ABSTRACT

of the dissertation of Alexander Neske "Managing Sustainability-Related Complexity in Supply Chains: A Capability-Based Managerial Framework for Organizational Response", submitted for the degree of Doctor of Philosophy (PhD) in the educational programme "8D04101– Management"

Relevance of the research topic. Amid the accelerated transformation of global markets, supply chains have become the principal object of regulation in the field of sustainable development. The requirements placed on organizations have become numerous, heterogeneous in origin, unstable over time and, which is of fundamental importance, evidence-based: compliance must not be declared but confirmed by verifiable data at several tiers of the value chain. Acts of the European Union, documents of the Organisation for Economic Co-operation and Development and the Standards of the Global Reporting Initiative (GRI) establish the shift from voluntary disclosure of information to mandatory due diligence and verifiable reporting. Sustainability thereby ceases to be a matter of reputation and becomes a matter of the governability of the organization and of its supply chain.

For the Republic of Kazakhstan this set of problems acquires particular significance, since environmental and regulatory pressure is concentrated in several complex, emission- and water-intensive industries. The oil and gas sector accounts for approximately 17 % of gross domestic product and for about half of total exports, whereas non-ferrous metallurgy and the agro-industrial complex form extended multi-tier value chains with a substantial environmental impact. The Environmental Code of 2021 extends the regime of best available techniques and integrated environmental permits to the 50 largest industrial facilities of the country, which together account for about 80 % of environmental pollution, and this points to substantial ESG gaps in the upper tiers of many supply chains.

A further factor of vulnerability is the state of water resources. Total renewable water resources are estimated at approximately 108.5 km³ per year, of which about 41.9 % are available, while between 34 and 44 km³ per year are formed beyond the national borders. Agriculture alone withdraws between 15.4 and 24 km³ per year, 78 % of which is directed to irrigation. This heightens risks in agribusiness and in water-intensive processing and transfers them into the supply chains of export-oriented companies.

In the external environment, the Carbon Border Adjustment Mechanism of the European Union (CBAM) raises competitiveness risks for emission-intensive exports wherever systems for the measurement, reporting and verification of emissions are absent. Aluminium production accounts for practically the entire volume of Kazakhstani exports to the European Union that fall under CBAM, and about 30 % of aluminium exports are directed to the market of the European Union. Germany, which is a significant sales market, has transformed expectations in the field of supply chain sustainability into mandatory due diligence requirements (the Supply Chain Due Diligence Act) and into the detailed requirements of the European Sustainability Reporting Standards. These requirements cascade to suppliers up the chain, including suppliers from Kazakhstan.

The consequence is a managerial contradiction. Companies are expected to document, verify and coordinate sustainability measures at several tiers of the supply chain, while the composition of the requirements differs depending on the counterparty and changes with

every regulatory cycle. At the same time, no organization is able to process the entire volume of these requirements with the resources available to it. Management is compelled to make choices: which external pressures to make visible, which response measures to make executable, and which forms of inter-firm interaction to use instead of building up its own internal capabilities.

The existing conceptual frameworks of sustainable supply chain management describe what such management should comprise, yet they give little indication of how organizations make this choice, how they stabilize it in routines, roles and evidence practices, and how the resulting outcome can be verified. In Kazakhstan, ESG expectations are growing faster than the institutional conditions, the databases and the assurance infrastructure required to produce evidence of verifiable quality are being formed. As a result, companies and authorized bodies have no model indicating in which sequence and along which route the corresponding capabilities should be built up.

A gap is thus formed between the volume of the requirements imposed and the volume of requirements that an organization is able to process. This gap has not only a practical but also a theoretical dimension: it defines the scientific problem of the dissertation research.

The unresolved state of this problem entails direct economic consequences. The absence of a governable and verifiable response raises coordination costs in supply chains, limits the access of Kazakhstani exporters to markets with a high density of requirements, reduces the effectiveness of investments in modernization and moves environmental risks into the category of market risks. In this context, sustainability-related complexity acts not as a particular problem of corporate reporting but as a systemic constraint on the competitiveness of the national economy.

The scientific problem of the research consists in the absence of a mechanism-level explanation and of a management-oriented model of how organizations in supply chains convert sustainability requirements that are heterogeneous in origin, unstable over time and evidence-dependent into an executable and auditable portfolio of capabilities, and of how institutional conditions — enforcement, assurance density and data maturity — alter the response route that is realized. The literature on sustainable supply chain management explains drivers, practices and expected outcomes, and the literature on disclosure explains reporting quality and its determinants; however, neither of these strands reveals the mechanism of selecting, configuring and stabilizing response capabilities, nor its connection with observable outcomes.

The position of the author is that sustainability-related complexity in supply chains constitutes a problem of choice rather than a problem of compliance. An organization retains the ability to act under growing pressure when it builds internal complexity in the form of packed capabilities in the domains of Strategy, People, Process and Technology sufficient to absorb the external complexity that it selects as material. The choice between building this complexity up inside the organization and absorbing it through mechanisms of collaboration is determined by two conditions of the organizational field: the degree to which sustainability issues are interpreted through shared standards, and the degree of development of the inter-firm verification infrastructure. Sustainability communication may precede embedded practice and, under transitional institutional conditions, is interpreted as a possible stage of capability development rather than as evidence of decoupling. A management model intended to resolve this problem must be evaluated by auditable outcomes — time-to-mitigation, the

coverage of supply chain tiers by evidence of verifiable quality, and coordination cost per unit of covered spend — and not by the number of practices an organization declares.

Under these conditions, research aimed at the development of a management model of organizational response to sustainability-related complexity in supply chains is relevant, scientifically significant and practically required. It is oriented towards overcoming the gap between the volume of external requirements and the managerial capacity of an organization to process them, towards the development of evidence-based sustainability management, and towards the formation of mechanisms that raise the verifiability of outcomes and reduce coordination costs in the supply chains of Kazakhstani companies.

Purpose of the research. The dissertation develops a capability-based Organizational Response Model to support the design, selection and governance of sustainability response portfolios in supply chains. It uses complementary evidence from German and Kazakhstani organizations to formulate links between response mechanisms and auditable outcomes and derive recommendations for Kazakhstan.

To achieve the aim set in the dissertation, the following **research objectives** have been defined:

1. To clarify the content of the category "sustainability-related complexity" in supply chains and to substantiate Social Systems Theory as the sensitizing lens for interpreting organizational complexity reduction, complemented by stakeholder, institutional and capability-based perspectives (sub-chapter 1.1).

2. To systematize the institutional, regulatory and assurance conditions of Germany and Kazakhstan as boundary conditions for organizational sustainability responses (sub-chapter 1.2).

3. To substantiate a two-study abductive research design that combines an embedded multiple-case study with a qualitative content analysis and to specify its quality criteria (sub-chapter 1.3).

4. To reconstruct, on the basis of 23 interviews in 17 German organizations, the Packed Business Capabilities through which organizations manage sustainability-related complexity across Strategy, People, Process and Technology (sub-chapter 2.1).

5. To identify, on the basis of a content analysis of 20 reports of 11 large Kazakhstani companies, the publicly articulated capability profiles of Kazakhstani firms and their inductive extensions (sub-chapter 2.2).

6. To compare the German and Kazakhstani response patterns, to formulate the comparative propositions P1 to P8 and to develop the four institutional mechanisms M1 to M4 as proposed explanations for the cross-context contrasts (sub-chapter 2.3).

7. To develop the Organizational Response Model with its construct dictionary, moderators, routing conditions, response types and outcome metrics, and to propose its quantitative operationalization as a GRI-anchored Capability Maturity Score with a formal classification function and to apply both to the full sample of Study II (sub-chapters 3.1 and 3.2).

8. To derive prioritized recommendations for Kazakhstani companies and policymakers, including an implementation guide and a KPI dictionary, and to evaluate the model as a design-science artefact (sub-chapter 3.3).

The object of the research is organizations in the supply chains of Germany and Kazakhstan as systems responding to sustainability requirements.

Subject of the research is the management mechanisms and capability portfolios that shape the organizational response to sustainability-related complexity, including decision points, moderators and boundary conditions that route the response between internal capability build-up and collaborative arrangements.

Research methods. The dissertation applies general scientific methods, namely systemic analysis, institutional analysis, comparative analysis, logical and structural-functional analysis, and the method of scientific generalization. Study I used an abductive embedded multiple-case design. It comprised 23 semi-structured interviews in 17 German for-profit organizations across six supply-chain cases: textiles, food retail, food production, beverages, cosmetics, and cleansing products. The interviews took place between August 2019 and March 2020. Study II used deductive-inductive qualitative content analysis of 20 sustainability and annual reports.

The scientific novelty of the research is specified in the following provisions obtained personally by the author:

1. The dissertation clarifies sustainability-related complexity in supply chains as a differentiated construct. It comprises regulatory, stakeholder, data and auditability, interorganizational, and temporal change complexity. The organizational response is conceptualized as selective stabilization into routines, roles, and evidence practices. This is developed in sub-chapters 1.1 and 3.1 and the construct dictionary.

2. The taxonomy of Packed Business Capabilities covers Strategy, People, Process, and Technology. It was developed from 23 interviews in 17 German organizations. Its applicability to publicly reported capabilities was explored through content analysis of 20 reports from 11 Kazakhstani companies. The analysis also identified context-specific capabilities, including strategic data infrastructures and logistics digitization standards. Sub-chapters 2.1 and 2.2 present these findings. See Table 49.

3. Eight comparative propositions, P1 to P8, describe differences between German and Kazakhstani organizations. They cover capability formalization, organization design, communication, the supply-chain operating model, risk integration, data and technology, and process and product innovation. Four institutional mechanisms, M1 to M4, are proposed as abductive explanations. These are enforcement and grievance channels, assurance and verification, legitimacy and decoupling, and capability cost and infrastructure. The analysis also identifies capability signaling as a transitional stage in which sustainability communication precedes embedded practice. Sub-chapter 2.3 develops these propositions and mechanisms.

4. The capability-based Organizational Response Model explains how organizations allocate effort between internal capability build-up and collaborative arrangements. It uses two routing conditions: perceptual convergence and prevalent cross-firm orchestration. These yield four response types: Internal-first, Co-Developer, Selective Joiner, and Collaborative-first. The model includes a normative transition logic, five moderators, and six mechanism claims with scope conditions. It links the capability portfolio to time-to-mitigation, auditable tier coverage, and coordination cost per covered spend. Sub-chapter 3.1 presents the model.

5. A GRI-anchored Capability Maturity Score with 30 indicators and a formal response type classification function have been developed and applied to the 20 reports from 11 Kazakhstani companies in Study II. The three outcome metrics have been operationally defined for future empirical testing. The dissertation also specifies 14 recommendations, an

implementation guide and a KPI dictionary for Kazakhstani companies and policymakers (sub-chapters 3.2 and 3.3).

Main provisions submitted for defence:

1. Organizations manage sustainability-related complexity by bundling capabilities across Strategy, People, Process, and Technology. The resulting Packed Business Capabilities architecture is stable across heterogeneous cases. It was reconstructed from 17 German organizations in six supply-chain cases. It was also reproduced, with context-specific extensions, in the public reporting of 11 Kazakhstani companies.

2. Capability maturity is clustered, but the two corpora show different sequencing patterns. The German organizations in Study I build their responses on People and Process capabilities. These include organizational structure and staff, employee empowerment, process innovation, supply chain sustainability, and risk management. Strategic Management, Communication, Data Management and Reporting, and Technology Adoption are articulated as less developed. The Kazakhstani companies in Study II lead with policy articulation and communication. Data capture and basic controls follow, while technology enablement arrives later and unevenly. Risk management is reported as an established capability, as described in P5. The two corpora differ in country, period, sector, and evidentiary modality. Study I uses interviews from 2019 to 2020. Study II uses reports published from 2022 to 2025. The sequencing patterns were reconstructed from these accounts and documents. The provision therefore claims patterns identified in the two corpora and does not claim a country effect isolated from period, sector and data source.

3. Four institutional mechanisms, enforcement and grievance channels, assurance and verification, legitimacy and decoupling, and capability cost and infrastructure, are proposed as abductive explanations of the observed cross-context contrasts, and sustainability communication in transitional contexts is interpreted as capability signaling that can precede and catalyze embedded practice. The mechanisms are theoretically and empirically informed explanations whose independent effects have not been separated from period, sector and evidentiary modality and remain to be assessed through matched comparative research.

4. The Organizational Response Model uses perceptual convergence and prevalent cross-firm orchestration to distinguish four response types and specify proposed portfolio configurations and transition paths. These conditions are modeled as constraints on organizational choice.

5. The dissertation proposes that the organizational response becomes governable when the capability portfolio is linked to three mechanism-oriented outcome metrics, time-to-mitigation, auditable tier coverage and coordination cost per covered spend, and this linkage can be operationalized through a GRI-anchored Capability Maturity Score and a formal classification function that an analyst can apply to public sustainability reports under documented decision rules, as demonstrated by its application to all 20 reports of Study II with every score above 0 anchored to a cited page of the source report. The proposition is developed from the empirical material and has not been validated. The three outcome metrics are specified but not measured in this dissertation.

6. Under the transitional assurance density of Kazakhstan, the companies of Study II correspond predominantly to the Co-Developer response type. Collaborative-first occurs only where third-party assurance coincides with membership in international schemes, namely at Air Astana JSC, Karachaganak Petroleum Operating B.V. (KPO), National Atomic Company

Kazatomprom JSC, and, in its sustainability reports, JSC National Company KazMunayGas (KMG). Internal-first is confined to financial-sector documents without a materiality process, and no report in the corpus meets the condition for the Selective Joiner type, which requires low perceptual convergence together with high orchestration, a combination that does not occur here because the seven reports with high orchestration all show high convergence as well. The absence of platform evidence in the reports leaves open whether such a platform exists in the field. Since the Process domain is the weakest domain of the sample (document-level mean over the 20 reports 49.6 against 91.8 for Strategy) and the lowest-scoring domain in 15 of the 20 reports, the disclosure gaps support prioritizing data integrity, supplier pre-qualification and exception governance, and local closure rights, while state-linked holdings and regulators can accelerate diffusion by raising verification capacity and field-level orchestration.

The theoretical significance of the dissertation lies, first, in the clarification of the category of sustainability-related complexity as a differentiated construct and of the organizational response as selective stabilization, which extends the conceptual apparatus of sustainable supply chain management beyond lists of practices. Second, the dissertation contributes to organizational capability theory a routing mechanism that explains when organizations generate requisite variety internally and when they absorb it through collaborative arrangements and thereby specifies the make-or-join decision, which the dynamic capabilities literature treats only in general terms, as a function of two observable field conditions. Third, the dissertation identifies capability signaling as a mechanism that connects the legitimacy logic of institutional theory with the maturation logic of capability theory and explains why communication can precede embedded practice without necessarily indicating decoupling. Fourth, the dissertation extends the application of Social Systems Theory to a cross-national and cross-method research design as an interpretive lens. The contribution to Social Systems Theory is deliberately interpretive and delimiting: the dissertation does not test the theory and does not operationalize autopoiesis, and it does not claim to develop a new grand theory. Its theoretical contribution is a mid-range, capability-based explanation of organizational response under sustainability-related complexity.

Practical significance of the research. The results can be used by the groups. Companies in the extractive, energy, financial, construction and transport sectors of Kazakhstan can use the Packed Business Capabilities taxonomy and the Capability Maturity Score to diagnose their current response configuration, the routing conditions to decide between internal build-up and collaboration, and the 90-day and 12-month implementation guide with its KPI dictionary to govern the response. Ministries and authorized bodies of the Republic of Kazakhstan, the Astana International Financial Centre and the Kazakhstan Stock Exchange can use the four mechanisms and the policy levers of sub-chapter 3.3 to design instruments that raise verification capacity and field-level orchestration and thereby reduce coordination cost for companies. Consulting and audit firms can use the CMS and the outcome metrics as a structured diagnostic for sustainability governance and assurance readiness. Higher education institutions can use the model, the case material and the CMS in the training of specialists in management, supply chain management and sustainable development. The results correspond to the objectives of the Strategy for Achieving Carbon Neutrality by 2060, the Concept for Transition to a Green Economy and the Environmental Code of the Republic of Kazakhstan, and to SDG 12, SDG 13 and SDG 17.

Approbation of the research results.

The main results of the dissertation research have been published in 4 scientific works, including 2 articles in journals recommended by the Committee for Quality Assurance in the Sphere of Science and Higher Education of the Republic of Kazakhstan, 1 paper in the proceedings of international scientific and practical conferences, and 1 chapter in a collective monograph of the publishing house Peter Lang indexed in the Scopus database.