation, product development, and entrepreneurship in Management Science	115	2004	Technological innovation	USA	West
Wang, HL; Li, JT	Untangling the effects of overexploration and overexploitation on organizational performance: The moderating role of environmental dynamism	115	2008	Technological innovation	China	East
Nicoll, K	Recent environmental change and prehistoric human activity in Egypt and Northern Sudan	115	2004	Technological innovation	England	West
Steensen, S	ONLINE JOURNALISM AND THE PROMISES OF NEW TECHNOLOGY A critical review and look ahead	114	2011	Technological innovation	Norway	West
Belloc, F	CORPORATE GOVERNANCE AND INNOVATION: A SURVEY	112	2012	Technological innovation	Italy	West
Grawe, SJ	Logistics innovation: a literature-based conceptual framework	110	2009	Technological innovation	USA	West
Hou, TY; Chuan, CN; Teng, SH	Current status of MALDI-TOF mass spectrometry in clinical microbiology	110	2019	Technological innovation	Taiwan	East
Fincheira, P; Quiroz, A	Microbial volatiles as plant growth inducers	110	2018	Technological innovation	Chile	Other
Leal, W; Ellams, D; Han, S; Tyler, D; Boiten, VJ; Paco, A; Moora, H; Balogun, AL	A review of the socio-economic advantages of textile recycling	106	2019	Ecological and energy innovation	Germany; England; Portugal; Estonia; Malaysia	Global
Ghisellini, P; Ji, X; Liu, GY; Ulgiati, S	Evaluating the transition towards cleaner production in the construction and demolition sector of China: A review	105	2018	Ecological and energy innovation	Italy; China	Global

Sulpizio, JA; Ilani, S; Irvin, P; Levy, J	Nanoscale Phenomena in Oxide Heterostructures	104	2014	Technological innovation	Israel; USA	West
Mariani, M; Borghi, M	Industry 4.0: A bibliometric review of its managerial intellectual structure and potential evolution in the service industries	103	2019	Social and business model innovation	England	West
Tao, QL; Xu, PC; Li, MJ; Lu, WC	Machine learning for perovskite materials design and discovery	98	2021	Technological innovation	China	East
Qian, QH; Lin, P	Safety risk management of underground engineering in China: Progress, challenges and strategies	98	2016	Technological innovation	China	East
Chen, LJ; Chen, PP; Lin, ZJ	Artificial Intelligence in Education: A Review	98	2020	Technological innovation	China	East
Stock, GN; Tatikonda, MV	A typology of project-level technology transfer processes	97	2000	Technological innovation	USA	West

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