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INDUSTRIAL CLUSTERS IN INTERNATIONAL VALUE CHAINS

CONCEPTUAL ADVANCEMENT AND EMPIRICAL EVIDENCE FROM EUROPEAN ICT CLUSTERS

Joanna Bohatkiewicz-Czaicka and Marta Gancarczyk

ROUTLEDGE

Industrial Clusters in International Value Chains

Clusters are considered crucial nodes in the ongoing transformation of international value chains (IVCs). Due to technological advancements and external shocks, such as pandemic and political conflicts, value chains (VCs) have been spatially and functionally shortening, and clusters are well suited to address the resulting demand for more diversified and higher value-adding activities in geographical proximity, such as European economic area. However, clusters differ in their positions and capability to advance in IVCs, which induces the research problem of the conditions for cluster upgrading (CU). This monograph aims to develop a theoretical framework for regional CU and empirically verify this framework based on ICT clusters in Europe. It advances the theory of upgrading by linking the VC governance and capability approaches, broadening the empirical evidence on the conditions of CU, and providing policy recommendations. The unique value of the findings from research and practice results in the identification of the determinants for CU and conceptualizes them into new theoretical constructs of the sufficient Framework Conditions and the necessary and sufficient Public-Private Knowledge Governance. Our empirical basis is European clusters in ICT, an industry being one of the Key Enabling Technologies (KETs) for innovation and VC transformation.

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Introduction

Background and Research Problem

Clusters are considered crucial nodes in the ongoing transformation of international value chains (IVCs) (Stöllinger et al., 2018). Due to technological advancements and external shocks, such as pandemic and political conflicts, value chains (VCs) have been spatially and functionally shortening to focus on friend-shoring and nearshoring (De Marchi et al., 2017; Gong et al., 2022; Zhan et al., 2020). Rather than a global, uniform, and large-distance approach to markets and collaborative structures, this transformation favors substructures sharing spatial and institutional proximity in international trade, such as the European economic area. The VC fragmentation implies collaborating and competing for value added in IVCs that cover fragmented (regionalized) cross-border trade and global value chains (GVCs) (Cieślik et al., 2021; Kano et al., 2020; Zahoor et al., 2023). The shortened VCs demand a more comprehensive and diversified supply in the nearby international environment. Clusters concentrate on innovation, industrial transformation, and the branching out of new industries around their core specializations (Hollanders & Merkelbach, 2020). Therefore, they are well suited to addressing this demand for more diversified and higher value-adding activities in geographical proximity.

However, clusters differ in their value chain positions and capability to advance in VCs, which induces the research problem of the determinants of cluster upgrading (CU) (Karlsen et al., 2023a). Upgrading in VCs is the advancement into higher value-adding activities (Coe et al., 2014; Gereffi, 1996; Humphrey, 2004; Humphrey & Schmitz, 2002, 2004; Kleibert, 2020). In relation to clusters, upgrading is the improvement of the relative competitive position of clusters' dominant industries in GVCs (Gancarczyk & Bohatkiewicz, 2018a; Humphrey & Schmitz, 2002). Since the referred VC transformations are in progress, there is a need for both conceptual advancement and empirical investigations of clusters in IVCs (Coe, 2021; Coe & Yeung, 2019; Gereffi, 2018).

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Clusters are broadly understood as spatial concentrations of networked companies in one or adjacent industries that form relationships with business environment organizations (Becattini et al., 2009; Bohatkiewicz-Czaicka & Gancarczyk, 2018; Delgado et al., 2016; Doeringer & Terkla, 1995; European Commission, 2002; Gancarczyk, 2015; Jacobs & De Man, 1996; Muizer & Hospers, 2000; Porter, 1990, 1998; Rosenfeld, 1997; Sölvell et al., 2003; World Bank, 2009). In this vein, clusters represent the systems including enterprises, organizations of the business environment (such as universities, governmental, non-governmental, and financial institutions), and regional resources (Gorynia & Jankowska, 2007; Markusen, 1996). These systems are the foci of industrial change, initiating the transformation of economies or effectively responding to it (Ceglie & Dini, 1999; De Marchi et al., 2017; Feser et al., 2008; Jankowska & Götz, 2017; Kaplinsky, 2015; Sonobe & Otsuka, 2006). Consequently, clusters have been either the core of industrial, regional, and innovation policies or have proven to be conducive for the implementation of policies, such as regional innovation policies, smart specialization strategies, and the development of Industry 4.0 (Balland & Boschma, 2021a, 2021b; De Propris & Bailey, 2020, 2021; Foray, 2015; Gancarczyk et al., 2021; Götz, 2020b; Müller et al., 2017).

The research and policy on clusters have advanced from the identification of determinants of cluster competitive advantage to research on cluster dynamics, their evolution, and life cycles (Belussi & Sedita, 2009; Bergman, 2008; Fornahl et al., 2015; Fornahl & Hassink, 2017; Frenken et al., 2015; Gancarczyk, 2013, 2015; Gancarczyk & Gancarczyk, 2016; Martin & Sunley, 2011; Menzel & Fornahl, 2010; Tavassoli & Tsagdis, 2014). The latter stream of research assumes a predominantly positive approach to explain the processes of how clusters transform and what drivers and pathways they follow (Hassink et al., 2019; Scholvin et al., 2022). However, there is a natural expectation that the research on cluster dynamics raises also the recommendations regarding a progressive direction of industrial change toward a higher comparative position in terms of value added in international VCs, a core of cluster upgrading (Caspari, 2003; Enright, 2000; Fernandez-Stark & Gereffi, 2019; Gancarczyk & Bohatkiewicz, 2018a; Gereffi & Lee, 2016a; Humphrey & Schmitz, 2002; Trippl et al., 2015). Within the broad research on cluster dynamics, the research on cluster upgrading differentiates by a normative lens, valuable for both theory and business and policy practice (Gancarczyk et al., 2023).

The challenge of upgrading clusters is currently even more compelling due to the geographical and functional shortening of VCs and the growing need for higher value-added and more diversified products and services in the spatial proximity (De Marchi et al., 2017, 2017, 2018; Gong et al., 2022). In response to digital technologies and external shocks, such as political and pandemic phenomena (Cattaneo et al., 2010; Gereffi, 2014;

Neilson et al., 2014), international VCs have been shortening to seek inputs and markets in geographical, political, and economic alliance proximity, as reflected in the nearshoring and friend-shoring (De Marchi et al., 2018; Dicken, 2007; Gong et al., 2022; Kamakura, 2022; Maihold, 2022; Sammarra, 2005). For a VC structure, it means a switch from global sourcing of narrowly specialized activities for cost advantages toward nearby sourcing of necessarily more diversified activities in search of human talents and risk avoidance (Parrilli et al., 2014). Moreover, the adoption of digital solutions, such as artificial intelligence, reduces human involvement in standardized VC activities and removes or aggregates some VC functions (Gancarczyk et al., 2022; Götz, 2020b; Lasak & Gancarczyk, 2022). This requires increased qualifications and a capability to refocus from simple, standardized functions toward knowledge-based and technologically advanced activities (Mudambi, 2008; Muizer & Hospers, 2000).

Clusters are assigned the crucial role in the transforming VCs since they can effectively address the challenges of innovation and diversification (Hollanders & Merkelbach, 2020; Zhan et al., 2020). Industrial agglomerations are in nature based on related diversification around region-specific competences. Using a common pool of specialized knowledge, they are capable of providing an array of related, new or improved, products and services (Götz, 2021). However, they also differ in their global or international VC positions and ability to advance, which induces *the research problem of the determinants of cluster upgrading*, addressed in the proposed monograph (Coe, 2021; Coe & Yeung, 2019; Gereffi, 2018).

Research Gaps, the Aim, and the Contribution

Research on industrial upgrading in international VCs reveals important *research gaps*, in particular with respect to the most recent VC transformations stated above. *First*, the research on upgrading predominantly focuses on the regions and countries of the Global South, while the cases of the Global North and developed countries are much less explored (De Marchi et al., 2018; Gereffi, 2018; Gereffi & Lee, 2016b; Karlsen et al., 2023a; Ponte, Gereffi, et al., 2019). Nevertheless, regional industries and clusters of the North also reveal differences in terms of VC positions and potential to upgrade (Hollanders & Merkelbach, 2020). The value chain activities sourced from distant locations have been undergoing nearshoring and friend-shoring, thus requiring adequate supply in nearby locations, such as within the European context. *Second*, the conceptual lens of industrial upgrading is strongly based on the GVC perspective that demands a re-theorizing toward the ongoing VC shortening and transformation to international, that is, global and fragmented (regionalized) cross-border trade, rather than global perspective only (Coe, 2021; Kano et al., 2020; Ponte, Gereffi, et al., 2019; Zahoor et al., 2023; Zhan et al., 2020). *Third*, the GVC perspective is deterministic in its emphasis on the initial contract conditions and bargaining power of buyers and suppliers (Belussi & Sammarra, 2009; Colombelli et al., 2019; Gereffi, 2005; Gereffi & Lee, 2016a; Humphrey & Schmitz, 2000; Ponte & Sturgeon, 2014; Schmitz, 2004). Capability-based determinants, in particular their dynamic nature as a basis for upgrading, are either less explored or approached heuristically, thus requiring a conceptualization and a systematic analysis (Expósito-Langa et al., 2011; Fritsch & Kublina, 2018; Hervas-Oliver et al., 2012a; Howell, 2020a; Karlsen et al., 2023a). *Fourth*, the research on upgrading is predominantly focused on the industrial upgrading of regions and countries, while upgrading of clusters is less explored (Karlsen et al., 2023b). Clusters are increasingly expected to be the kernels of innovation, generating knowledge-based and technologically advanced products and services rather than standardized solutions (Boschma & Ter Wal, 2007; Cooke, 2001; Götz, 2021; Saxenian, 2007). This demand has even been strengthened by the adoption of artificial intelligence and the achievements of Revolution 4.0 (Götz, 2020c). The resulting VCs require high expertise instead of basic competence, and clusters are well equipped to be at the forefront of these processes. *Fifth*, empirical research on cluster and regional upgrading is predominantly based on qualitative methodologies, such as case studies of selected territories or industrial agglomerations, while comparative and quantitative research in this area remains scarce. Qualitative studies allow for analytical generalization only, while quantitative methods enable statistical verification and generalization, and broader comparative evidence.

In response to the research gaps mentioned, *this monograph aims to* develop a theoretical framework for regional cluster upgrading and empirically verify this framework based on ICT clusters in Europe. Our research provides *theoretical, methodological, and practical contributions.*

It contributes to theory, in particular, to the current research stream on clusters' integration into IVCs (Gereffi, 2018; Gereffi & Lee, 2016b, 2016b; Turkina & Van Assche, 2018; Zhu & He, 2018a). *The major contribution and unique theoretical value of this monograph rests in the integrative conceptual framework that links the governance and the capability-based view, a framework derived from the state-of-the-art and empirically verified in our research.* Moreover, the book will give input to knowledge accumulation in CU, since it will discuss the essence of cluster concept, from the ideas of clusters' competitive advantages to the ideas of cluster dynamics. Therefore, the contribution will also be a systemized knowledge in this area. *The monograph broadens the empirical evidence on the determinants of CU* (Giuliani et al., 2005; Grondeau, 2007), *based on the European regional agglomerations of the ICT industry*, being one of the key enabling technologies (KETs) for innovation (European Commission, 2019). ICT represents an industry whose advancement and upgrading are conducive for the entire economy through externalities, including knowledge spillovers. Moreover, the ICT industry is the core of the emerging Digital Industry, a result of the convergence of a bulk of business areas related by digital technologies (Hollanders & Merkelbach, 2020). We will focus on the European geographical scope in response to the VC transformation toward nearshoring and regional fragmentation (Stöllinger et al., 2018; Zahoor et al., 2023).

The monograph is also distinguished by *a methodological contribution*. It adopts a deductive and quantitative method to enable a generalization. Scientific validity is ensured by adopting a deductive research framework, uniquely integrating existing concepts and empirical findings to reflect the specificity of CU. A quantitative identification of the determinants of the cluster position in VCs represents an original approach in view of existing research, dominated by qualitative case study methodologies (Gancarczyk & Bohatkiewicz, 2018b). Moreover, our method provides opportunities for replication and adaptation to other industries beyond ICT.

This study also provides *a contribution to practice*. The framework of the conditions for CU will raise practical recommendations for businesses and policymakers as to how upgrading can be accomplished in international VCs (Akinwale & Kyari, 2020; De Marchi & Alford, 2022a; Götz, 2020a; Karlsen et al., 2023a). Based on scientific and methodological relevance, it ensures relevance for economic policy toward clusters, pointing to areas of support that can lead to a high VC position of clusters, with a focus on the ICT industrial agglomerations. The support measures can be derived from the observed variables forming the theoretical constructs that proved to affect CU in our empirical study. The observed variables are accessible in the public, long-term databases, which enhances both the understanding of their meaning and monitoring over time. It should be assumed that these support measures can stimulate the development of ICT, but also the entire region and other than ICT industries, through externalities.

Our *research framework* acknowledges the influence of the governance structure, capability-related factors, and public support on cluster upgrading. From the VC governance theory and empirical findings, we derive the assumption that non-hierarchical rather than hierarchical governance structures of collaboration, among companies and business environment organizations, enhance learning, innovation development, and eventually CU in international VCs (Gancarczyk et al., 2017; Gancarczyk & Bohatkiewicz, 2018b; Gancarczyk & Gancarczyk, 2016). The governance approach is inherently static and assumes a deterministic position in contract relationships, as determined by initial conditions. It does not explain the dynamics of a cluster upgrade induced by potential learning and capability (Karlsen et al., 2023a; Ponte, Gereffi, et al., 2019; Ponte, Sturgeon, et al., 2019). These insights are offered by the capability approach that assumes a competence development in VC relationships and thus a possibility of accomplishing a non-hierarchical, balanced power relations, leading to CU, that is, a higher comparative VC position in terms of value added (Gancarczyk et al., 2017; Gancarczyk & Bohatkiewicz, 2018b). Based on the literature review, we decompose the capability approach into two theoretical variables of absorptive capacity and innovation capacity, hypothesizing their positive impact on cluster upgrading. Following Cohen and Levinthal (1990) and Zahra and George (2002), we treat a cluster's absorptive capacity as this cluster's potential to absorb and internalize external knowledge (Aslesen & Harirchi, 2015; Giuliani et al., 2017; Hervas-Oliver et al., 2012b; Menghinello, de Propris, et al., 2010; Menghinello, De Propris, et al., 2010; Munari et al., 2012; Pietrobelli & Rabellotti, 2011; Sammarra & Belussi, 2006). Consequently, absorptive capacity forms conditions for adopting new ways of functioning and establishes a basis for innovation capacity (Cohen & Levinthal, 1990; Munari et al., 2012). According to Leonard-Barton (1992) and Dyer and Singh (1998), innovation capacity includes the identification, evaluation, and exploitation of external knowledge, in particular technology, to implement new or improved products and processes. Consequently, we define a cluster's innovation capacity as its potential to commercialize knowledge, that is, to develop innovations, and exploit their economic effects (Giuliani et al., 2017; OECD, 2005; Pietrobelli & Rabellotti, 2011). Innovation capacity determines the position of a cluster and the potential for upgrading in international VCs. Both absorptive capacity and innovation capacity are evolutionary and path-dependent concepts, therefore, their impact and outcomes need to be considered in a broader regional context and a long-term perspective (Gong & Hassink, 2019, 2020; Hassink, 2019; Hassink et al., 2019; Sirén et al., 2012). We also assume the role of public support in cluster upgrading, since financing technical support and innovation projects can enhance a higher value added and advancement in VC (De Marchi & Alford, 2022b; Götz, 2020a; Howell, 2020b; Karlsen et al., 2023b; Matsuzaki et al., 2021; Shen & Li, 2022; Zhu & He, 2018b). This research framework was built on *four major hypotheses* assuming a positive influence of absorptive capacity, innovation capacity, nonhierarchical governance, and public financing on cluster upgrading in IVCs.

The Method

In the theoretical part of the monograph, we adopt the method of *narrative literature review*. The review covers theoretical literature and empirical studies in cluster competitive advantage and dynamics, industrial upgrading, as well as VC governance perspectives of GVCs and global production networks. The outcome of this analysis is the said research framework.

In the empirical part, a method of secondary data analysis was employed, based on the Regional Innovation Scoreboard, Regional Statistics, and Structural Business Statistics of Eurostat. As an empirical basis, we chose European ICT clusters. The following rationales support this choice. First, this industry provides a considerable and still growing input to the European economy as ICT sector's value added was estimated to be over €631 billion and represented the equivalent of 5.2% of the EU's GDP share in the UE GDP in 2020 (ICT sector – value added, employment and R&D, 2023). Second, the ICT industry is crucial for efficiency and innovation in all other industries, which use digital solutions to reduce costs and time of operations. Third, this industry demonstrates both quantitative dynamics, as per value added and turnover, and qualitative transformation as an emerging Digital Industry, an outcome of the convergence of the industries related to information technologies. Fourth, ICT represents a technological platform for an array of innovative products and processes throughout the economy, being one of the KETs.

The European ICT clusters have been identified with the use of the two criteria constituting the phenomenon of clusters, namely, (i) spatial and industrial concentration and (ii) network relationships. The criterion of spatial and industrial concentration was met by the adoption of the location quotient (LQ) of employment at the NUTS 2 level, with a threshold LQ of at least 1.25. The LQ has been computed for three service segments of ICT, namely, J61 (telecommunications), J62 (computer programming, consultancy, and related activities), and J63 (information service activities). The choice of the ICT service clusters was due to the measurement of the VC position of the cluster. According to theoretical assumptions, the VC position was measured as value added compared to other clusters. Value added was approximated by the average wages, a way of calculating value added that is possible at the NUTS 2 level. Wages are a more accurate approximation of value added in services than in manufacturing; therefore, we chose the ICT service clusters for investigation. The criterion of network relationships was met by matching the clusters identified based on the LQ with cluster initiatives that formalize network relationships among industry and organizations of business environment, as reported in the dataset of the European Cluster Collaboration Platform (https://clustercollaboration.eu/). Although industrial spatial concentration and geographical proximity induce formal and informal network relationships, the presence of formal and institutionalized cluster initiatives supports the evidence on the networking around the industrial specialization.

We created a unique database of the European ICT service clusters in the years 2008–2020 (1521 records for 171 clusters in this period). The research sample reflects a variety of VC positions and related characteristics of the European ICT service clusters. The clusters were located in the NUTS 2 regions of 21 countries. The data included the sets of observable variables reflecting the theoretical variables of the research framework (absorptive capacity, innovation capacity, governance, public support). Due to incomplete data coverage for particular years in the referred period, we were not able to calculate average dynamics for the independent variables, and the dynamics between the frontier years can be biased. Therefore, we focused on the position of the cluster in a particular year and the state of the independent observable variables in that particular year. In this way, we were able to derive the conditions for cluster upgrading based on the characteristics of clusters that demonstrate a relatively high position compared to low-position European ICT clusters. Furthermore, to control for exogenous country-level conditions for regional clusters, we have included control variables such as the parent country GDP and the labor productivity of ICT service clusters under research.

To test the hypotheses that stem from the research framework, we applied a logistic regression in which the data for individual years represented observations. This type of regression may be applied when there is a binary dependent variable and the database includes some incomplete annual data (Hosmer & Lemeshow, 2000).

Findings

This research has identified the determinants of the position of clusters within international VCs and the hierarchy of these determinants, in the context of the European ICT service clusters. To achieve these results, the regression models with the VC position of the cluster as a dependent variable were developed. The models proved a positive impact of absorptive capacity, innovation capacity, and non-hierarchical governance on the VC position of service ICT clusters in Europe. Ultimately, in order to identify the key determinants of the position of clusters in VCs and their hierarchy, an aggregate model was adopted, taking into account the previously identified factors in three individual models with control variables. The aggregate model revealed that non-hierarchical governance influences a high VC position of clusters and thus indicate the prospects for CU. To ensure the validity of the findings from the regression models (Grochowiecki & Migut, 2023; StatSoft, 2023), we applied a number of detailed analytical tests, techniques, and methods, such as CART analysis, Cramer's V, Hosmer-Lemeshow test, ROC curve, and AUC analyses, as well as Akaike Information Criterion (AIC) (Aczel, 2000; Bendel & Afifi, 1977; Grochowiecki & Migut, 2023; Henderson & Denison, 1989; Hosmer & Lemeshow, 2000; Jennrich & Sampson, 1968; Johnsson, 1992; Migut, 2009; Stanisz, 2007). Based on the regression results and confirmed determinants of CU, we have developed higher-order constructs and proposed an empirically verified framework of cluster upgrading.

The Structure of the Monograph

This monograph includes five chapters, Introduction and Conclusion. *The first chapter* highlights the relationships between the phenomena and concepts of clusters and IVCs. The key structural features and theoretical foundations of clusters were synthesized. Based on the understanding of the core properties clusters, the methods for identifying regional industrial concentrations were discussed. Acknowledging the processes of VC cross-border expansion, the recent transition from global to international VCs was recognized. Furthermore, we analyze the types of value chain governance in cross-border contexts and its effects on learning and capability development. The consequences of cluster internationalization and insertion into cross-border VCs conclude Chapter 1.

In the second chapter, the essence and antecedents of cluster dynamics, in particular, its upgrading in international VCs was discussed. Moreover, the core and types of cluster upgrade in international VCs were analyzed. Following the GVC governance theory, we focused on value added as a measure of the cluster position in international VCs. The literature review enabled the identification of determinants of cluster upgrading and the formulation of research hypotheses regarding the influence of non-hierarchical governance, absorptive capacity, innovation capacity, and public support on CU.

The content of Chapter 3 covers the methodology of the empirical study. The research problem, aim, and hypotheses were gathered to develop a research framework for empirical verification. The research framework highlights the main relationships among theoretical variables leading to CU. This was followed by the justification of research methods and techniques, and a research procedure. The operationalization and measurement of variables, and the presentation of data sources complement the methodological issues. The final section justifies the ICT clusters as an empirical basis and explains how the research sample was identified.

Chapter 4 covers research findings on the determinants of cluster position and upgrading in VCs. The characteristics of the research sample were presented together with the major properties and importance of the European ICT industry as a context of this study. Then, we analyzed the results of individual logistic regression models with independent variables and of an aggregate logistic regression model for all independent variables, previously identified in the individual models. Based on these findings, we established the hierarchy of the identified determinants and retheorized them into higher-order constructs. Ultimately, an empirically corroborated framework of cluster upgrading was proposed.

The fifth chapter includes a discussion and a detailed explanation of the theoretical, methodological, and practical contributions. We reflect on the empirical results against the existing research on the determinants of cluster dynamics and upgrading. In particular, the chapter discusses how the original research framework has been verified in this empirical study. Moreover, we explain the theoretical and methodological input and provide recommendations for business and policy practice. Limitations and future research directions conclude the chapter.

The concluding section explains how the main aim was accomplished in this monograph. Furthermore, this section synthesizes the content of the monograph and provides the major outcomes and recommendations.

The major value of the presented research rests in theoretical implications and practical recommendations relevant for business strategies and public policies at the regional level with an ambition to deliver value as well as to collaborate and compete at the international level. Due to the nature of clusters as industry-specific spatial systems, we focus on one industrial specialization. Nevertheless, the ICT industry is highly relevant due to its economy-wide interrelations that revitalize and inspire innovation and efficiency in all sectors. Moreover, it is representative of knowledge-based industries gaining prominence in the European economic area as a means to increase value and advance in VCs. We can also assume the possibility to extend the proposed findings and implications to other industrial contexts, acknowledging their technological and spatial specificities. Another, wider contribution from the volume consists in proposing the determinants of industrial transformation toward a higher international comparative position to benefit the entire territorial units and economic actors. This input can be treated as more general theoretical outcome that broadens the empirical evidence and supports the theoretical potential of the industrial transformation and upgrading concepts as relevant for researchers, policymakers, and business practitioners.

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1 Clusters and International Value Chains

1.1 The Essence and Key Properties of Clusters

1.1.1 The Key Properties and Definition of Clusters

Clusters are usually perceived in three different ways as (i) a phenomenon of the industry's spatial concentration, that is, an observable phenomenon of industry agglomerations, (ii) as a form of industry governance, often presented from the perspective of structures (or modes) of governance, and (iii) as a theoretical perspective, namely a set of concepts describing this observable phenomenon and mode of governance. In this section, the authors wish to explain the essence of a cluster as a spatial form of industry governance and the theoretical foundations of the phenomenon, providing readers with examples of how such industrial agglomerations operate in particular regions.

From the point of view of industrial economics, clusters should be treated as a specific form of organizing highly specialized production and governance structure due to its spatial nature (Bain, 1959; Chamberlain, 1949; Coase, 1937, 1960; Fujita & Krugman, 1995; Fujita & Mori, 1997; Gong et al., 2022; Granovetter, 1985; Hospers et al., 2008; Krugman, 1993; Pessoa, 2014; Porter, 1990, 2001; Pyke & Sengenberger, 1992; Robinson, 1969; Scott, 1988, 1993; Storper, 1995, 1997; Storper & Scott, 1990; Williamson, 1975, 1985, 1998, 2005). The governance form is an institutional solution covering the whole set of rules and norms affecting the operations of a particular system (Colombelli et al., 2019; Williamson, 2000). Clusters are treated as a coordination structure typical of an industry located in a particular territory and demonstrating ties with this geographic context (Gancarczyk, 2010; Gancarczyk & Konopa, 2021; Gorynia & Jankowska, 2007; Jankowska, 2002).

Analyses of a localized industry usually concentrate on the processes of spatial polarization of development and the explanation of the reasons of and benefits from the location of an industry in spatial proximity. Clusters are perceived as manifestations of geographical polarization and they are

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distinguished by the existence of critical mass of specialized enterprises in a given territory, i.e. the presence of above-the-average economic activity in a particular sector or related sectors in a particular region (Brodzicki & Szultka, 2002; Enright, 2000; Fornahl et al., 2015; Główka, 2016; Klepper, 2007; Longhi, 1999; OECD, 2000; Rosenfeld, 1997). A structural attribute of a cluster is thus industrial and spatial concentration of a given economic activity, constituting the foundation of regional specialization (Bellandi, 2001; Krugman, 1991b; Micek et al., 2017; Porter, 1998b; Sabel & Piore, 1986). This concentration expresses critical mass, above-the-average concentration of entities (number of enterprises, workers, employees) or of their outputs (revenues, value added). Concentration on a given area is accompanied by spatial proximity of particular entities, i.e. their agglomeration. Therefore such phrases as *industry concentration* or *industry agglomeration* are often used as synonyms of clusters.

Spatial proximity or agglomeration of economic activity and concentration, i.e. the existence of critical mass of enterprises and their above-the-average activity in a particular territory, provide the foundation for building network connections (Asheim & Isaksen, 2002; Brusco, 1982; Doeringer & Terkla, 1995; Gancarczyk & Gancarczyk, 2013; Markusen, 1996; Porter, 1990; Pyke & Sengenberger, 1992; Rosenfeld, 1997; Saxenian, 2007).

The existence of network linkages constitutes the second structural attribute of a cluster, demonstrating that there are relations among enterprises and between enterprises and organizations from the business environment, such as providers of finance, advisory services, local authorities, and non-governmental organizations. The network nature of these connections accounts for a phenomenon known as 'coopetition', a combination of cooperation and competition. Competition is a natural phenomenon as industry participants offer goods that satisfy a similar need (Porter, 1990). Cooperation, on the other hand, allows to share risks when implementing an investment, provides access to complementary resources from suppliers, which are other enterprises and business environment organizations, and supports the process of innovation generation and diffusion (Delgado et al., 2016).

Structural features of clusters are reflected in their definitions. The broadest group of definitions comprise both attributes, i.e. special and industry concentration as well as network connections as characteristics of this mode of industrial governance. One can mention here, inter alia, definitions proposed by Rosenfeld (1997), Muizer and Hospers (2000), Jacobs and De Man (1996), European Commission (2002, 2016), Brodzicki and Szultka (2002), World Bank (2009), Jankowska (2012), Ketels and Protsiv (2016), Hołub-Iwan and Wielec (2014), Buczyńska, Frączek and Kryjom (2016), Gancarczyk (2010, 2015), and Gancarczyk, and Bohatkiewicz (2018). The definitions based on spatial concentration and network relationships are also those created by Doeringer and Terkla (1995), (Ceglie & Dini, 1999), and Główka (2016) *(Table 1.1)*.

Table 1.1 Selected definitions of clusters based on attributes of spatial concentration and network relations

Authors	*Definitions*
Porter (1990, 2001)	Geographically proximate group of interconnected companies, specialized suppliers, service providers, enterprises operating in related sectors and institutions in particular areas; competing, but also cooperating with one another
Doeringer and Terkla (1995)	Geographical agglomeration of interconnected companies, specialized suppliers, entities providing services, companies operating in related sectors, and related institutions (for example, universities, standardizing entities, and industry associations) in particular areas; competing, but also cooperating with one another
	Geographical concentration of industries, gaining competitive advantage in productivity thanks to co-location
Rosenfeld (1997)	Geographically specified concentration of entities of similar or complementary specialization, connected by economic transactions, communication, specialist infrastructure, labor and service markets, and shared opportunities and threats
(Ceglie & Dini, 1999), Główka (2016)	Regional and territorial agglomerations of companies manufacturing and selling similar or complementary products, and, therefore, forced to overcome similar problems and challenges. This results in the development of specialist competencies and skills and specialist services
European Commission (2002, 2016)	Geographical concentration of companies from the same or related industries, with developed relations with organizations of business environment
Brodzicki and Szultka (2002)	Spatially concentrated agglomeration of companies – simultaneously competing and cooperating with one another in some aspects of their activities, and institutions and organizations connected in a developed system of mutual relations of both formal and informal nature, based on a specific development trajectory (for example, technology and markets)
World Bank (2009)	Agglomeration of connected companies, suppliers, service providers, and institutions in a given sector, remaining in geographical proximity, enjoying external advantages and synergies, such as access to specialized human resources, diffusion of knowledge, and high productivity, thanks to mechanisms of competition

(*Continued*)

Table 1.1 (Continued)

Authors	*Definitions*
Buczyńska et al. (2016)	Specific form of organizing production, consisting in concentration of flexible companies conducting complementary activities in a given area
Hołub-Iwan and Wielec (2014)	Geographical concentration of independent economic entities representing a particular specialization, cooperating and competing with one another in a value chain
Ketels and Protsiv (2016)	Geographical concentration of independent entities, representing a particular specialization, cooperating and competing with one another in a value chain; cooperation within the cluster is formalized and is implemented horizontally and vertically, aimed at the accomplishment of mutual goals; a cluster constitutes a source of benefits and creates value for all types of entities participating in it, such as enterprises, universities and other scientific units, business environment institutions and other supporting organizations

Source: Own elaboration on the basis of Bohatkiewicz-Czaicka and Gancarczyk (2018).

The contemporary understanding of clusters has been shaped by the works of M. Porter (1990, 2001), who presents this phenomenon as a geographical concentration of interconnected companies and business environment organizations with the common specialization profile, connected by means of relations of cooperation and competition, typical of network connections (Gancarczyk, 2017; Porter, 1990). Porter takes into consideration a wide range of cluster participants, who are interconnected, comprising, apart from companies, also numerous organizations of business environment connected with knowledge transfer, financing, and advisory services (Porter, 1994, 2001). Doeringer and Terkla (1995) point at the attributes of spatial concentration and coopetition, linking specializations of companies and suppliers with related connections within the value chain. On the other hand, the European Commission (2002, 2016) focuses on the industrial nature of the regional concentration of companies, which have developed related connections (supplier-buyer) within the value chain. Emphasizing similarly the importance of concentration, specialization, and network connections, Rosenfeld (1997) stresses intense communication and transactions among entities with similar profiles, i.e. on the same level of the value chain or bound by related connections, those of supplier-buyer type, in the value chain. He also points out common development paths resulting from similar conditions created by the environment for participants of industry agglomeration.

The definitions provided by Ceglie and Dini (1999), Brodzicki and Szultka (2002) also emphasize the interdependencies within regional agglomerations. They indicate that such connections lead to similar challenges, problems, and development trajectories, as well as benefits offered by specialization and differentiation through tailoring to customer's needs. Brodzicki and Szultka (2002) offer a similar understanding of a cluster to Porter's definition, drawing our attention to the formal and informal nature of connections and development based on common technologies and markets.

International institutions, such as the European Commission (2002, 2016) and the World Bank (2009), take up the subject of specialized concentrations of companies due to their importance in economic policy. Therefore, they focus on benefits generated by clusters, such as external benefits and synergies, access to specialized human resources, knowledge diffusion, and increased productivity thanks to competitive incentives.

Having systematized definitions and identified structural features, we will define a cluster here as *geographical concentration of companies from the same or related industries, remaining in network relations and in connections with organizations and resources of their regional environment* (European Commission, 2002, 2016; Gancarczyk, 2010, 2015; OECD, 1999, 2001; Porter, 1998a, 2001; Vanhaverbeke, 2001). In this definition, clusters (industrial agglomerations, industrial concentration) will also cover such phenomena as industry districts and industrial production systems (Marshall, 1920; Sabel & Piore, 1986; Vanhaverbeke, 2001).

1.1.2 Clusters vs.the Adjacent Constructs of Economic Policy

Some researchers distinguish clusters only on the basis of network governance, assuming there is agglomeration, but omitting the spatial concentration aspect as well as critical mass of companies representing regional specialization. In this approach, the composition of entities and the types of relations between them are of vital importance, as well as the institutions providing framework for their operations and constituting a source of their effectiveness (Williamson, 2000). The researchers promoting the understanding of a cluster as a form of governance include such names and institutions as: Muizer and Hospers (2000), Ottati (2002), OECD (1996), as well as Jacobs and De Man (1996) *(Table 1.2)*.

As a form of industry organization and coordination structure, the cluster is characterized by inter-sector horizontal and vertical ties which are subject to regulations by the leading entity (Jacobs & De Man, 1996; OECD, 2005). The form of coordination in a cluster is associated with the institutional sphere (Muizer & Hospers, 2000) since the system of industrial agglomeration remains part of a larger socio-economic system on a given territory (Ottati, 2002).

Table 1.2 Selected definitions of clusters based on the network relations attribute

Authors	*Definitions*
Jacobs and De Man (1996)	Geographical or spatial agglomeration of business activity; horizontal and vertical relations between industries, using common technologies, presence of a central actor, and effectiveness of a cluster determined by quality of cooperation between companies
OECD (1996)	Production networks of closely related companies (including specialized suppliers), knowledge transfer institutions (universities, research centers, engineering companies), intermediary institutions (brokers, consultants), and clients in the added value chain
	Geographical concentration of industries which gain advantage in productivity thanks to co-location
Muizer and Hospers (2000)	Agreement on cooperation, whose main strategic goal is to maintain or increase competitiveness; the geographical dimension dominates, along with horizontal, vertical, and institutional connections
Ottati (2002)	Complex form of organization (governance) connected with economy and society

Source: Own elaboration on the basis of Bohatkiewicz-Czaicka and Gancarczyk (2018).

Clusters differ as to the level of networking among companies and organizations of the business environment (Trippl et al., 2015). They also differ in the level of development, i.e. the evolution or lifecycle stage (Karlsson, 2008; Martin & Sunley, 2007). The diversity of clusters can also be attributed to the level of spatial industrial concentration, regional specialization, as well as structures and nature of ties between industrial agglomeration members. Those ties are responsible for the flow of information, know-how between members of the cluster, as well as for innovation diffusion (Asheim & Isaksen, 2002; Brusco, 1982; European Commission, 2002; Gancarczyk, 2015; Gancarczyk & Bohatkiewicz, 2018; Markusen, 1996; Porter, 1990, 1998a; Pyke & Sengenberger, 1992; Saxenian, 2000; Vanhaverbeke, 2001).

A deeper analysis of governance forms in clusters shows that their network connections may be formal or informal and are based on joint resources. Such resources include complementary products or services, business processes, technical and research and development infrastructure, human capital, markets, and distribution channels (Baran, 2006; Porter, 2001; Rosenfeld, 2002). Moreover, networks in industrial clusters are currently expanding so that they go beyond the region and reach the international environment. That environment extends access to the above-mentioned complementary resources in order to limit costs and ensure access to knowledge sources and qualified human resources.

The definitions of clusters presented in Table 1.2 reflect the conviction that competitiveness does not lie in spatial concentration or co-location, but in network cooperation and geographical proximity. The latter become sources of external effects, including knowledge spillovers, economies of scale and scope, as well as low transaction costs. It must be emphasized, however, that the above-listed benefits may occur on a significant scale only if there is a critical mass of specialized entities. The presence of cooperation among less numerous entities does bring positive effects, but their scope is limited to a specific network rather than the whole territory or a comparative advantage on a domestic or international level.

On the other hand, network cooperation may be treated as the basis for expansion of a given group of enterprises and development of a cluster as specialized concentration of a specific industry or related industries. This value of the network cooperation was acknowledged in developing public support policies, based on the establishment of cluster organizations and cluster initiatives, regional innovation networks, and regional innovation systems (Jankowska, 2012). These concepts are similar to clusters, though they reveal their significantly different nature (Table 1.3).

Cluster initiative constitutes formalized cooperation between cluster members; its essence lies therefore in signing a relevant agreement (Dzierżanowski, 2012; Hołub-Iwan & Wielec, 2014; Palmen & Baron, 2016). Such a contract regulates cooperation for development, negotiations and strategy development, with participation of companies, public administration, and universities (Sölvell et al., 2003). The activity of such initiatives is aimed at education and transfer of knowledge and innovations from technically advanced industries that operate in close proximity (Sölvell et al., 2003). Cluster initiative may be coordinated by an entity defined as a cluster organization or without such an entity (Szultka, 2012).

Cluster organization, on the other hand, is a public-private entity, usually with a legal personality, which represents cluster initiative in such undertakings as project implementation, obtaining external financing, and concluding agreements (Jankowska, 2012; Kładź-Postolska, 2019). The activities of cluster organizations as associations usually include soft aspects, such as intermediary activities, promotion, as well as exchange of knowledge and information and communication. Complex ventures are usually taken by cluster organizations in the form of capital partnerships. They mainly deal with obtaining finance and implementation of commercial projects (Szultka, 2012).

Cluster initiative and cluster organization support the establishment and development of clusters, though they are not identical with them. Clusters usually occur as spontaneous structures, characterized by specific critical mass and specialization. Cluster initiatives and organizations constitute formalized types of cooperation for such structures, however, they are not distinguished by specialization or spatial concentration. Cluster initiatives and organizations may, on the other hand, constitute seeds of future clusters or stimuli for the growth of those agglomerations that are less advanced.

Other phenomena of economic policy referring to the model of a cluster include regional innovation network and regional innovation system (European Commission, 2002). It can be assumed that the nature of a cluster implies the presence of a regional innovation network as organized, formalized cooperation between companies in the region aimed at innovativeness. Such formalized cooperation is based on trust, norms, and rules which strengthen innovative activities of companies. However, not every regional innovation network is a cluster, as its definition does not reflect either spatial or industrial concentration. Thus it is not organized around specialization or common key competence, and it may combine entities from various, unrelated industries for the purpose of innovativeness. Moreover, cooperation in a cluster does not have to be formalized, which is the requirement of an innovation network (Table 1.3).

Regional innovation system is a broader concept than regional innovation network, as it occurs when cooperation for development and spreading

Table 1.3 Clusters and adjacent constructs related to economic policy

Construct	*Meaning and authors*
Cluster	Geographical concentration of companies from the same or related industries, remaining in network relations and creating connections with organizations and resources of regional environment (European Commission, 2002; Gancarczyk, 2010, 2015; OECD, 1999, 2001; Porter, 1998a, 2001; Vanhaverbeke, 2001)
Cluster initiative	Formalized cooperation between members of a cluster, gathering key players for the purpose of development; form of partnership in which development actions are agreed and implemented (Dzierżanowski, 2012; Hołub-Iwan & Wielec, 2014; Palmen & Baron, 2016)
Cluster organization	Public-private organization, usually with legal personality, established for the purpose of supporting the growth of a cluster in a particular region, usually representing cluster initiative for implementation of projects, securing financing, contracting agreements, or representing cluster initiative outside (Jankowska, 2012; Kładź-Postolska, 2019)
Regional innovation network	Organized cooperation between companies in the region, based on trust, norms, and rules which strengthen innovative activities of companies (European Commission, 2002)
Regional innovation system	Cooperation covering not only companies but also organizations of the environment, aimed at development and spreading knowledge in the region (European Commission, 2002)

Source: Own elaboration.

knowledge in the region not only comprises companies, but also organizations from the business environment (Asheim, 2001; Asheim & Isaksen, 2002; Cooke, 1998; European Commission, 2002). As in the case of innovation network, we can assume that nearly all clusters operate as innovation systems, since their activities concerning spreading knowledge and development of innovations not only cover companies, but also broadly understood institutions of technology transfer, financing, technical advice, and state institutions. However, not every regional innovation system can be identified as a cluster. Regional innovation system is not determined by attributes of companies concentration or specialization in particular areas of economic activity (Asheim & Isaksen, 2002). Regional innovation system may facilitate the development of clusters, which usually constitute part of such a system. As far as specialized regions are concerned, it is likely that their innovation system will be very similar to the scope of clusters operating in those areas. However, in diversified regions, usually a group of clusters will operate.

1.2 The Concepts of Cluster Competitive Advantages

1.2.1 Marshall's External Costs and Benefits

To explain the advantages of clusters we will adopt an extended theoretical framework of externalities. This approach is well justified by the development of the cluster concept since A. Marshall's (1920) analysis of industrial districts. Externality refers to the very characteristics of clusters, namely to common resources or club goods accessed by their participants and to governance modes that support the distribution of those common resources. We propose a comprehensive approach to externality that encompasses external costs and benefits, knowledge spillovers, network externalities, agglomeration economies, and transactions cost economics. To-date contributions normally focus on one of them or use them as separate constructs that explain different aspects of the cluster phenomenon. There have been limited efforts to apply them in one analytical framework that has common assumptions and rationale and that reveals logical links among them.

Since A. Marshall (1920), agglomeration advantages have been attributed to external economies of scale and scope based on specialized input-output linkages, information spillovers, and on the access to qualified personnel. Untraded interdependencies (Storper, 1997) comprise partially this phenomenon with reference to path-dependent relations based on conventions, informal rules, and habits that form a specific regulatory framework under conditions of uncertainty. These relations build a regional differentiation that relates to knowledge stock (what is done, how it is done) (Storper, 1997, p. 5) or broadly understood technology. In this view, externality is path-dependent, i.e.

developed through historical process of social interactions and transactions. External economies are independent of managerial decisions but they are dependent on the environment. In this approach, the company is treated as an autonomous and independent unit and there is a clear-cut separation of the organization and the environment (Saxenian, 2000).

According to Marshall (1920), benefits derived from division of work and related specialization are determined by spatial concentration of qualified workers, as well as suppliers and clients. Spatial proximity and critical mass of enterprises allow them to limit costs connected with mobility of goods, people, and ideas. Industry agglomeration is particularly important for external effects of knowledge or knowledge spillover or intellectual spillover (Krugman, 1991c; Rosenthal & Strange, 2003). Marshall describes this phenomenon as industrial atmosphere conducive to creativity, specialization, and learning (Belussi & Caldari, 2009). Spatial concentration also ensures productivity growth for companies, since they have easier and cheaper access to specialist production factors, such as labor resources, and investments in the production process (Brodzicki & Szultka, 2002; Mariussen, 2001).

The development of specialist labor market ensures mobility and increases the productivity of workers, limiting pay differences (De Blasio & Di Addario, 2002; Diamond & Simon, 1990; Krugman, 1991a). Such developed labor market attracts other companies to the cluster, enlarging the scale of the agglomeration and thus external benefits available in the environment (Combes & Duranton, 2006; Dahl & Klepper, 2007; De Blasio & Di Addario, 2002; Ellison et al., 2010). Similarities in specialization encourage cooperation and capital ties.

Marshall's district was composed mainly of small, local enterprises, which took advantage of flexibility and development of new products rather than economies of scale. Contracts between companies concentrated on close space and were of long-term nature. The district was resistant to external turbulences as main investment decisions were taken locally (Bohatkiewicz-Czaicka & Gancarczyk, 2018; Markusen, 1996). However, from the perspective of individual companies, workers' mobility and external effects of knowledge spillover mean problems with internalizing benefits.

According to Marshall, external benefits and costs occur when the production function of a particular company incorporates the effects of activities performed by other companies in a close environment (Marshall, 1925, p. 267). External benefits can be seen as increased incomes of the population and development of infrastructure. There are also external effects of scope, such as development of product and service range (Panzar & Willig, 1981). Moreover, there appear external economies of scale, related to production growth observed not in one company, but in the whole cluster as a production system. This effect depends on the district size, measured by the number of companies, clients, suppliers, and subcontractors.

1.2.2 Externalities by Marshall, Arrow, and Romer

Marshall's concept of external benefits and costs was then developed by A.C. Pigou (1952), who used the general category of external effects (externalities). In this vein, externalities appear when benefits and costs affect other entities than those directly involved in a specific transaction (Greenwald & Stiglitz, 1986; Pigou, 1952; Stiglitz, 2004, pp. 98–99, 254). Externalities are also treated as accessible in the environment goods, which are not taken into account in decision-making (Baumol & Oates, 1997; Stiglitz, 2004, pp. 98–99, 254). Moreover, the assumption is that the entity affected by externality cannot control or influence the extent of activities of those who form this environment. It is not possible to assign individual benefits and costs and to exclude others from specific benefits (Kasper & Streit, 1998). Some costs and benefits cannot be internalized and appropriated as private, and thus they become social benefits and costs. When social benefits exceed private benefits, we deal with positive externalities (external benefits); when social costs exceed private costs, this provides for negative externalities (external costs) (Greenwald & Stiglitz, 1986; Pigou, 1952). As the theory developed, the aspect of regional space gave way to the generalized theory of benefits and costs concerning the parties that are not directly engaged in economic transactions.

The return to the spatial character of external effects of knowledge spillover can be found in the works of P. Romer (1986) and R. Lucas (1988), who consider this effect as one of the main factors of economic growth. Correspondingly, three types of agglomeration externalities are differentiated, namely urban externality (Marshall, Arrow, Romer (MAR), localization externalities, and Jacobs' externality (Neffke et al., 2011). Localization externalities are based on the spatial proximity of companies in the same or related industries and they resonate with Marshall's types of external benefits.

The MAR concept explains the external effects of knowledge within the same industry. It indicates that spatial proximity of entities conducting related activities is crucial to knowledge transfer, whereas local specialization and market domination of some entities ensures better effectiveness than competition (Gustavsson, 2003). On the other hand, (J. Jacobs, 1969) argues that the sources of innovativeness and knowledge are exogenous and originate outside the industry or region. Development depends on critical mass and differentiation of local activities, i.e. diversification within geographically proximate industries (Gustavsson, 2003). Krugman (1991c) points at close ties between the aspects of specialization and spatial agglomeration as well as at growing economies of scale, which justify the establishment of clusters.

1.2.3 External Economies of Scale and Scope in Italian Industrial Districts

Research on industrial districts was continued by Italian scientists, such as G. Becattini, A. Bagnasco, M. Bellandi, S. Brusco, G. Garofoli, and F. Sforzi. Giacomo Becattini analyzed the region of Tuscany (Becattini, 1966, 1969, 1975), referring to the output of Marshall (Becattini, 1962, 1975). His research led to the conceptualization of the so-called new industrial districts. Those districts were dominated by specialist networks of SMEs in consumption industries, located in the Central and Northern parts of the country, named Third Italy. Thanks to innovativeness, they developed an ability to compete globally, based on luxury consumption goods (Bellandi & Lombardi, 2012; De Marchi, Giuliani, et al., 2018; Long & Zhang, 2011; Rabellotti, 1997; Saxenian, 2006; Schmitz, 1989). In a cluster of this type, there was high staff turnover between competing companies and high share of staff performing knowledge-intensive activities (such as designing, research and development, and advanced manufacturing).

Italian districts, just like Marshall's districts, have the structure based on specialist, cooperating, and competing SMEs. However, they differ in their openness to foreign markets, greater cooperation and coordination of markets than competition, and they go beyond the production system to the social and cultural system. Bagnasco emphasized the importance of traditions, local ties, and common system of values, which support both external and internal effects in a cluster (Becattini, 1990, 1991). There are strong industrial associations which, when entering into relations with banks and local authorities, establish the so-called consortia aimed at financing large investments, including research and development, and foreign expansion.

Companies cooperating in this way acted as a virtual organization, gaining external economies of scale and scope. District participants experienced external economies of scale, for example, in joint purchases and shared distribution channels for specific goods. External benefits of scope consisted in joint use of one resource in order to produce more than one good, i.e. to portfolio diversification. This concerns, for instance, use of common research and development infrastructure, the place brand, and investment financing instruments.

The specialization strategy based on the autarchic SME system following Marshall's model may lead to development lock-in (Rosenfeld, 1997). Therefore, the Italian district shifted from rigid specialization of manufacturing techniques and markets to related diversification of products and customers, based on flexible specialization technology (Pyke & Sengenberger, 1992; Sabel & Piore, 1986). This technology allows to produce, in small batches, goods tailored to the needs of a larger number of customers, which helps avoid overdependence on one or few buyers.

1.2.4 Externalities Subsumed by Transaction Cost Economizing

Italian industrial agglomerations were also analyzed by representatives of the Californian school of localization (Pyke & Sengenberger, 1992; Sabel & Piore, 1986; Scott, 1988; Storper, 1995; Walker, 1989). On the other hand, research in the US conditions was conducted by Christopher and Storper (1986), who analyzed the movie industry in Los Angeles; Scott (1986) and Scott and Paul (1990), who described Orange County; and Saxenian (1990, 1991, 2007, 2011, 1996, 2000), who presented the origins and growth of the Silicon Valley. The Californian school described the phenomenon of flexible specialization and introduced the concept of *new industrial spaces*, which were the outcomes of vertical disintegration and fragmentation of production (Olejniczak, 2003).

Unlike Italian districts, which were characterized by the superiority of cooperation, in American industrial agglomerations we can observe the dominance of competition (Doeringer & Terkla, 1995; Olejniczak, 2003). Both forms of coordination were based on informal institutions, rules, or untraded interdependencies (Storper, 1997, p. 5). The Californian school also described a district from the perspective of economizing on transaction costs (Coase, 1937, 1960; Williamson, 1989, 2000, 2005). Transaction cost economics (TCE) is claimed to subsume the externality problem, as an incidence of market failure that cannot be resolved by private negotiations and contracts (Arrow, 1964; Coase, 1937, 1960). In the view of TCE, externality exists when it is not possible to assign private benefits and costs to exchange partners due to excessive transaction costs, whereby transaction costs are the costs incurred when negotiating and implementing market contracts. TCE points to the cost of exchange in inter-organizational relationships rather than to the benefits of cooperation. According to Williamson, economizing on transaction costs can be achieved by aligning a specific transaction with a proper governance structure (Williamson, 2005). In determining how to fit the transaction with the governance mode, TCE integrates technological and behavioral assumptions, treating asset specificity and opportunism as the major determinants of transaction costs. Asset specificity means that these assets are tailored to the needs of an individual party in the exchange. Hence, it is difficult to redeploy them in another business relationship, and they increase the dependency of partners. The latter leads to opportunism treated as 'self-interest seeking with guile' and rent appropriation at the cost of the transaction partner. Opportunistic behaviors induce a holdup problem and other issues related with the contract implementation. Therefore, asset specificity, as a technical and technological construct, and opportunism, as a behavioral factor, are generic determinants of transaction costs.

The problem of opportunism in clusters is limited by unique governance form, based on the relationships of mutuality and trust. Transaction costs are reduced due to social capital and untraded interdependencies. The impact of asset specificity can be alleviated by production systems unique to clusters, such as flexible specialization that limits dependence from one or few buyers or suppliers. Moreover, geographical proximity limits the costs of transport and communication. Proximity and untraded interdependencies build trust and reciprocity, limiting, inter alia, transaction costs related to obtaining information on contract partners and monitoring contract implementation.

1.2.5 Porter's Externalities

M. E. Porter (1990, 2001) popularized the concept of a cluster as a geographical agglomeration of related industries, which create a value chain that is conducive to synergy effects. While noticing the importance of ties between companies, emphasized in the concept of an industrial district, Porter emphasizes dependencies between industries creating the value chain in the region. Analyzing cases of regions characterized by agglomerations of highly competitive industries (ceramic tiles in Italy, food processing in Denmark, manufacturing of printing machines in Germany, production of medical equipment in the United States, production of robots in Japan), Porter described their mode of governance. Regions drawing competitive advantage from synergies between industries determine the competitive advantage of countries. While emphasizing the significance of supra-regional and supra-national competition in the growth of the region and inspiring innovativeness of companies, Porter draws our attention to the need for opening clusters to the international environment.

Porter's 'diamond' model presented factors shaping the international competitive advantage of countries based on clusters. Porter's model was based on such factors behind the origin and competitiveness of industrial agglomerations as the context of strategy, structure and rivalry between companies, demand-related factors, production factors, as well as related and supporting industries. Influenced by Porter, development policy concentrated on strong support for regions, accompanied by ambitions to copy the success of the Silicon Valley and other leading clusters. Porter demonstrated that it is local competition rather than monopolistic structures that supports innovation and knowledge spillover. These so-called Porter's positive external effects are typical for regions with high level of internal competition between cluster participants on the same stage in the value chain.

1.2.6 Network Externalities

A modified view of externality is presented in the concept of network externality. The theory of network externality was initiated by Katz and Shapiro (1985) and the origins were not regionally bounded as in the case of its predecessor, i.e. externality, but it was based on the observations of competition rules, mainly in telecommunications, electronics, computer, and transportation industries. Network externalities take place when the value of a good increases with the increased number of its users, including producers of final goods, subcontractors, suppliers, buyers, and consumers (Katz & Shapiro, 1985). Networks are stimulated by individual choices of consumers and companies who search for benefits from communication, compatibility, comparability, and from complementary goods and services. The benefits gather users around a specific good or technology to establish it as a standard and a dominant solution. Network externalities explain the mechanisms of technology battles, standardization, and dominance (Katz & Shapiro, 1994), the latter achieved through path dependence, switching costs, and locking users in the leading standard. This lock-in situation also implies negative network externalities, such as (Liebowitz & Margolis, 1996), dominance of technologically inferior but more popular technological solution, and unfair internalizing network benefits by individual or few companies, monopoly, and eliminating competitive innovative activity.

In the 1990s, researchers in economic geography and sociology applied the concept of network externality in a novel way (Antonelli, 1993; Capello & Nijkamp, 1996; Gancarczyk, 2010; Saxenian, 1994, 2000). These effects are understood as external benefits and costs shared by participants of a particular network. Regional connections cover social networks and business networks, building context or embeddedness of the cluster in the socio-economic structure of the region (Gancarczyk, 2012; Granovetter, 1985). The external effects of a network require specific critical mass, i.e. a sufficiently high number of entities belonging to the cluster.

The focus of regional research on network externalities was not on the products that gather users in networks, as in the original theory, but on the benefits from knowledge spillovers provided by networks. This approach can be treated as a contribution to the general theory of network externalities, which is basically product-focused. In particular, the dynamics between hierarchical and heterarchical networks, with different power and agency relations, and varying prospects for knowledge and innovation development, can be seen as affecting both an individual firm and the entire cluster performance (Huggins & Johnston, 2010; Lorentzen, 2008; Wall & Knaap, 2011; Wall & van der Knaap, 2011; Zucchella, 2006).

Networking forms a foundation for cluster competitive advantage, due to knowledge spillovers (Asheim & Isaksen, 2002, 2003, pp. 36–40; Markusen, 1996; Porter, 2001; Pyke & Sengenberger, 1992; Saxenian, 2000). Agglomeration externalities, including localization externalities, are based on co-location, where information spillovers are in place and can be absorbed unwillingly, for instance, via personnel fluctuations and market transactions (Audretsch, 1995; Glaeser & Kerr, 2009; Gompers et al., 2005).

Information, as a collection of organized data, can be codified and exchanged without the necessity of purposeful and deepened interactions. However, knowledge, which denotes the capacity to utilize the information, is often informal, tacit, and built into employee competence and organizational processes and routines. Knowledge spillovers require strategic behavior, directed at deepened, network interactions (Gertler, 2007; Molina-Morales & Martínez-Cháfer, 2016; Nonaka, 1991). Network knowledge is a term describing knowledge as a network property. Consequently, knowledge spillovers should not be considered from the perspective of an autonomous individual company, but from the perspective of the network, as a joint resource underpinning its competitive advantage (Saxenian, 2000; Vicente & Suire, 2007).

The lock-in phenomenon described in the original, product-based theory of network externalities, has its reflection in the regional stream of this research focusing on knowledge spillovers (Gancarczyk, 2010). In this stream, lock-in implies trapping users into the technological solution, which may prove inferior, and may impede the competition of network members (Delgado et al., 2010). In regional studies, lock-in can be exemplified as binding into the regional network of suppliers. This inward focus impedes creativity, new ideas, and new relationships for innovation and efficiency purposes. Rigid and closed interactions among the same actors are referred to as over-embeddedness (Alberti, 2006; Molina-Morales & Martinez-Fernandez, 2007; Soda & Usai, 1999). Over-embeddedness is induced by high switching costs of the established contracts, difficulty in finding partners with adequate specific assets, and petrified social and business connections. Excessive closeness of the network leads to the trap of rigid specialization or sterilization (Grabher, 1993), inability to enter into new areas of activity when the existing industries prove unprofitable. Conversely, the ability to refocus from mature and cost-led industries to new, technologically advanced and knowledge-intensive helps to avoid the decline (Boschma & Frenken, 2011). The examples include the changing profile of the Basil cluster, from dye industry to chemical and pharmaceutical products; Tsubame in Japan, from cutlery to the production of construction equipment; Silicon Valley and the Cambridge region, from computer, electronic and precision instruments to software, biotechnology and environment protection; and Montebelluna in Italy, from footwear to sportswear (Gancarczyk, 2010).

Faced with lock-in, the cluster strength of density and power of network relationships turns into its weakness. A cluster becomes unable to keep up with international competition on design, new product, technology, and costs (Sornn-Friese & Simoni Sørensen, 2005). This mechanism can also be explained by the original concept of network externality, in which network benefits are derived from expanding the network globally.

The concept of network external effects was used by A. Saxenian (1996), who described the origins and development of Silicon Valley and the decline of Route 128 in the USA. According to Saxenian's observation (1996, 2000), competitiveness of the Silicon Valley was due to the use of network effects both inside and outside the cluster, through supra-regional and international exchange. Saxenian noticed that geographical proximity alone does not determine the capability of companies and clusters to adapt and transform. Also ties between entities in geographical proximity are vital (Florida & Kenney, 1990; Gancarczyk, 2010; Saxenian, 1996). Companies in the Silicon Valley cooperated and competed, which was accompanied by both planned and spontaneous knowledge spillover. On the other hand, Route 128 was dominated by autarchic corporations, concentrated on formal relations within the agglomeration and using the model of closed innovation (Chesbrough, 2003; Saxenian, 1996). A. Saxenian (1996; 2000, 2007) considered the so-called brain circulation, consisting in expanding the cluster to other agglomerations with similar industry profile within GVCs, to be of key importance (Saxenian, 1996, 2007).

The network mode of district governance was also emphasized by A. Markusen (1996). Markusen (1996) abandons the assumption of dominance of small- and medium-sized enterprises (SMEs) in the agglomeration structure, so typical of districts, as well as internal orientation of the regional production system. The author indicates that industrial agglomerations may also be concentrated around entities other than SMEs and emphasizes the importance of international markets and subcontractors for the development of companies and their parent regions. Markusen (1996) proposes four types of districts, differentiated by dominant entities and types of contract relations between companies. The entities creating the district center include a large company with its headquarters in a particular cluster, a branch of a foreign company, as well as state companies and institutions. He emphasizes the essential role of large companies located in the district, acting as gate-keepers to foreign markets, technologies, and production factors. The distinguished types of network ties directly affect the possibilities of sharing investment risk and access to finance and sources of technology. Access to international resources of knowledge and capital becomes a vital factor in the development of a cluster and its home area.

1.3 The Concepts of Cluster Dynamics

1.3.1 Resource-based View and the Strategies of Cluster Lead Firms

The resource-based view (RBV) in research on clusters relies on the microeconomic theory of company growth developed by E. Penrose (1959), evolutionary economics (Nelson & Winter, 1982), and organizational science

(Barney, 1999; Peteraf, 1993; Teece, 2007; Wernerfelt, 1984). In its original form, the RBV indicates organizational resources, particularly dynamic capabilities (Teece, 2007) as sources of competitive advantage. The industry environment and the macro-environment in this concept yield to companies' internal potential (Cohen & Levinthal, 1990; Kogut & Zander, 1992; Penrose, 1959). Nevertheless, they remain an essential reference point, as companies grow by matching their capabilities with environmental opportunities (Penrose, 1959).

In this scope, clusters are specific, as companies subjected to the network form of regulation develop a system benefiting from common resources (club goods and external effects of the network). The rooting in the socio-economic system of the region and the above-mentioned external effects make it impossible to fully separate private benefits and costs within the cluster, and account for the necessity to treat regional resources as resources of industrial agglomeration in a particular territory (Expósito-Langa et al., 2011; Fritsch & Kublina, 2018; Gancarczyk & Bohatkiewicz, 2018; Gancarczyk & Gancarczyk, 2018; Hervas-Oliver et al., 2012; Karlsen et al., 2023). Attention is drawn to the development of resources and cluster capabilities, as those processes introduce a dynamic and evolutionary perspective. The concepts discussed earlier focused on foundations of the cluster competitiveness as a network governance mode, characterized by external effects and partial inseparability of resources. However, they did not indicate the change or dynamics of these structures. In fact, the understanding of change constitutes a foundation for planning development by companies, as well as planning and selecting instruments within economic policy.

One of key concepts determining the development potential of regions and clusters is the concept of absorptive capacity (AC) (Cohen & Levinthal, 1990; Expósito-Langa et al., 2011; Fritsch & Kublina, 2018; Hervas-Oliver et al., 2012; Karlsen et al., 2023). AC can be defined as the cluster's capacity to integrate, build, and reconfigure internal and external competencies in response to changes occurring in its environment. Absorption capacity constitutes thus industrial agglomeration's potential for absorption and internalization of external knowledge (Ahlin et al., 2014; Cohen & Levinthal, 1990; Gancarczyk & Bohatkiewicz, 2018; Zahra et al., 2006).

At the same time, the resource-based approach does not limit cluster resources and capabilities only to the home region. Just as in the network approach, it indicates the necessity to expand regional networks into international ones, so as to secure investment and gain access to external knowledge, resources, and technologies. The resource perspective additionally points at sources of change, which depend on companies' capabilities to exploit the knowledge already existing in the cluster and to explore new opportunities and areas of activity (Gancarczyk & Bohatkiewicz, 2018; Maskell & Malmberg, 2007). The challenge lies in maintaining and developing competencies and technologies constituting resources of a particular network through international exchange, as well as exploration of new, prospective areas of activity. This can be achieved by appropriate methods of international expansion, including relocation strategies, which help to avoid the hollowing out of the cluster and to maintain its identity and technological advantage. These strategies depend on the choices of lead companies (focal, dominant), which coordinate the network of a particular agglomeration and perform the function of gate-keepers, as well as access to international markets, sources of knowledge, and other investments.

1.3.2 Evolutionary and Life Cycle Approaches

The resource-based approach stresses the importance of international ties of the cluster and indicates pathways of its development determined by strategies of lead companies. However, it does not describe how clusters change and what possible stages and reasons for such development are (Fornahl et al., 2015; Ter Wal & Boschma, 2011; Trippl et al., 2015). These problems are addressed in the concepts of cluster life cycle and evolution (Frenken et al., 2015; Martin & Sunley, 2006, 2007; Ter Wal & Boschma, 2011; Trippl, 2004; Trippl et al., 2015). The dynamics of the cluster's position in GVC is analyzed in connection with the stage in the life cycle of an industrial agglomeration (Braunerhjelm & Feldman, 2006; Gancarczyk & Bohatkiewicz, 2018; Swann, 1998). The cluster's growth depends on the development stage dominating in the industrial agglomeration, whereby cluster development is possible in early stages of the cycle, when knowledge is not standardized yet and technological diversity dominates (Ter Wal & Boschma, 2011). However, industrial agglomerations may develop independently of the industry life cycle, based on competencies and socio-economic conditions specific to companies and the region.

The criticism of the life cycle concept stemmed from determinism of biological phenomena and the sequential view (Bergman, 2008; Martin & Sunley, 2011; Maskell & Kebir, 2006; Oinas et al., 2013; Ter Wal & Boschma, 2011). Nevertheless, cluster changes can be irregular and disruptive, and caused by external factors (Boschma & Fornahl, 2011; Martin & Sunley, 2007; Trippl et al., 2015). In this situation, the development of clusters is better explained by the concept of evolution and structural change. The decline and revival of clusters may be perceived from the perspective of the evolution of network ties, which lead to changes in the agglomeration structure (Biggiero, 2006; Gancarczyk, 2010; Sammarra, 2005; Sammarra & Belussi, 2006; Saxenian, 2000, 2007; Sturgeon, 2003; Waxell & Malmberg, 2007; Zucchella, 2006). The development of a cluster depends on its ability to avoid the isolation effect (lock-in).

One of the ways of avoiding the isolation effect is to preserve diversity in the industrial agglomeration by joining international exchange and by development of capabilities (Ter Wal & Boschma, 2011; Trippl et al., 2015). Therefore, cluster dynamics and international competitive edge are explained from the perspective of internationalization and inclusion in global value chains (Aslesen & Harirchi, 2015; Humphrey & Schmitz, 2002; Pietrobelli & Rabellotti, 2011). In the GVC concept, whose in-depth analysis will be presented in the next chapter of the book, cluster capabilities and resources, including ability to absorb external knowledge, support processes of information diffusion, learning, and generating innovations, which strengthens the position of a particular agglomeration in international exchange (Gancarczyk & Gancarczyk, 2018; Marshall, 1920; OECD, 2000).

1.4 Global, Regional and International Value Chains

1.4.1 The Essence and Origins of Global Value Chains

The concept of value chain was formulated by M.E. Porter (1985, 1990), who analyzed this phenomenon on the level of companies and industries. Porter (1985) presented a company value chain as a systematized sequence of activities leading to value for a consumer. Within these activities he distinguished primary and support functions as well as margin. Primary functions comprise logistics and operational activities, marketing and sales and after-sale services. Support functions include management and administrative activities, research and development, design and supply chain management. Identification of key value-creating elements provides the base on which division of work and specialization within key competencies of a company are determined. A particular entity may concentrate on elements building its competitive edge, outsourcing those areas in which it does not have cost or technological advantage (Magretta, 2014). These areas become the subject of cooperation with suppliers and buyers, and subsequently, lead to vertical disintegration and fragmentation of the value chain.

In consequence, the value chain is also analyzed from the industry perspective, as vertical relations with suppliers and buyers, which constitute separate sectors of activity. Further development of this concept can be found in Porter's 'diamond' model (1990), which, in place of a single company, focuses on ties between industries in the region. One element of the 'diamond' is relations between the sector of companies – producers of final goods and related and supporting sectors. The origin and development of regional agglomeration is determined not only by strategy, structure, and level of competition between final producers. Of vital importance are also network ties between the sector of final producers and specialist- related industries which comprise providers of components and services in the manufacturing process. On the other hand, quality and innovativeness of industries in the vertical system are shaped by supporting sectors, comprising, inter alia, providers of finance, technical support, and distribution. These regional value systems achieve effectiveness and specialization exceeding the boundaries of one region. Internal competition somehow pushes companies to compete internationally and thus clusters become the foundation of international competition of national economies.

Following the processes of internationalization of economic activity and geographical fragmentation of production, the idea of Porter's regional value chain was developed into the concept of a global value chain (Chilimoniuk-Przeździecka & Kuźnar, 2016; Gereffi et al., 2005; OECD, 2013; Rudny, 2013; Sturgeon, 2013). A global value chain is treated as a series of production stages, beginning from research and development activities, designing, distribution, through manufacturing to marketing, sales, transport, and after-sale services, generating the value of goods and services on an international scale (Banga, 2013; Humphrey & Schmitz, 2000; Kaplinsky & Morris, 2001; Ponte, Sturgeon, et al., 2019).

The main problem analyzed in the GVC concept concerns the division and location of added value in the international system (Caspari, 2003). Consequently, the concept of global value chains aims at explaining the method of generating, seizing, maintaining, and using value in economic relations on the international level (De Marchi et al., 2018; Gereffi & Fernandez-Stark, 2016; Gereffi & Lee, 2016; Humphrey, 2004, 2020; Humphrey & Schmitz, 2002; Kaplinsky, 2015; Sturgeon & Gereffi, 2012).

Value is geographically dispersed among countries and regions (Caspari, 2003; Giuliani et al., 2005; Humphrey, 2007; Ponte & Sturgeon, 2014). The scope of chain fragmentation depends on the level of industry maturity and standardization of its technologies. In mature industries with formalized, standardized technologies, the value chain is significantly dispersed geographically (Sturgeon, 2002, 2003). The dissemination of technological standards allows international expansion, based on the exchange of formalized knowledge and efficient communication of expectations concerning product and service parameters required from foreign subcontractors (Caminati, 2006; Funk, 2009). Porter's model (1985, 1990), the GVC concept allows us to divide activities of companies and industries into key or primary ones, directly connected with production of a particular good, and accompanying or supporting activities, concentrated on quality and innovativeness of basic functions, for example through human resource management and strategic planning (Kaplinsky & Morris, 2001).

The decomposition of the value chain in this concept is connected primarily with identification of activities with relatively higher and lower added value and spatial distribution of the function with diversified level of this value (Todeva & Rakhmatullin, 2016). The activity characterized by low added value, such as production of standard components and assembling, is a standardized and routine activity, whereas added value stems here from the implementation of required technical norms and cost advantages (Biggiero, 2006; Sturgeon et al., 2008). High added value activity is distinguished by knowledge absorption and considerable share of non-formalized or tacit knowledge, such as research and development, design, engineering, advanced manufacturing, marketing, and after-sale services. The central part of the value chain contains standard activities (Mudambi, 2008). Higher added value is located at the ends of the value chain, i.e. in its initial stages (research and development, design, prototype-building) and its final stages (marketing, customer service, after-sale service). This accounts for the 'smiling curve' of the value chain (Mudambi, 2008; Yan & Islam, 2011).

GVC not only involves functions, but also varied entities – stakeholders who can be presented according to their roles. Dominant companies (leaders, lead firms, focal companies) coordinate the value chain as international corporations and providers of final goods (OEM, original equipment manufacturers). Contract manufacturers are also large corporations, acting as coordinators of the whole production system or turnkey manufacturers. They possess technical and organizational capabilities to act as key sub-suppliers for dominating companies. They are advanced providers of production and engineering services. On the other hand, subcontractors of standard goods are often called capacity suppliers (De Marchi et al., 2017). This division of roles builds a hierarchical system on a global scale, with varied positions and share in added value of companies and industries and their domestic regional and national economies (Markusen, 1996). It is often a persistent system, resistant to change. This demonstrates the determinism of GVC structures and limited prospects of upgrading.

An internal factor which may potentially lead to the change of the position in the GVC are institutions transferring knowledge to local suppliers, such as universities, training centers and research and development centers, trade associations, patent institutions, and financial institutions. They may become intermediaries, specific knowledge brokers, and support in negotiating contracts determining the position of local enterprises in the GVC (Brusco, 1982; Corno et al., 1999; De Marchi, Di Maria, et al., 2018; Molina-Morales & Martínez-Cháfer, 2016; Porter, 1990).

The intellectual foundation for the concept of GVC was global commodity chains (Bair, 2005; Gereffi & Korzeniewicz, 1994) and global production networks (Coe & Yeung, 2015; Henderson et al., 2002; Neilson et al., 2014). Compared to global commodity chains and production networks, the idea of GVC is distinguished by its emphasis on added value instead of production activity or delivery of standard investment (Ponte, Gereffi, et al., 2019; Sturgeon*, 2009, p. 117). Moreover, the global nature of this phenomenon does not concern only the geographical scope, but also refers to technological and functional integration and interdependencies of markets and industries internationally (Dicken & Thrift, 1992; Gereffi & Korzeniewicz, 1994; Ponte, Gereffi, et al., 2019).

1.4.2 From GVCs to Regional and International Value Chains

The idea of GVC is currently being developed and transformed toward such approaches as regional and international value chains (IVC) (Gong et al., 2022; Zahoor et al., 2023; Zhan et al., 2020). On the one hand, changes are significantly triggered by digital technologies and climate change pressure (Gancarczyk et al., 2022; Łasak & Gancarczyk, 2021b, 2021a). They increase flexibility and efficiency of chain coordination; they also account for integration of certain activities, for example, via artificial intelligence, and thus functionally shorten and simplify the chain structure. Another reason behind the shortening and simplification of supply chains is care for the environment expressed in limiting energy consumption and emission of pollution related to logistics and transport to distant locations.

On the other hand, we can observe the influence of external shocks on IVC transformation. In recent years we have seen disruptions, holdups, and even terminations of value chains (Stöllinger et al., 2018; Van Hassel et al., 2022; Zahoor et al., 2023). Recently, these phenomena became observable as a result of the financial and economic crisis of 2007–2009, then the Covid-19 pandemic, and at present – the military conflict in Ukraine. The disruptions and holdups in supply chains undermined trust in economic relations and increased the perceived risk of cooperation (Kano et al., 2020; Zahoor et al., 2023). The immediate effect was a series of changes in the GVC range, such as near-shoring, i.e. shortening of chains and limiting their geographical scope to the countries of the nearest region, for instance those in Europe or North America (Cieślik et al., 2021; Kaivo-Oja et al., 2018; Piatanesi & Arauzo-Carod, 2019; Van Hassel et al., 2022). The choice of partners in proximity is often based on the additional criterion of friend-shoring, which is a concept similar to the understanding of institutional – regulatory and cultural – proximity (Banaszyk, 2023; Boschma, 2005).

The above-mentioned technological changes and external shocks lead to the reconfiguration of GVC and the co-existence of global and regional value chains, covering cooperation in the close international space (Cieślik et al., 2021; Kordalska & Olczyk, 2023; Stöllinger et al., 2018). As a result, a general concept of international chain values has been introduced recently, covering regional chains, within international areas, characterized by physical and socio-economic proximity, and GVC (Cieślik et al., 2021; Kordalska & Olczyk, 2023; Stöllinger et al., 2018). In this book we shall use the general concept of IVC, which reflects the contemporary model of international cooperation, as some sort of a patchwork of regionalization, joining partners that are close to one another spatially and institutionally, and globalization, which assumes integrated and uniform approach to differentiated markets. In the empirical part of our study we shall focus on the perspective of regional chains in Europe, in the context of upgrading, i.e. increase in added value. The shortening of value chains requires access to more varied products and services in the nearby international space. In addition to specialization in the value chain, it is essential to ensure the necessary level of activity diversification. From the point of view of prosperity growth, this should be the diversification of products and the development of functions characterized by higher added value in IVCs, namely, diversification toward upgrading.

The determinants of the coordination form and the upgrading within IVC can be analyzed from the bottom-up or top-down perspective. The latter would concentrate on the geographical distribution of chains and international division of labor. The reference point is the activity of dominant companies and their relations with subcontractors (Gereffi et al., 2005; Gereffi & Fernandez-Stark, 2016). Specialization in the global approach becomes vertical and focuses on supplier-buyer relations in the value chain (Grodzicki, 2018). Coordination of dominant companies may adopt the form of modularization, relational cooperation, or hierarchical cooperation (Ponte & Sturgeon, 2014; Sturgeon, 2002, 2003). In this approach, international corporations are an indicator of international division of income and capital flow; they also constitute a basic unit of IVC analysis (Dicken, 2007; Gereffi et al., 2001; Ponte & Sturgeon, 2014).

The bottom-up perspective of the upgrading processes emphasizes the importance of the local institutional context and resources mobilized in order to upgrade the position within the IVC (Gereffi, 1999; Gereffi et al., 2005; Humphrey & Schmitz, 2000). It takes into account strategies and policies of countries, regions, clusters, and local stakeholders operating for this position (Gereffi, 2010; Gereffi & Lee, 2016). In our book, we adopt the bottom-up perspective, aiming to specify the determinants of the clusters' position on the basis of their capabilities and forms of coordination shaped with their participation (Gereffi & Lee, 2016).

1.5 The Insertion in IVCs and the Transformation of Clusters

1.5.1 The Rationales and Methods of Clusters' Insertion in IVCs

The essence of clusters lies in tying the system of network relations between companies and organizations of the environment to the resources of a particular area, usually – a region. This is reflected in the already presented concepts of competitive advantage and dynamics of clusters. According to the concepts of competitive advantages (Section 1.2), the basis of a cluster's capability of competing on an international scale is a set of endogenous factors, such as external benefits, synergies, and consciously shaped instruments of risk-sharing, financing, and access to information and knowledge. Local advantages serve international expansion, searching markets for specialist supply which exceeds the regional or domestic demand. However, the developed system of the value chain in the region remains an asset. The chain not only constitutes a production structure, but also a repository of technical and organizational knowledge for the entities belonging to it. According to the concepts of competitive advantages, the cluster regional system creates capabilities allowing it to generate income through foreign expansion in the form of exports (Bellandi, 2001; Porter, 1990, 2001). Examples can be seen in export activities of small- and medium-sized companies in the Italian cluster, or export activities of large companies in a hub-and-spoke agglomeration described by A. Markusen (1996). In the last case, internationalization of the cluster's large enterprises is achieved not only through exports, but also through cooperation within other functions, such as distribution and production. External cooperation does not disturb long-term investor-enterprises relations within the original cluster.

In the discussed concepts of competitive advantages, internationalization of the production function is manifested in direct inward investment from international corporations, attracted to the cluster's specialist production factors and expertise. The cluster structures concentrate then on corporation branches, with headquarters and investment decisions outside the agglomeration. This induces a change in the cluster network structures, which become weaker as the ties between the satellite branch and the main company grow stronger. This also weakens the common mechanism of sharing risk, investment, and knowledge development. In the presented concepts of competitive advantages, reasons for cluster internationalization comprise mainly specialization of supply and need for bigger markets, search for high-quality inputs at optimal cost, and need for external investment capital from foreign corporations (zu Köcker & Buhl, 2007).

The concepts describing cluster dynamics as resource-based concepts, as well as the concepts of cluster evolution and life cycle, concentrate on internal changes within the agglomeration. While describing these changes, they refer to models of stage development of networks or industry's technology life cycle (Gancarczyk, 2015; Gancarczyk & Gancarczyk, 2018). They pay less attention to mechanisms connected with internationalization of activities of enterprises comprising a cluster, though they appreciate its significance for the development of regional structures. In the resource approach and in the concepts of life cycle and evolution, excessive concentration on internal relations (excessive inward focus) poses threats of isolation and lock-in. In order to maintain the development of a cluster, it is necessary to preserve the diversity of technologies and business models. One source of such diversity may lie in opening enterprises to international cooperation.

Active involvement of clusters in international exchange and IVC, however, is not broadly discussed in the main theoretical approaches to clusters. This subject is developed within the GVC concept and the research trend integrating the RBV and the international business theory (Aslesen & Harirchi, 2015; Gancarczyk & Bohatkiewicz, 2018; Gereffi et al., 2005; Humphrey & Schmitz, 2002; Pietrobelli & Rabellotti, 2011; Sturgeon, 2003). The latter analyzes inward investment of cluster companies and considers the influence of such processes on industry agglomerations. Cluster integration in IVC is also the subject of economic policy and analysis of international institutions, such as the European Commission (2016; Ketels, 2017; Ketels & Protsiv, 2016), the World Bank (Cattaneo et al., 2010; Webber & Labaste, 2009) or UNCTAD (UNCTAD, 1998, 2021). The reasons for cluster internationalization include not only expansion of markets and access to external tangible and intangible resources. These reasons are also connected with strategies of lead companies and stem from their preferences concerning market development, technologies, or cutting costs.

The research trend referring to international strategies of companies points, inter alia, at different roles played by companies in agglomeration networks and in international exchange. Apart from leading companies, such as brand suppliers of final goods in Italian clusters, there is a significant group of small- and medium-sized enterprises – suppliers dependent on the dominant entities' strategy. There are also companies specializing in the production of a particular component, within which they maintain their leadership on an international scale. Companies may also act as production system coordinators in IVC for brand manufacturers, who then concentrate on research and development as well as marketing and branding.

One can distinguish a passive and a proactive approach to internationalization (Jankowska, 2010). The passive approach, typical of small- and medium-sized subcontractors, treats international markets as a source of expenditure and knowledge as well as investment capital. It covers such methods of internationalization as import of inputs, offshore outsourcing of components and services, acquisition of intangible assets and intellectual property (for example, licenses), and sale of shares or joint ventures with foreign investors. The active approach, typical of cluster leaders – large companies and some competitive SMEs, treats foreign markets not only as a source of demand and expenditure, but also as an area of expansion. It is manifested in exports of goods and foreign outward investment – relocation of the distribution and production functions by establishing branches, as well as mergers and acquisitions.

Empirical research on cluster internationalization and their inclusion in IVC remains scarce and is usually based on single or multiple case studies, which does not allow for statistical generalizations. Quantitative analyses of these phenomena remain rare; therefore, our book is aimed at filling this research gap.

1.5.2 The Transformation of Clusters in VCs

The transformation of clusters concerns transformations within the major attributes of this phenomenon, influenced by evolutionary processes or economic events (Gancarczyk et al., 2023; Gancarczyk & Gancarczyk, 2013). Transformation may then be evolutionary, by means of cumulative, incremental changes, or radical changes, triggered by external shocks and breakthrough events (Gancarczyk & Gancarczyk, 2013). Transformation denotes significant changes in key attributes of a cluster, such as degree of industry concentration, scope of specialization, and nature of network relations. Changes in spatial concentration may consist in the growth or decline of critical mass of companies, which is most frequently reflected in the location quotient (Ketels & Protsiv, 2014). Location quotient measures the relation between the share of the industry in the region's economy compared to its share in the country's economy. The most popular indicators taken into account include such industrial outputs as its sales and employment (Carroll et al., 2008; Górska & Łukasik, 2013; Szabó, 2015; Yoo, 2003). The dynamics of the industry results can also be presented in an input-output analysis (Hauknes, 1998; Szabó, 2015; Titze et al., 2011; Yoo, 2003). However, the application of this analysis is limited on the regional level due to a lack of data on particular industries. Changes of industry and geographical concentration indicators show the dynamics of specialization from the perspective of industries tied in input-output relations.

Internal and external ties may be defined by such theoretical variables as institutional thickness and level of density (Amin & Thrift, 1995; Putnam, 1995) as well as level of embeddedness. Institutional thickness shows the number of entities, critical mass of enterprises and business environment organizations (Amin & Thrift, 1995). The level of density refers to the number of business and non-business ties between cluster entities (Gancarczyk & Gancarczyk, 2013; Putnam, 1995; Storper, 1995). The level of embeddedness, i.e. the power of ties in the region, may be measured by the number of ties in the region compared to the number of ties outside the cluster, the duration of such ties – their durability, and the complexity of transactions performed in the region compared to external transactions. By analyzing these variables in time, we can determine structural changes in the network organization of the cluster (Gancarczyk & Gancarczyk, 2013).

Outward foreign investment and international strategies of companies in the cluster led to the inclusion of agglomerations into IVC and their specialization within these international relations (Bellandi, 2001; Gancarczyk &

Bohatkiewicz, 2018; Krugman, 1991a; Porter, 1998a; Sabel & Piore, 1986). This specialization is often of a hierarchical nature, i.e. causes their division into those offering lower and higher added value. The processes of cluster internationalization translate into varied spatial development. Activities with higher added value will usually be located in developed countries, whereas activities with lower added value – in developing countries (Gereffi, 1999; Geodecki, 2020; Pyndt & Pedesten, 2006; Smakman, 2003). Along with the development of global value chains we can observe the deepening division into peripheries, semi-peripheries, and development centers, which are based on knowledge-intensive activities.

Centers manage value creation and control added value in a chain. They can also impose standards on peripheries. Moreover, we can also observe the phenomena of knowledge and wealth spillovers thanks to foreign investment in countries with lower level of development. Less developed countries may try to catch up with the more advanced ones taking advantage of diffusion of technologies and management practices (Yan & Islam, 2011).

The types of cluster transformations depend on the strategy in the IVC. Beneficial transformation triggered by participation in the IVC consists in taking up an activity of high added value and outsourcing outside the cluster (to more cost-beneficial areas) activities with lower added value. This type of transformation is usually reached through strategies of differentiation, such as market niche strategy, change of scope of activities, or selective relocation (Gancarczyk & Gancarczyk, 2015, 2018). The market niche strategy usually leads to initiation or reinforcement of a high added value activity and concentration on knowledge-intensive products and services (Biggiero, 2006). The change of the scope of activities consists in moving to an activity in a related sector, characterized by more advanced technology and product (Sammarra & Belussi, 2006; Zucchella, 2006). Selective relocation in sectors of advanced and intermediate technology is based on changing the location of selected elements of value chains in search of complementary technologies, by moving research and development centers to foreign locations (Gancarczyk, 2010; Gorynia & Jankowska, 2007; Lam, 2007; Waxell & Malmberg, 2007).

Cost strategies do not contribute as much to the growth of a cluster's position in IVC, though they may also support upgrading. Among available options we can find strategies of selective relocation and replicative relocation. The former is based on subcontracting production or purchase of materials and components, inward processing, or foreign direct investment in some elements of activity, usually with lower added value. Selective relocation relies on carving out a fragment of the value chain from the cluster activities and commissioning this activity to entities outside the industry agglomeration (Gancarczyk, 2010; Gancarczyk & Gancarczyk, 2015, 2018). It usually leads to cluster transformation toward specialization and directing activities toward more knowledge-intense activities, which generate higher added value. This strategy helps the cluster to move away from simple imitation and stimulates development of competencies. The search for information and knowledge transfer using transnational ties allows the cluster to avoid the isolation effect. Replicative relocation consists in moving abroad the whole value chain rather than its elements. It forces cluster participants to break the current ties and resources, which leads to erosion of the whole cluster's competitive advantage (Gancarczyk & Gancarczyk, 2013).

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2 The Processes and Determinants of Cluster Upgrading in IVCs

2.1 The Essence and Processes of Cluster Upgrading in IVCs

2.1.1 The Rationale and Essence of Cluster Upgrading

Since the beginning of the 1990s we have observed two stages in the development of cluster international ties and processes of their insertion in IVC. The first stage can be described as dynamic internationalization stimulated by regulatory openness, technological advances of digitization, relocation of activities conducted by leading companies, and inward and outward foreign direct investment (Gong et al., 2022; Rabellotti, 1995). The second period is determined by the financial and economic crisis of 2007–2009 and subsequent external shocks, such as the COVID-2019 pandemic and military conflicts, especially the war in Ukraine.

In the first period, through inward investment of foreign corporations' subsidiaries, clusters became participants of global chains (Caspari, 2003; Gereffi, 2014; Glückler & Panitz, 2016; Kaplinsky et al., 2002). Different forms of governance in global corporation networks and cluster resources defined the position of industrial agglomerations, understood as a share in the value of the final good. This value, as already mentioned, depends on the type of function in the chain, where the greatest value is added in the initial and final functions (Gereffi, 2014; Morgan, 2012; Ravenhill, 2014). Empirical analyses of relocations and direct investment point at such consequences as, for instance, hierarchical structure of relations between clusters in the international system or relocation of lower value-added activity from highly competitive clusters to places with low costs of production factors (De Marchi et al., 2018; Gancarczyk & Bohatkiewicz, 2018; Gereffi et al., 2005; Gereffi & Lee, 2016; Saxenian, 2007; Schmitz, 2004).

Hierarchical structure of relations between clusters leads to their division into agglomerations occupying high positions in global chains as far as generated value is concerned, and those which were locked-in in low value. The above-mentioned hierarchy usually reflects the division of the global economy into countries and regions of high, moderate, and low levels of

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development, and is usually persistent. We can treat relocation of lower value-added activity from highly competitive clusters and spreading it over low-cost locations as a complementary phenomenon. This process leads to the development of a group of leading clusters which operate as knowledge centers and sources of technical standards and innovations for the industries they represent. Spatial concentration is still important in sharing tacit knowledge and less formalized technology, whose transfer depends on long-term, repetitive relations. Processes of building hierarchies in clusters and concentration on the most advanced elements of value creation have led to global specialization. Persistent specialization of this type, however, faces criticism and postulates of creating opportunities for changing the global position and promotion to higher positions expressed by locations occupying unfavorable and subordinated positions.

The second stage of cluster internationalization is connected with the global economic order following the 2007–2009 crisis, recent pandemic experiences and the continuing military conflicts. In this period, we can observe a tendency to limit risk related to spatially and institutionally distant regions of the globe, through reshoring, nearshoring, and friend-shoring. As a result, global and international value chains are shortened and reconfigured, also thanks to digital technologies and Industry 4.0 (Gancarczyk et al., 2022; Götz, 2021). Shortened and reconfigured chains call for another change of specialization and clusters and their movement toward smart specializations or related diversification. Clusters inherently possess resources needed for related diversification, focused on their key technologies, in order to ensure close access to products and services sourced from remote locations. Taking into account knowledge resources, it is natural that such industrial agglomerations become sources of high-value and high-quality jobs, thus leading to the prosperity of their home territories.

Both analyzed stages of cluster internationalization point at a scientific and practical problem concerning the nature and ways of securing the upgrading in international exchange. The higher the share of added value generated in the cluster in the total value (price) of a given product, the higher the cluster's position in the value chain for that product (Gereffi, 2014; Morgan, 2012; Ravenhill, 2014). Cluster upgrading in IVC can be defined as the improvement of comparative competitive position by advancing into more sophisticated, higher value-adding activities (Aspers, 2010; Gancarczyk & Gancarczyk, 2016; Gereffi, 1996; Gereffi et al., 2005; Giuliani et al., 2005; Humphrey & Schmitz, 2002; Ivarsson & Alvstam, 2011; Kaplinsky & Readman, 2001; Porter, 1990; Schmitz, 2006; Simms & Trott, 2014). Upgrading is accomplished through introducing new products, processes, functions, and entering new value chains (Gereffi, 1996; Humphrey & Schmitz, 2002, 2004a, 2004b). Downgrading represents the opposite phenomenon, namely, going down the value chain, toward standardized, lower value activities (Lager, 2000; Simms & Trott, 2014). Downgrading can be caused by the commoditization of products, processes and functions, rigid specialization, and withholding from innovative activity.

Innovation activity should be treated as an input to accomplish an advancement in IVC, by introducing new products, processes, functions, and new value chains (Gancarczyk & Gancarczyk, 2015; Humphrey & Schmitz, 2002; Kaplinsky & Morris, 2001; OECD-Eurostat, 2018). Product or service upgrading is accomplished by widening the current portfolio of a cluster or considerable improvements in the products or services within the existing portfolio of this cluster. Such upgrading is based on the introduction of product and service innovations. Process and functional upgrading, such as from manufacturing to research and development, to design, or to marketing, stems from business process innovations (OECD-Eurostat, 2018). Chain upgrading, that is, entering new value chains, results from product and service innovations that do not fall within the current portfolio of the cluster's products and services but initiate new industries in an agglomeration. Chain upgrading is complex and radical and thus it also requires business process innovations related to the new value chains.

To discriminate between innovation activity and upgrading we need to acknowledge the core of upgrading as the increase of value and comparative competitive advantage, while innovations do not necessarily lead to relative competitive advantage, but also to small and incremental improvements that are new-to-firm only (Gancarczyk & Gancarczyk, 2015; Kaplinsky & Morris, 2001; OECD-Eurostat, 2018). Therefore, upgrading requires a higher level of innovation scope, such as being new to the world or new to a cluster's market to establish relative competitive advantage, as well as a nexus of innovation activities. To sum up, the difference between innovation and upgrading can be defined as the difference between inputs, that is, innovations, and performance or outcomes, that is, upgrading.

Innovation, as a source of upgrading, is based on cluster's capabilities and on the knowledge transfer in IVC from technologically advanced customers (Aspers, 2010; Ivarsson & Alvstam, 2011; Lager, 2000; Simms & Trott, 2014; Sturgeon et al., 2008). Therefore upgrading processes are often determined by technology absorption and learning of clusters from less developed economies through cooperation with corporations and clusters from developed countries.

2.1.2 The Processes of Cluster Upgrading and IVC Governance

Upgrading processes are basically processes of learning and knowledge development in clusters occupying lower positions in IVCs (Gancarczyk, 2015a; Geodecki & Grodzicki, 2015; Lam, 2007; Lorentzen, 2008; Makó et al., 2011; Malecki, 2010; Propris et al., 2008; Tolstoy, 2010; Wach, 2012; Wall &

Knaap, 2011; Wall & van der Knaap, 2011). Clusters – suppliers from less developed countries – demonstrate their advantage predominantly in lower costs. In order to be competitive partners in IVCs, they need to advance their technology and other capabilities relevant for their collaborations (Lungwitz et al., 2006; Makó et al., 2010). The upgrading phenomenon is predominantly considered in the context of learning and development by companies and industries from emerging economies of the Global South, with the use of qualitative case studies (Aspers, 2010; Ivarsson & Alvstam, 2011; Lager, 2000; Schmitz, 2006; Simms & Trott, 2014). However, the literature on cluster upgrading is scarce, in particular in the context of varied performance of clusters in developed or medium-developed countries and regions. This monograph intends to fill this gap by focusing on cluster upgrading in IVC of European clusters.

According to the literature in GVC, IVC, and global production networks, supplier upgrading depends on the governance mode of VC collaboration. The type of governance defines the roles of collaboration partners and the prospects for possibility of learning and knowledge exchange, including technology transfer (Gereffi et al., 2005; Humphrey & Schmitz, 2002; Pietrobelli & Rabellotti, 2011). Based on this literature, we can consider two IVC governance types, namely hierarchical and non-hierarchical governance, and link these governance types with the possibilities for knowledge transfer and innovation output. Hierarchical IVCs feature asymmetric capabilities and uneven economic power among the collaborating parties. Non-hierarchical IVC governance involves balanced capabilities and balanced economic power among the collaborating parties. Hierarchical IVC governance types include corporate internalized governance and buyer-driven or captive IVC governance. Corporate IVC occurs when product parameters are difficult to formalize, since such goods are characterized by complexity. If it is hard to find suppliers with a sufficient level of competencies, it is necessary to internalize such activities within corporate governance. In this situation companies – final producers – design and manufacture independently (Gereffi et al., 2005). The decision to integrate vertically is justified in the economics of transaction costs (Williamson, 1975; 2000). This theory shows that complex and specific technology requires adjustments on the supplier's side, which, in turn, may cause an issue of opportunism of the exchange parties and the growth of coordination costs independently (Gereffi et al., 2005).

Captive or buyer-driven governance is characterized by dominance of international companies, which cooperate with subordinated suppliers possessing low competencies (Ashenbaum, 2018; Gereffi et al., 2005). Leading companies impose requirements related to standard of ordered components and terms of delivery since technology is formalized. In this type of networks, suppliers easily yield to the lock-in effect, as their interactions with buyers are limited to the completion of orders in line with their specifications

(Gereffi et al., 2005). The inferior position of suppliers is revealed in their competition based on low costs and prices rather than innovations. Leading companies take advantage of their position, offloading costs onto their suppliers and dictating terms of contracts. Such contracts usually concern VC functions of low value added (for instance, assembling or packaging).

Non-hierarchical IVC governance types include markets, relational governance, and modular governance. Market-based or arm's-length governance is based on market transaction rules – spot contracts determined by price (Ashenbaum, 2018). This type of governance is used for products and contracts of low complexity and high level of technology formalization. Suppliers produce goods and render services on the basis of parameter specifications, hence interactions, knowledge exchange, and learning of suppliers remain limited. This type of governance does not cause overdependence of any party due to the availability of offering and buying entities on the market, making their decisions on the basis of price (Gereffi, 2005).

Modular IVC governance occurs when modular technologies are used, i.e. when design and production are based on sets of elements demonstrating specific functionality. There is a possibility of flexible design and production within specialist modules, which, connected by means of standard interfaces, create the final product. Technology is complex, however, the level of its standardization remains high. This limits the need for long-term relations and interactions, and hence resembles market relations. A supplier should demonstrate high competencies in order to be able to meet complex specifications. Thanks to competencies and technology standardization, the supplier does not become over-dependent on the buyer. Technology standardization also allows buyers to avoid overdependence on selected suppliers. Both parties to the contract preserve flexibility in choosing contractors (Gereffi, 2005, p. 85; Gereffi et al., 2005). This type of governance provides the supplier with the possibility of learning complex and formalized technology, and even forward and backward vertical integration – toward higher value added.

Relational IVC governance happens when product technology is complex and it is difficult to formalize and standardize. Then the need arises for selecting long-term, specialist suppliers with high competencies, who will be included in the innovation process of the company (the buyer). By engaging in frequent interactions, suppliers actively participate in designing and distributing goods, taking this opportunity to learn and participate in technology transfer. Frequently, relations typical of geographical proximity and cooperation within the industrial agglomeration are needed (Menkhoff, 1992). Costs connected with replacing a contractor grow as un-codified knowledge and routine of organizational cooperation develop (Fernandez-Stark & Gereffi, 2019). Both subcontractors and suppliers are characterized by high level of competencies and experience development (Gereffi et al., 2005).

2.2 Types of Cluster Upgrade

2.2.1 Cluster Companies' Upgrading

In the original GVC concept, upgrading was considered mainly from the perspective of companies and industries. However, this concept inspired broader thinking, involving clusters, territories, and socio-economic systems. This broader definition of upgrading works well for clusters, which comprise companies of a specific industry or industries as well as associated organizations of the environment and resources of a particular area. Therefore, we will analyze the types of upgrading referring both to companies and socio-economic systems in IVC.

Upgrading of companies and industries covers the improvement of positions within a product, a process, or a function and thanks to the development of new value chains (Humphrey & Schmitz, 2002). *Product upgrading* means widening of a product range or implementing improvements in the current product portfolio. *Process upgrading* stands for improvement of business processes concerning production, administration, information systems, logistics, and marketing. *Functional upgrading* is achieved through introduction of new functions, especially those constituting extreme elements of the 'smile curve', such as research and development and design, value chain coordination, and marketing. *Chain upgrading* occurs when a new value chain is developed or when a new value chain is joined thanks to the launch of new products and services compared to the existing activity portfolio (Gereffi, 1999). Chain upgrading is a complex and advanced form of upgrading one's position in IVC, requiring frequent introduction of new products as well as upgrading processes and functions (Caspari, 2003; Gancarczyk & Gancarczyk, 2016; Humphrey & Schmitz, 2000, 2002). In addition, literature on upgrading in IVC lists *small- and medium-sized enterprises upgrading*, which focuses on a group of enterprises that most frequently play the role of dependent subcontractors (Gancarczyk et al., 2017; Gancarczyk & Gancarczyk, 2016). The improvement of an SME position may occur thanks to already-mentioned forms of upgrading, though it usually concerns learning new business processes and incremental changes within the functional specialization. The upgrading and growth of the offered value are determined not only by the form of coordination in international cooperation, but also by development of SME suppliers' capabilities. Due to their poor investment potential, the improvement of competencies is expected on the basis of external support from public authorities concerning transfers of technologies and foreign market knowledge. One can also find *innovation upgrading*, when companies base their development on innovative activities and move to more advanced forms of innovation (Hu et al., 2021; Matsuzaki et al., 2021; Ye et al., 2020).

As an example we could quote here the movement from an innovation which is a novelty to an innovation on a global scale, from incremental, small innovations to breakthrough innovations, or from business process innovations to product and service innovations.

2.2.2 Socio-Economic Upgrading of Clusters

Upgrading may occur with reference to clusters as socio-economic systems, which are not limited only to enterprises. Then we can consider progress of the whole territorial system or its selected dimensions. The progress of the whole socio-economic system in a given location is known as *territorial upgrading*. The improvement of the position may concern different territorial units, such as a region, a country, or a region of the world. Then we can observe macro-economic development, marked by higher value added generated by a given territory and increased wealth of the society compared to other units participating in GVC. Territorial upgrading of the system is usually achieved by gradual changes within the socio-economic system, covering elements of this system (Benner, 2022; Coe, 2021). Those incremental changes include *social upgrading* or *human resource* or *human capital upgrading*, as improvement in labor regulations, pay terms, employment stability, and social welfare, as well as respect for workers' rights and quality of human capital, concerning level of education and competencies (Barrientos et al., 2011; Gereffi, 1999; Gereffi & Lee, 2016; Henning & Eriksson, 2021).

Backward and forward upgrading of territorial units consists in improving the company's position concerning backward and forward relations (Fernandez-Stark et al., 2014). Backward upgrading can be observed when local companies begin to contribute higher value added products and services to international corporations operating within IVC. On the other hand, forward upgrading stands for offering higher value added on more demanding and richer markets. This requires satisfying higher standards, norms and practices of activity, and even transforming one's business model. Usually, we can observe a combination of backward and forward upgrading, leading to new industrial and territorial path development (Bohatkiewicz, 2018).

On the other hand, *institutional upgrading* is a reaction to changing legal conditions and requirements concerning adjustment to structures of international projects (for instance, Via Carpathia, New Silk Road, Logistics Center, Baltic-Adriatic, Baltic – Black Sea). For example, regulations concerning Green Deal and emissions limits evoke the need for upgrading based on eco-innovations, whereas participation in them requires specific functional specialization which a cluster should develop. Upgrading based on eco-innovation can also be treated as *sustainable upgrading*, that is, advancement in VC that acknowledges environmental and responsible development concerns.

2.3 The Measurement of Cluster Upgrading

2.3.1 Comparative Value Added and Value Added Dynamics as Outcome-Based Measures

According to the definition of upgrading in IVC, the major outcome-based measures of a cluster's upgrading are comparative (relative) value added and dynamics of comparative value added of the industry or industries represented by this cluster. The relative component of this measurement is based on comparing VA of a given cluster to VA of its counterparts in IVC.

As D. Ricardo (1817) claimed, value comes from work and depends on relative amount of work necessary to produce a given good. Ricardo tied the concept of value to scarcity of goods and work, measured with both time of producing such goods and efforts and creativity. Moreover, the value of goods depends on work connected with creation of appliances, tools, or buildings used in production of goods.

On the other hand, value added is treated as value surplus which is generated in the production process and in the process of transforming work into goods and services (Coe & Yeung, 2015, p. 16). Value may also be treated as economic rent generated in a situation of limited resources and the existence of entry barriers protecting industries or specific types of activity (Coe & Yeung, 2015; Kaplinsky, 1998, 2005). Value added determines the value which companies add to each produced good or rendered service in all stages of the production process (Hall & Taylor, 2000, pp. 27–52). It is a difference between the value of products generated in an economic unit and the sum of real production costs, i.e. material costs of production factors which have been used in the production process (Begg et al., 2014, p. 24; Milewski & Kwiatkowski, 2018, p. 308). In this situation, the sum of revenues from the sale of the final product equals the sum of added values resulting from the whole process of producing goods or rendering services (Colander, 1997, pp. 186–187). VA is referred directly to work productivity and is presented as costs of production factors divided by the number of employees. Work productivity shows how efficiently work is combined with other production factors and how it is used in the production process (Glossary, 2023).

Taking into account Ricardo's understanding of sources of value, value added in services is adequately reflected in the level of remuneration, being also referred to as productivity but calculated in a different manner. This measure is useful especially on the level of research on regional industrial clusters, since data on VA for particular industries is not available in public statistics on the regional level. This kind of approximation of VA to clusters is used in the methodology of the so-called 'five stars' of the European Commission and Eurostat (Hollanders & Merkelbach, 2020). This approach is justified with the scale of productivity in clusters, as average productivity is approximately 25% higher than in companies outside clusters. Moreover, work productivity based on average wages per employed person is, in basic-performing clusters, 15% higher than the average work productivity in the EU, whereas in clusters characterized by high results, it more than doubles the average productivity. On the other hand, in exporting clusters, wages are approximately 10% above the average for all industries (Hollanders & Merkelbach, 2020). The wages measure is often used in analyses of industrial structures or market competitiveness (Brakman et al., 2004).

The process of creating value added is a process of transforming resources into goods and services whose value exceeds the value of those resources (Magretta, 2014, p. 199). In analyses of IVC structure, the main problem is the location of high value added and the ways of upgrading VA positions by companies, industries, clusters and territories located on lower levels of the value chain (Gancarczyk, 2015a; Gereffi et al., 2005; Humphrey & Schmitz, 2004a, 2004b; Pietrobelli & Rabellotti, 2009; Ponte & Sturgeon, 2014; Saxenian, 2007).

In this book we focus on cluster upgrading from the perspective of comparative value added, since this measurement directly reflects the nature of its position in IVC and output rather than achievement rates or required investment. Methodology based on VA, including that using approximation of remunerations, ensures objectivity in evaluation of positions occupied by clusters in international value chains. It coincides with the idea of value added as an indicator of the position occupied in IVC, measured by value added from work and economic results rather than input indicators. Remunerations provide a good measure of work productivity, especially in service activities, including knowledge-intensive business services. In these type of activities, company value added is largely generated through intellectual work of highly qualified staff.

The research and the practice of measuring international position of clusters also includes more complex, multi-criteria measuring methods. They do not necessarily express objective results, but combine elements of results and inputs, taking into account cluster development potential in shape of resources, activities, and competencies. Examples of input-based approaches are presented below.

2.3.2 Input-Based Approaches to the Measurement of Upgrading

The methodology of 'five stars' of the European Commission and Eurostat expresses the position of a cluster as power, reflected in the number of stars on a 5-star scale, where stars constitute aggregated, complex indicators (Hollanders & Merkelbach, 2020). Clusters are analyzed in five categories, such as cluster size by number of workers, specialization expressed by the location quotient, productivity measured by level of remunerations, SMEs output determined by the number of high-growth enterprises, and presence of innovation leaders as the number of innovators on a global scale (Hollanders & Merkelbach, 2020). Taking into account high-growth SMEs and innovation leaders points at complementary roles played by large and small companies and at potential dynamics of VA, based on innovations and their output in shape of high growth of companies. The cluster size is demonstrated by output concerning employment, namely the total number of workers expressed in a full-time equivalent in the industry in a given geographical region. The specialization analysis is based on the quotient of locating employment in a particular industry. A cluster with high degree of specialization will have the value of above one of these indicators. Productivity is measured with average wages and salaries per worker (in full-time equivalents) in the region. The lack of data for the regional value added in the industry was addressed with the wages and salaries measure.

SME performance is measured with the number of high-growth enterprises which demonstrate annual turnover or employment growth in the past three years at the level of at least 20%, while observing minimum thresholds of employment and turnover at the start (Hollanders & Merkelbach, 2020).

Innovation leaders are determined by the number of global frontier firms, which represent 5% of firms with highest productivity measured with value added per employee, calculated by adding the incomes of production factors received by workers (salaries) and capital owners (profits) within any cross-sector (emerging) industry or any exporting industry in a given year (Hollanders & Merkelbach, 2020, p. 11).

The star methodology assesses clusters belonging to the so-called exporting industries, or trade industries, or industries incorporated in IVC, i.e. those representing relatively high exporting activity compared to other industries. The main strengths of this methodology are its multidimensionality, measurability, and objectivity. Unfortunately, it lacks coherent conceptual foundations and it combines both indicators measuring the current position (work productivity) and those constituting input or productivity conditions (SME results, specialization, presence of global leaders). Therefore, it is a method of measuring the current and potential strength of a cluster rather than its position based on economic results, not on input indicators or conditions in which such results are achieved.

The methodology used by Duke University's Center on Globalization, Governance, and Competitiveness (Duke CGGC) assesses the position in IVC according to top-down and bottom-up elements. Each of these elements is analyzed in six dimensions, namely the input-output structure, geographical scope, governance, VA growth within IVC, institutional context, and analysis of stakeholders. This methodology thoroughly analyzes the context and factors describing the position in IVC and, to a lesser degree, determines directly this position. It may, therefore, constitute a valuable supplement to quantitative analyses and help us understand processes leading to transformation and relations between stakeholders in IVC. Its value lies in taking into account the institutional aspect and the qualitative approach, useful in the case study method. However, it does not provide strong foundations for quantitative approaches and objective measurement of the position in IVC. Quantitative analyses remain scarce and often do not fully correspond to theoretical assumptions concerning VA as a determinant of this position.

The PARP methodology is used in assessing the development of cluster initiatives in Poland (Red. Piotrowski et al., 2021). PARP research consists of two main parts: characteristics of cluster initiatives and benchmarking (Red. Piotrowski et al., 2021). The following benchmarking areas have been selected: resources, processes, outcomes achieved by a cluster initiative, influence on environment, and internationalization. Criteria of cluster initiative evaluation comprise, for instance, time of conducting business activity, number of participants, organizational form, geographical concentration, and multi-industrial characteristics. What differentiates PARP methodology is its abandonment of the characteristics of cluster industry specialization and concentration on cluster initiatives as inter-organizational cooperation phenomena.

The research presented in the next chapters is quantitative and relies on the IVC theory, the concept of clusters and located industry, while taking into consideration some elements of the cluster identification methodologies described earlier, as well as identification of their position in IVC.

2.4 Determinants of Cluster Upgradation

Research on factors determining clusters' position in IVC has been dispersed and fragmentary so far, as it does not present the full set of factors and is based on different theoretical approaches (Blažek, 2016; Gancarczyk & Bohatkiewicz, 2018; Humphrey & Schmitz, 2002). Dispersion and differentiation of factors can be attributed to the nature of research on cluster dynamics, which is usually based on case studies, not on comparative or quantitative analyses. Being a specific form of industry organization, clusters are rarely subjected to a complex analysis in the context of determinants of their position in international value chains. This creates an important research gap which the authors of this book hope to bridge.

The observation of cluster dynamics forces us to pose a question of what factors (determinants) determine the cluster's position concerning high or low value added. If we define the determinants of such change (especially upgrading), then we can outline the policy of cluster and region development. Conditions of cluster dynamics in IVC are analyzed within the economics of localized industry, political economics, economic geography, as well as entrepreneurship and regional development (Aslesen & Harirchi, 2015; Gancarczyk & Bohatkiewicz, 2018; Gereffi et al., 2005; Sturgeon, 2003).

According to the IVC concept, possibilities of learning, developing competencies, and thus value added and position in the chain, depend on cluster capabilities, existing governance, and public support policies (Fornahl et al., 2015; Gereffi et al., 2005; Gereffi & Lee, 2016; Morgan, 2012; Ravenhill, 2014). Capabilities are determined by the potential of agglomeration as a system covering companies in their relations with organizations of the environment and regional resources (Gancarczyk, 2015b; Klepper, 2007; Maskell & Malmberg, 2007; Menzel & Fornahl, 2010; Mossig & Schieber, 2016). The governance and state policy constitute institutional factors, defined as regulatory mechanisms or rules governing operations of a given system and its efficiency (Colombelli et al., 2019; Gereffi et al., 2005; Gereffi & Lee, 2016; Williamson, 2000). Based on this, we put forward hypothesis 1.

2.4.1 Absorptive Capacity

In the IVC-related literature, cluster capabilities as a factor determining its position in the chain are not defined terminologically or conceptually, but evoke general features of technology or skills (Gereffi et al., 2005; Gereffi & Lee, 2016). This requires further specification of the analyzed factor based on the existing capability concepts in the mezzo-economic and spatial dimensions. Regional determinants of companies and industries development are often expressed through the concept of absorptive capacity (AC) (Expósito-Langa et al., 2011; Fritsch & Kublina, 2018; Hervas-Oliver et al., 2012; Howell, 2020). AC is 'ability to recognize, identify, assimilate and use new, external information' (Cohen & Levinthal, 1990, p. 128; Zahra & George, 2002). This term is also understood as dynamic ability to create and use knowledge, which contributes to maintaining business activity, and starting its development (Winter, 2000). It also stands for gaining and maintaining competitive advantage and developing competencies (Zahra & George, 2002). In its narrow sense, AC is identified with assimilation of technological information (Kedia & Bhagat, 1988). On the other hand, broader definitions of this phenomenon emphasize that it is the ability to learn and solve problems (Kim, 1997, 1998), as well as a set of competencies directed at gaining and transforming knowledge (Mowery & Oxley, 1995). Kim (1998) identified absorptive capacity with organizational learning, consisting of two areas: absorption of knowledge leading to imitation and development of new knowledge, which stimulates innovative activity. Lane and Lubatkin (1998) point at the importance of cooperation in developing collective absorptive capacity. It leads to increasing knowledge resources, which supports the process of multi-dimensional development (Cohen & Levinthal, 1990; Raff, 2017; Todorova & Durisin, 2007; Yeoh & Roth, 1999).

Summarizing the analyses and research so far, we can conclude that *the cluster's absorptive capacity is the potential to assimilate and internalize external knowledge by a cluster as a system covering companies in their relations with organizations of the environment and regional resources* (Aslesen & Harirchi, 2015; Cusmano et al., 2010; Giuliani et al., 2017; Hervas-Oliver et al., 2012; Menghinello et al., 2010; Munari et al., 2012; Pietrobelli & Rabellotti, 2011; Sammarra & Belussi, 2006). Absorptive capacity depends on prior knowledge possessed by the cluster, as well as on sources and specificity of obtained knowledge (Todorova & Durisin, 2007). On the other hand, scientists point at barriers to knowledge absorption, such as conflict with existing knowledge resources, limitations of human capital, or path-dependency (Gavetti & Levinthal, 2000; Helfat, 2000; Langlois & Steinmueller, 2000; Leonard-Barton, 1992; Todorova & Durisin, 2007; Tripsas & Gavetti, 2017). As emphasized by Christensen and Bower (1996), there is also a risk that the choice and evaluation of external knowledge will be determined by the needs of current key clients, but also in the situation of power asymmetry between cluster participants, which may be reflected in the influence of lead firms that impose, for instance, technological standards or determine division of tasks within the value chain, without the possibility of modifications on the side of other cluster participants. This may lead to the rejection of high-potential knowledge that could be used in the future.

The process of knowledge acquisition should be accompanied by a thorough evaluation of its compatibility and complementariness to existing knowledge resources, as well as value for organizations, both in the long and short term (Todorova & Durisin, 2007). This is similar to the work of Cohen and Levinthal (1990), who, instead of the stage of knowledge acquisition, pointed at recognizing the value of knowledge. These obstacles may also be overcome by transforming the acquired knowledge, especially when such knowledge cannot be simply incorporated in the organization. External knowledge resources then may not translate into newly-created products or services (Baker et al., 2003). On the other hand, as emphasized by Carter (1989), highly educated staff who build the structures of organizations participating in a cluster, thanks to their level of competencies will be able to evaluate correctly external knowledge resources.

Absorptive capacity also leads to the evolution of a cluster and changes in its structure. AC covers knowledge acquisition, knowledge assimilation, knowledge transformation, and knowledge exploitation (Jansen et al., 2005). For Zahra and George (2002), absorptive capacity is a set of routines and processes, aimed at acquiring, assimilating, processing, and using knowledge (Amit & Schoemaker, 1993; Dierickx & Cool, 1989; Grant, 1991, 1996; Prahalad & Hamel, 1990). In this approach, the so-called potential absorptive capacity is distinguished, particularly important when operating in a turbulent, rapidly changing environment, as realized absorptive capacity. The former consists in acquiring and assimilating knowledge, whereas realized capacity is identified with both processing and applying knowledge. Zahra and George (2002) enriched the concept with the aspects of activation triggers and social integration mechanisms, typical of clusters. Simultaneously, what bonds processes covering absorptive capacity are systems of adopting knowledge and relations of power.

The expected effects of absorptive capacity include creation of innovations, increased productivity, or improved flexibility. The role of clusters in social integration mechanisms should be emphasized here (Todorova & Durisin, 2007; Zahra & George, 2002). As indicated by Cohen and Levinthal (1990), absorptive capacity of a cluster depends on its elements that build the collective absorptive capacity of an industrial agglomeration. AC guarantees good use of participation in IVC. Economic entities and other organizations characterized by high level of absorptive capacity will influence the cluster, while AC of the cluster allows it to take advantage of its participation in IVC. Simultaneously, the cluster itself may affect the AC level of a part or the whole value chain.

The analysis of the absorptive capacity of a cluster or a region is mainly based on examining human capital of a given community. Mangematin and Nesta (1999) indicate that highly qualified workers increase an organization's knowledge resources by using their own knowledge, skills and attitudes in professional work, as well as initiating relations with people of similar competencies operating in the organization's environment. Using such external networks of knowledge, especially in an activity based on scientific knowledge, is extremely valuable both for workers, the organization, as well as for groups of organizations – clusters (Rothwell & Dodgson, 1991). Keller (1996) pointed out that absorptive capacity stems from a long-term development of human capital in a particular community. He analyzed the percentage of students of engineering in the number of graduates of second-degree studies, the number of scientists and engineers per 1 million of inhabitants, the number of scientists and engineers employed in research and development per 1 million of inhabitants. Liu and White (1997) used the indicator of input on R&D personnel. Cohen and Levinthal (1990) also emphasize that absorptive capacity is determined, inter alia, by the level of R&D intensity, which allows to include and exploit resources of new knowledge.

A different approach was presented by Boynton et al. (1994), whose starting point for further analyses was the identification of absorptive capacity with the degree of using IT solutions in the process of knowledge management in an organization. They analyzed IT managers' knowledge of business processes and value of information technologies, as well as the efficiency of IT processes in managerial activities. Veugelers (1997) measured absorptive capacity taking into account the number of departments conducting full-time R&D activities, the number of R&D departments employing PhD degree holders, and the number of R&D departments conducting basic research activities. Lane and Lubatkin (1998) emphasized the significance of cross-organizational cooperation and ties, especially learning alliances, in the process of building absorptive capacity and determined it with synthetic measures, dividing them into those concerning evaluation of new knowledge resources for organizations, and those related to knowledge assimilation and further commercialization of knowledge application results.

AC is also based on training competencies, taken into account by Lane et al. (2001) in their research. They call them jointly the ability to apply knowledge. They also differentiate the ability to understand the external knowledge, identified with the level of trust and the so-called relative absorptive capacity. The concept of trust, so important for cooperation in clusters, is based on the concept of a disciple-student (Buckley & Casson, 1988; Chiles & McMackin, 1996; Gulati, 1995; Inkpen, 1998; Inkpen & Curall, n.d.; Kogut, 1988; Lyles & Baird, 1994; Parkhe, 1993; Schoorman et al., 1996; Smith et al., 1995; Zand, 1972). Here we have cooperation based on the common sphere of competencies, values, norms and standards, which leads to knowledge transfer (Lane, 1996; Lane et al., 2001; Lane & Lubatkin, 1998; Szulanski, 1996). Spatial proximity within the cluster usually implies such a sphere of knowledge development and exchange.

To conclude, AC reflects the cluster's potential to achieve a particular position in IVC. Therefore, we formulate the following hypothesis 1:

H 1. There is a positive relationship between the cluster's position in international value chains and its absorptive capacity.

Some research, however, shows that the potential for assimilating and processing knowledge determined by human capital and related investment does not guarantee commercialization of knowledge and its transformation into economic value. Innovations, development of new, fast-growing enterprises, requires input and resources more strongly tied to the sphere of business and economic activity. The concept of innovation capacity (IC) reflects the potential for creating innovations, and consequently implementation of products and processes which determine the position and constitute a foundation for its upgrading (Zahra & George, 2002). Liu and White (1997) indicated that innovations are the outcome of investment made in research and development activity and imports of new technologies. Also Veugelers (1997) associated innovations with economic effects of developing company capacity. On the other hand, Kim (1998), having analyzed the case of Hyundai Motor Co., pointed at a certain process of evolutionary transition of an organization from the stage of AC and assimilation of external knowledge, to the stage of R&D transformed into innovations.

Leonard-Barton (1992), as well as Dyer and Singh (1998) indicate that IC comprises identification, evaluation and use of external knowledge, especially technological one, in implementation of new or improved products and processes. As shown by March and Simon (1958, p. 188), innovations come mostly from borrowing and acquiring external solutions rather than from internal generation. Cohen and Levinthal (1990) offer a number of examples of research whose outcome confirms the above claim (for instance (Hamberg, 1963; Johnston & Gibbons, 1975; Mueller, 1962; Myers & Marquis, 1969; von Hippel, 1988). That is why there is a close relationship between absorptive capacity and IC (Cohen & Levinthal, 1990). As emphasized by Chesbrough (2003, 2006) and Gassmann and Enkel (2006), we should strive at striking a balance between the ability to use external sources of knowledge (determining the level of absorptive capacity) and competencies in developing and using internal knowledge, which lead to innovations (Cassiman & Veugelers, 2002). As a result of combining external sources of knowledge and internal innovation activity, company results improve (Cassiman & Veugelers, 2002; Vanhaverbeke et al., 2011; Veugelers, 1997).

In clusters, as in particular business activities, competencies concerning research and development activity support the process of using external knowledge and *know-how* (Arora & Gambardella, 1994; Cohen & Levinthal, 1989). Moreover, as indicated by Granstrand et al. (1992) or Brusoni and Prencipe (2001), such changes as increasing costs of conducting own research and development activities, growing degree of technological complexity of products and services, development of science-based technologies, have led to the phenomenon of open and modular innovations. They consist in the wide use of network cooperation in the process of innovation development (Chesbrough, 2003, 2006; Rigby & Zook, 2002). Open innovations are conducted by leading companies in a cluster as well as specialist providers of technologies and services and products of medium-high and high technology (Brusoni & Prencipe, 2001; Granstrand et al., 1992). Cluster participants may, thanks to this, achieve economies of scale or increase their specialization, using technologies and ideas developed outside.

Technology obtained externally and research and development activity may supplement each other, developing synergies. However, it is necessary then to integrate internal and external knowledge. Contrary to closed innovation within the company structures, in open innovations, cluster participants modify internal processes applying technologies and technological standards used in the cluster and in IVC.

In conclusion, IC of a cluster is treated as its potential for commercialization of knowledge and development of innovations and using their effects (Giuliani et al., 2017; OECD, 2005; Pietrobelli & Rabellotti, 2011). IC is one of the determinants of a cluster's position in IVC, therefore hypothesis 2 was formulated.

H 2. There is a positive relationship between the cluster's position in international value chains and its innovation capacity.

According to a commonly used definition, institutions are informal or formal rules that govern human activity (North, 1990). Literature on institutional economics lists such institutions as, inter alia, conventions, norms and formally sanctioned rules, usually in the form of formal regulations, such as provisions of law (Vatn, 2007). However, informal institutions, such as beliefs and systems of values, customs, practices, and routines are also analyzed (Ostrom, 2005; Veblen, 1904). The institutional system determines the possibilities of cluster development (Giuliani et al., 2017; Pietrobelli & Rabellotti, 2011).

Essential elements of the institutional system comprise the governance form of a cluster in international exchange (Gereffi et al., 2005; Markusen, 1996; Sturgeon et al., 2008; Williamson, 2000). Hierarchical relations in international exchange weaken the flow of knowledge and learning opportunities that suppliers from less developed economies have (Pavlínek, 2012; Rugraff, 2010). Balanced (non-hierarchical) relations are conducive to innovativeness and knowledge transfer. The governance structure can be approximated with such factors as size differentiation of companies in a cluster as well as differences in size between companies in a cluster and their clients, forms of company ownership (local ownership, foreign branches), location of leading companies' headquarters in the cluster or outside, as well as power of relations inside the cluster and its external relations (Markusen, 1996; Pavlínek, 2012; Rugraff, 2010). The analyzed observable phenomena help us determine the level of cooperation between companies and organizations of the environment, and inclusion of the cluster in structures of international value chains.

Cooperation with organizations occupying a higher position in the chain may contribute to a high position of a cluster as far as value-added generation is concerned. Similarly, processes of mergers and takeovers by higher level entities are of vital importance here. Governance affects distribution of income and risk within the dominant industry in a cluster, and subsequently, evolution and change of its position in international exchange (De Marchi et al., 2017; Gereffi, 2018; Gereffi et al., 2005; Humphrey & Schmitz, 2000, 2002). Consequently, we treat *the cluster governance form as a set of principles and rules governing relations between entities in a cluster and those related to a cluster's external relations.*

Institutional determinants of a cluster's position also stem from policies of public authorities regarding support for a given industry in a cluster and region (Fornahl & Hassink, 2017). It may be based, for instance, on shaping the policy of supporting cluster formation processes and facilitating its inclusion in international value chains. Due to structural characteristics of clusters and international value chains, cluster types differ as to the probability of being included in hierarchic or non-hierarchical value chains. Hierarchical global value chains may be typical for anchor-type clusters due to dominance of external knowledge sources and investment decisions taken by public decision-makers (Markusen, 1996). Similarly, a satellite cluster, composed of branches of large companies, whose headquarters are located outside the industrial agglomeration and are subjected to investment decisions outside the cluster, may demonstrate a tendency to join hierarchical IVC (Markusen, 1996). This is attributed to the influence of dominant companies on smaller entities, branches, and their cooperators within the cluster.

A global value chain based on non-hierarchical ties may appear in Marshall's district and in 'hub and spoke' clusters (Markusen, 1996). Both types of industrial agglomerations are characterized by the presence of strong, often long-term internal and external ties with stakeholders, whereas interpersonal and intra-organizational ties, but inside and outside the cluster, form an essential part of their operation. In the 'hub and spoke' cluster, there are vertically integrated, large companies occupying a dominant position in the cluster, as well as a number of smaller suppliers which are key, long-term cooperators within the cluster and outside it. The relations between the cluster type and the form of governance do not constitute a closed set, i.e. it is possible to join clusters and international and local forms of governance on various levels, by means of configuration. The referred interdependencies support hypothesis H 3.

H 3. There is a positive relationship between the cluster's position in international value chains and non-hierarchical form of governance.

The position of a cluster may be shaped by public authorities supporting clusters and cluster initiatives and their incorporation in international value chains. The involvement of public administration may be in the form of direct support, offered to particular entities and covering financial transfers, advisory services, programs of co-finance, and subsidies. The other form of support is indirect support. It is connected with shaping regulatory and infrastructural environment for business activity. Such support may be based on friendly legal solutions, such as protection of intellectual property and competition, reduction of bureaucratic burden, and development of material infrastructure (Gancarczyk, 2010, 2019).

The policy of cluster support may be created and implemented in a particular country or supra-nationally. In the first case, favorable environment may be built through tax preferences connected with developing business activity in a given region, thus supporting the local labor market and enabling further development of such initiatives on a national and supranational scale (Gancarczyk, 2019). Support policy frequently concerns direct actions aimed at the development of more formalized structures, such as cluster initiatives and organizations. When such market structures gain corporate identity, state authorities are able to act more effectively in order to develop certain industries. This may coincide with the adopted assumptions concerning strategies for a region or country, either in the form of smart specializations, key national clusters, or strategic and priority industries.

Institutional, international, and public support for clusters implemented in connection with their position in international value chains may also be connected with New Industrial Policy (NIP), whose goals may be defined as (EU industrial policy, 2024):

1 Strengthening the competitiveness of the EU industry,
2 Increasing strategic autonomy of the European Union economy,
3 Promoting digital economy characterized by sustainability, resilience of the single market, and ability to create jobs,
4 Accelerating and supporting transformation processes (especially green and digital transition).

Among the elements of NIP related to cluster support processes, one can find such aspects as: enabling and accelerating innovations, increasing competitiveness of ventures located in the European Union, helping small- and medium-sized companies, supporting international value chains in order to ensure free flow of goods and services, especially when facing potential crises in the future (in the form of the so-called single market emergency instrument). The part of NIP concerning strategic autonomy of the EU seems to offer special justification for supporting clusters in the context of their participation in international value chains. It assumes that various international partnerships and industrial alliances will be established and developed in strategic areas of economy, while strategic dependencies will be monitored (EU industrial policy, 2024).

The policy of cluster support by public authorities can be defined as activities performed by entities belonging to public administration, directed at creation and development of clusters, as well as supporting their international activities. The economic policy supports clusters with the aim of stimulating high value added activities through investment in research and development and innovation, stimulating companies investment, improving access to information, material, financial, and human capital resources. The support is also directed at stimulating processes of internationalization and joining structures of international value chains. Among its instruments one can find transfer of information and knowledge of foreign markets, databases, export credits, and export subsidies

(Gancarczyk, 2010, 2019). Therefore, we can put forward hypothesis H 4, namely that directed public support stimulates clusters toward higher value added activity.

H 4. There is a positive relationship between improved cluster position in international value chains and the cluster support by public authorities.

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3 Methodology of Empirical Research

3.1 Research Framework

The main goal of this *empirical research is* to verify the research framework of industrial cluster upgrading (CU). In terms of detailed objectives, we aim to (i) identify the determinants of upgrading among European ICT clusters, (ii) identify a hierarchy of those determinants, as well as (iii) synthesize higher-order constructs and relationships for an ultimate, empirically corroborated framework of CU.

Summarizing the analysis of the subject literature in Chapters 1 and 2 as well as the identified knowledge gaps, we formulate the *research problem as the identification of CU determinants in international value chains*. In order to respond to this research issue, we identified four explanatory (independent) variables for the research framework, which affect clusters' upgrading. These are: absorptive capacity and innovation capacity, both representing capability-related determinants of CU, and governance form and public support for clusters, as governance-related determinants of the upgrading. These are complex theoretical variables, determined by a set of detailed observed variables.

In Chapter 2, in line with the concepts of clusters and IVCs, as well as the existing empirical research, we formulated the hypotheses concerning the relationship between the indicated theoretical variables and the cluster's position in IVCs. In our hypotheses, we define the main elements and cause-effect relations of the research model which will undergo empirical verification (Figure 3.1).

The framework proposes that a set of internal determinants, connected with the cluster's capabilities is composed of absorptive capacity and innovation capacity of the cluster. It is assumed that there is a positive relationship between the cluster's position in IVCs and the absorptive capacity of this cluster (H 1). Similar claims are formulated with reference to innovation capacity, assuming a positive relationship between the cluster's position in IVCs and its innovation capacity (H 2).

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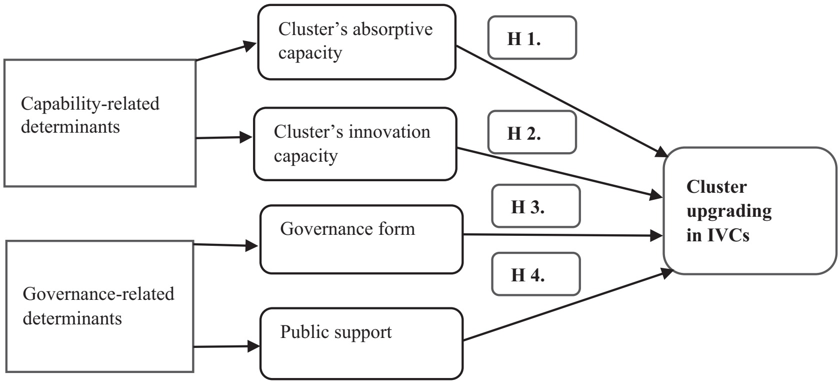

Figure 3.1 The research framework of the determinants of clusters' position in IVCs

Governance-related determinants cover governance form to which a cluster is subordinated and public support. We assume a positive relationship between non-hierarchical form of cluster governance and this cluster's position in international value chains (H 3). We also claim that there is a positive relationship between the cluster's position in IVCs and the cluster support implemented by public authorities (H 4).

The research framework will adopt European ICT clusters as its empirical basis. The following rationales support this choice. Firstly, this industry provides a considerable and still growing input to the European economy as ICT industry's value added was estimated at over €631 billion and represented the equivalent of 5,2% of the EU's GDP share in 2020 (ICT sector – value added, employment and R&D, 2023). Secondly, the ICT industry is crucial for efficiency and innovation in all other industries, which use digital solutions to reduce costs and time of operations. Thirdly, this industry demonstrates both quantitative dynamics, as per value added and turnover, and qualitative transformation as an emerging Digital Industry, an outcome of the convergence of the industries related to information technologies. Finally, ICT represents a technological platform for an array of innovative products and processes throughout the economy, being one of the key enabling technologies (KET).

3.2 The Identification of the Research Sample

Our research sample includes three sub-industries of ICT, namely, telecommunications, computer programming, consultancy and related services, and information service activities. The European ICT service clusters have been identified with the use of the two criteria constituting the phenomenon of clusters, namely, (i) spatial and industrial concentration and (ii) network relationships. In order to identify clusters in European economies, the location quotient (LQ), based on the number of employed in a NUTS2 region, was used. The quotient determines the above-average concentration of workers employed in a particular type (or types) of business activity (its comparative basis being the national or international scale). It has been established that an ICT cluster exists in a particular region when its location quotient equals at least 1.25 compared to a country economy. The network relationship criterion has also been met, since the clusters identified in this research mostly correspond to cluster initiatives, distinguished by the European Observatory for Clusters and Industrial Change.

The primary sources of data concerning the ICT industry comprise Structural Business Statistics (SBS), Regional Statistics, National Accounts and Statistics on Research and Development published by Eurostat, as well as Regional Statistics and National Accounts produced by OECD.

As far as the ICT industry is concerned, the methodology adopted by Eurostat distinguishes its two main areas, namely manufacturing and services. It is composed of the activities listed in the Statistical Classification of Economic Activities of the European Community, Rev.2 (NACE Rev. 2), and presented in Table 3.1.

On the other hand, Reference and Management of Nomenclatures (RAMON) indicates the following areas of activities comprising ICT (RAMON, 2018):

- Publishing activity, including software publication (in Poland – relevant classes of section 58 of the PKD – Polish Classification of Activities),
- Activities related to film and audio recording production (in Poland – relevant classes of section 59 of the PKD),
- Radio and TV activities (in Poland – relevant classes of section 60 of the PKD),
- Telecommunication (relevant classes of section 61 of the PKD),
- Activities related to information technologies (in Poland – relevant classes of section 62 of the PKD),
- Other services concerning information (in Poland – relevant classes of section 63 of the PKD).

The scope of ICT resulting from statistical classifications can be compared to the chain value of the information and communication industry. When selecting particular clusters from this industry, the following criteria were adopted:

- These clusters participate in international value chains (Kilar, 2009),
- These clusters conduct activities within priority sectors on a regional, national, or international scale (such as through classifying the cluster's

Table 3.1 The structure of the information and communications technologies industry

Type of activity	*Group*	*Class*	*Description*
Manufacturing	C26 Manufacture of computer, electronic, and optical products	26.1	Manufacture of electronic components and boards
		26.2	Manufacture of computers and peripheral equipment
		26.3	Manufacture of communication equipment
		26.4	Manufacture of consumer electronics
		26.8	Manufacture of magnetic and optical media
Services	G46 Wholesale trade, except for motor vehicles and motorcycles	46.5	Wholesale of information and communication equipment
	J58 Publishing activities	58.2	Software publishing
	J61 Telecommunications	61	Telecommunications
	J62 Computer programming, consultancy, and related activities	62	Computer programming, consultancy, and related activities
	J63 Information service activities	63.1	Data processing, hosting, and related activities; web portals
	S95 Repair of computers and personal and household goods	95.1	Repair of computers and communication equipment

Source: Eurostat – ICT sector, 2022.

activities as smart specialization strategies or other programs of supporting specific industries; Bessède & Heitzmann, 2004; Ketels & Protsiv, 2017; Ternaux & Kolarova, 2007; UNCTAD, 2013),
- These clusters conduct activities that are knowledge-intense, which allows us to consider these activities as demonstrating a considerable potential for generating high value added,
- Availability of data on a particular industry in Europe.

Due to the importance of ICT services in the whole ICT industry, as well as the fact that such activities are based on intellectual work of human capital, generate high value added, and finally, taking into account that regional industries' value added has to be approximated through wages and salaries, the authors decided to focus on service sub-industries within ICT. Considering

Table 3.2 The structure of ICT industry adopted in the book

Group	*Description*
J61	Telecommunications
J62	Computer programming, consulting, and related activities
J63	Information service activities

Source: Own elaboration.

the above-mentioned criteria for the research sample and the availability of statistical data, the research sample included telecommunications activities, computer programming, consulting and related activities, and information service activities (Table 3.2).

The information and communication industry constitutes one of six priority industries distinguished within Key Enabling Technologies, which are expected to facilitate transformation of EU economies toward sustainable development. KETS also play a vital role in creating new industries. Their importance makes them a key element of the European industrial policy. At the same time, information and communication activities belong to traded industries (Franco et al., 2014).

The IVC concept points at the global and regional (proximate cross-country territory) nature of the international value chains. Our book will focus on the analysis of European clusters representing the information and communication industry in this regional IVC. It can be assumed that this empirical basis will be sufficient for generalizations relevant for knowledge-intensive industries affecting the whole economy.

3.3 Research Methods, Techniques, and Procedures

3.3.1 Research Methods and Techniques

We used the methods of literature review and secondary data analysis. The techniques adopted included descriptive statistics and econometric techniques. We applied logistic regression models, and in order to evaluate them, we used the Hosmer-Lemeshow goodness-of-fit test, Cramer's V measure of association between variables, analysis of the area under the ROC curve, Akaike Information Criterion (AIC), and the method of Classification and Regression Trees (CART). In order to identify clusters in European economies we used the location quotient (LQ) based on the number of employed in ICT service industries included in our sample.

Logistic regression (logit regression) enabled us to develop models for individual theoretical variables, and then to elaborate an aggregate model, reflecting previously distinguished upgrading determinants derived from the models with individual theoretical variables.

Logistic regression allows us to examine the influence of one or more independent variables (X_1, X_2, . . . , X_k) on one dependent binary variable, adopting value of either 0 or 1. It is used in modeling dichotomous outcome variables. The logistic model is often applied to predict the risk of binary outcome, taking into consideration the influence exerted by a set of risk factors. For clarity of interpretation, we assumed in our research that the value of 1 reflects the high position of a cluster, whereas the value of 0 – its low position. The regression equation estimates the likelihood of the value of a dependent variable being 1 for a particular set of estimations of parameters and values of independent variables. It may, therefore, be used as a predictive tool, enabling us to calculate the risk of a particular phenomenon (Grochowiecki & Migut, 2023). The interpretation of the logistic regression results boils down to determining the quotient of the chances that a particular phenomenon will occur.

For the binary dependent variable and p predictors as well as predictors X_1, X_2, . . . , X_k, the systematic part of the model is expressed in the following formula:

$$\ln\left[\frac{P\left(x_1, x_2, \ldots, x_k\right)}{1 - P\left(x_1, x_2, \ldots, x_k\right)}\right] = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k \tag{1}$$

The expression on the left side of the equation, known as the logit, is equivalent to the natural logarithm of the chance that a modeled phenomenon will occur. The logistic regression may therefore be analyzed as a linear regression on the odds logarithm.

This model can also be expressed in categories of probability of *y* result, using the following formula:

$$P\left(x_1, x_2, \ldots, x_k\right) = \frac{\exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k)}{1 + \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k)} \tag{2}$$

The logistic regression models developed in our research have the following theoretical form:

$$P = \frac{\exp\left(AC\beta\right)}{1 + \exp\left(AC\beta\right)} \tag{3}$$

where:

AC – vector of determinants of absorptive capacity (determined on the basis of models for absorptive capacity without control variables and with control variables),

β – vector of evaluation of parameters of the logistic regression model referring to absorptive capacity;

$$P = \frac{\exp\left(IC\beta\right)}{1 + \exp\left(IC\beta\right)} \tag{4}$$

where:

IC – vector containing determinants of innovation capacity (determined on the basis of models for innovation capacity without control variables and with control variables),

β – vector of parameters of the logistic regression model, evaluating innovation capacity;

$$P = \frac{\exp(GFGOV\beta)}{1 + \exp(GFGOV\beta)} \tag{5}$$

where:

GFGOV – vector containing determinants connected with external determinants (defined on the basis of models for external factors without control variables and with control variables),

β – vector of parameters of the logistic regression model, evaluating impact of external factors;

$$P = \frac{\exp(KD\beta)}{1 + \exp(KD\beta)} \tag{6}$$

where:

KD – vector containing key determinants of the cluster's position in IVC (defined on the basis of the aggregate model),

β – vector of parameters of the logistic regression model evaluating key determinants of the cluster's position in IVC.

The analyzed set of data contained some missing data, therefore, it was necessary to take remedial action related to imputation of deficits in order to build models and conduct the reasoning. Due to the significant level of deficits, we used the technique of variable discretization, changing missing data into a separate category. In this way, each of the partial observable variables, corresponding to the already-mentioned theoretical variables, was coded using the CART method.

The CART method is classified as a decision tree method (Aczel, 2000) and is used both for building predictive models and for predictive segmentation (Migut, 2009). It may also be used in a situation when a set of data contains some missing data for independent variables. In this situation, the divisions proposed in this method may be used as borders of classes for discretization, while the class with missing data becomes a separate class.

Ultimately, independent variables used in building models were qualitative and categorical variables. The assumptions adopted in models with one independent variable and models with many variables are similar. The quality of logistic regression models built in our work was verified in accordance with good practices used when reporting logistic regression results (Grochowiecki & Migut, 2023; Hosmer & Lemeshow, 2000). Such practices included:

- Verification of the power of ties between pairs of independent variables and between particular independent variables and a dependent variable (Cramer's V analysis) – that is the analysis of correlations between predictors,
- Presentation of single-factor models, indicating, inter alia, the quotient of probability of obtaining value 1 by the dependent variable (in our case, the probability that a cluster will be upgraded, that is it will achieve a high position in IVC),
- Presentation of a multi-factor model, determining the quotient of probability that the dependent variable will obtain the value of 1,
- Presentation of levels of significance of parameter evaluation and confidence intervals, together with Wald statistics for single-factor and multi-factor models,
- Verification of the number of model parameters compared to the number of observations (it is claimed that the number of observations belonging to a less numerous class of the dependent variable should be at least 10 times higher than the number of the model parameters, that is $n = 10(k + 1)$, where 'n' is the number of observations of a less numerous class of the dependent variable, whereas 'k' is the number of the model parameters),
- Conducting goodness-of-fit analysis, using the Hosmer-Lemeshow test, that is Hosmer-Lemeshow statistics analysis and calculation of the area below the ROC curve (for V-times cross-examination and teaching sample), analysis of the AUC value,
- Analysis of forest plots in order to present graphically the quotients of probability and their confidence intervals for the developed models,
- Using the AIC to compare the quality of two or more models and to choose the best one.

While building the model of logistic regression, we can choose one or more automatic methods selecting variables for the model, based on the assessment of significance of regression parameters, that is progressive introduction, backward elimination, stepwise elimination, progressive elimination, or stepwise-backward elimination. Variables can also be selected with the LASSO regression technique. However, it is believed that the most reliable selection method is the statistical and expert strategy, reflecting statistical correctness of the developed model and its substantive correctness.

Stepwise regression allows us to identify the list of determinants which correlate with the dependent variable and are in the lowest possible degree correlated with independent variables (Bendel & Afifi, 1977; A. Cohen, 1991; Henderson & Denison, 1989; Jennrich & Sampson, 1968; Johnsson, 1992; Stanisz, 2007, p. 138). It requires the execution of the following elements of the research procedure (StatSoft, 2023):

- Identification of the initial model,
- Using the stepwise procedure in an iterative way, that is gradually changing the model by adding or removing a predictor, following a relevant criterion,
- Ending the procedure.

In this book, in order to identify the optimal sub-set of predictors we initially used the stepwise progressing regression method and the stepwise backward regression method for all independent variables. The models we achieved in this way did not meet our expectations due to the lack of compliance of regression parameters evaluation with their substantive importance and due to the lack of fit (HL test). The models were treated as a starting point for applying statistical and expert methods in order to find such a configuration of parameters that would ensure the best quality of the model. In the course of our research, over 175 models of logistic regression were built. Finally, seven of them, characterized by high quality, were used.

Logistic regression models were built on the basis of the CU dependent variable and sets of observable variables, treated as proxies for theoretical independent variables. The names of theoretical independent variables reflect the following acronyms: AC for absorptive capacity, IC for innovation capacity, GF for governance form, and GOV for public (government) support.

3.3.2 Research Procedure

We do not know any other publications that would provide a similar, complex analysis of the issue of cluster position in IVC. The originality of the conducted research, the choice of the research sample, as well as the desire to explore an uncharted research area made it necessary to develop a detailed research procedure. It covered the following sequence of stages:

- Formulating the research problem and the main goal and specific goals of the empirical research,
- Formulating research hypotheses based on the current knowledge of clusters and their position in IVCs,
- Choosing the subject of research, namely identification of industry clusters which shall be analyzed,
- Determining the methodology of identifying clusters which will be the subject of our research,
- Determining methods of examining cluster positions and determinants of such positions,
- Operationalization of the main research variables included in hypotheses,
- Data processing, evaluation, and interpretation.

3.4 Operationalization and Measurement of Variables; Sources of Data

3.4.1 Operationalization of Variables

The theoretical variables of the research model, both the explained (dependent) variable and the explanatory (independent) variables, require operationalization by means of observed variables. Below we propose the operationalization of these variables, taking into account available public statistics in European conditions.

The theoretical explained variable is the cluster's upgrading in IVC, determined by the level of value added generated in the cluster. According to the concept of global value chains, the cluster's position is reflected by value added generated in it and productivity based on such value. As it is not possible to use data on value added in a particular industry on a regional level, in this book, like in all research so far, we point at productivity as an approximation of value added in the cluster, measured with wages and salaries per worker in the cluster's industry (Chen et al., 2018; Franco et al., 2014; Gereffi, 2018; Hollanders, 2020; Hollanders & Merkelbach, 2020; Parteka & Wolszczak-Derlacz, 2016). Expressed in this way, productivity reflects, in particular, knowledge intensity of a given activity, where high value added is associated with a high share of wages and salaries earned by highly qualified staff. Moreover, work productivity is an adequate approximation of value added for service activities. This is particularly true for knowledge-intensive and advanced-technology services, which require high competencies of the staff. Therefore, productivity, denoted by wages and salaries, is a good approximation of value added and the ICT cluster's position in IVC (Franco et al., 2014; Hollanders & Merkelbach, 2020; Ketels & Protsiv, 2016; Naumanen, 2019).

The dependent variable used in the models is a binary variable, calculated on the basis of Eurostat's Regional Databases within Structural Business Statistics. Here we used the 'SBS data by NUTS 2 regions and NACE Rev. 2 (from 2008 onwards)' database, from which we obtained data on the number of people employed in particular ICT subindustries and the value of wages and salaries in millions of Euro. Eurostat defines […] *the number of people employed as the total number of people who work in an observed unit (including working owners, partners, working regularly in the unit and unpaid family workers), as well as people working outside the unit, who belong to the unit and are paid by it (for example sales representatives, supplying staff, repair and maintenance staff). It does not cover the workforce provided by other enterprises, people performing repair and maintenance work in an observed unit on assignment from other enterprises, or people doing obligatory military service* […] (Eurostat – glossary: Persons employed – SBS, 2023).

As adopted in Eurostat, the variable 'Wages and salaries' contains *all expenses incurred during the reference period on the total gross remuneration, in cash or in kind, of all employees of the statistical unit.* 'Wages and salaries' is part of the variable 'Employee benefits expense' (Eurostat – glossary: Wages and salaries – EBS, 2023). Then we calculated the quotient of wages and salaries, and the number of employees, thus obtaining the value of wages and salaries per one worker. This method was used in calculating the values of wages and salaries per employee in three ICT subindustries (J61, J62, and J63), which constitute the subject of our analysis in this research.

Due to the fact that the research sample comprised various regions and countries, we additionally normalized this ratio, applying the harmonized indices of consumer prices (HICP) inflation rate. Then the mean and the median of these wages and salaries in all identified clusters were calculated. The final stage consisted in comparing the value of the wages and salaries per employee indicator corrected with the inflation rate in a given cluster, industry and year to the median of wages and salaries per employee for all clusters. If the value per employee in a particular cluster was above the median, it was assumed that the dependent variable had the value of 1, and this means that the cluster of this industry represented upgrading, i.e. generated high value added in this year and occupied a high position in IVC. The variable constructed in this way is a *proxy* of value added of a particular cluster analyzed here, based on which, we can determine this cluster's position within IVC. If the indicator of wages and salaries in the cluster was below the value of the median, it was assumed that the dependent variable in this observation was 0 and it represented low value added and position in IVC of a cluster in particular subindustry and year.

The direct adoption and application of the regional indicator of productivity (gross value added per worker) for ICT industries had the following rationales. First of all, the geographical classification adopted by OECD is not fully coherent with the classification adopted by the European Commission and Eurostat, which constituted the source of independent variables. Having conducted the analysis of the regions appearing in Eurostat and OECD databases, we noticed that half of the researched countries (those where clusters were identified) had a different geographical classification in these databases. Namely, in *Regional Innovation Survey*, OECD identifies TL2 and TL3 regions, whereas European databases follow NUTS 2 and NUTS 3 classifications). Moreover, it would be impossible to combine coherently the data concerning the scope of business activities conducted by a cluster (some databases offer data for subindustries, others – only for the entire industries only), which significantly affected the scope of our research. Considering this, it wouldn't be possible to build a coherent model based on the OECD data on regional value added in ICT, as defined in our evidence-based methodology.

The quantitative data on wages and salaries were obtained from the European databases, such as Eurostat's Structural Business Statistics. Moreover, other useful sources of data included, OECD regional databases, European Commission reports, including the European Cluster Observatory, Community Innovation Survey, and the data from Polish Statistics (GUS), Polish Agency for Enterprise Development (PARP), and Polish Cluster Observatory. Table 3.2 presents the operationalization of dependent and independent variables, their conceptual foundations, and relationship with the hypotheses. *Independent variables* reflect theoretical variables, such as cluster absorptive capacity, cluster innovation capacity, governance form, and public support. Each of these variables was expressed through a set of observable variables.

3.4.2 Measurement of Variables and Sources of Data

The selection of observable variables for the model was iterative. Initially, it was based on literature review, including the methodologies of researching clusters' position in IVC. The next selection occurred at the modeling stage, leading to the final choice of independent observed variables for the model. We used the following selection criteria:

- Substantive validity, or compliance of a given observed variable with the theory of clusters, international value chains, and clusters' position in IVC,
- Availability of statistical data based on:
  - Geographical scope according to NUTS2 minimum on the country level (for variables considered to be quantitative, statistical representation of external effects), and preferably on the regional level,
  - Possibility of adjusting statistical data to the scope of cluster activity (minimum on the level of the whole ICT, preferably distinguishing J61, J62, and J63 sectors),
  - Time range, that is availability of data at least for the 2014–2020 period.
- Ability to generate the regression model demonstrating high quality.

Quality was determined on the basis of, among others, statistical significance of the variable, its predictive power, obtaining logical dependencies between particular independent variables and the dependent variable in single-factor analyses, as well as all variables in a model in a multi-factor analysis. We used the Hosmer-Lemeshow test, Cramer's V correlation on the maximum level of 0.6 and the goodness-of-fit measure (the area under the ROC curve). Table 3.4 presents the measurement of variables and sources of data.

Table 3.3 Operationalization of the research model variables

Model variable	*Conceptual foundations and description*	*Source*	*Connection with the hypothesis*
CU in IVC (dependent variable)	IVC concept; value added approximated by the value of wages and salaries per person employed in the sector	Begg et al., 2014; De Marchi et al., 2018; Delgado et al., 2016; Enright, 2000; Gancarczyk, 2010; Gereffi et al., 2001; Hall & Taylor, 2000; Ponte et al., 2019; Porter, 1998, 2003; Sturgeon, 2009, 2013; Sturgeon & Gereffi, 2009	H 1 There is a positive relation between the cluster's position in IVC and its absorptive capacity. H 2 There is a positive relation between the cluster's position in IVC and its innovation capacity. H 3 There is a positive relation between the cluster's position in IVC and non-hierarchical cluster governance form. H 4 There is a positive relation between the cluster's position in IVC and the cluster support policy implemented by public authorities.

Cluster absorptive capacity (theoretical independent variable)	RBV and IVC concepts – capacity impact on position in IVC, cluster AC as potential to assimilate and internalize external knowledge by the cluster as a system comprising companies in their relations with environment organization and regional resources; observable independent variables: human capital education level (Edu), R&D personnel and scientist employment (R&D), IT competencies (CompIT), employment in knowledge intense technologies and sectors (EmHKIBS), employed IT specialists (EmITsp).	Aslesen & Harirchi, 2015; Boynton et al., 1994; W. M. Cohen & Levinthal, 1990; Cusmano et al., 2010; Giuliani et al., 2017; Hervas-Oliver et al., 2012; Keller, 1996; Mangematin & Nesta, 1999; Menghinello, De Propris, et al., 2010; Menghinello, de Propris, et al., 2010; Munari et al., 2012; Pietrobelli & Rabellotti, 2011; Sammarra & Belussi, 2006; Todorova & Durisin, 2007; Veugelers, 1997; Zahra & George, 2002	H 1 There is a positive relation between the cluster's position in IVC and its absorptive capacity.
Innovation capacity (theoretical independent variable)	RBV and IVC concepts – capacity impact on position in IVC; cluster IC as potential to commercialize knowledge and develop innovations and utilize their effects; observable independent variables: internal expenditure on research and development (GERD), venture capital expenditure (VCexp), PCT patent applications (PCTpatapp), presence of high growth companies (HGEpe), sale of innovations new to the market and new to companies (SalInn).	Cohen & Levinthal, 1990; Dyer & Singh, 1998; Giuliani et al., 2017; Leonard-Barton, 1992; OECD, 2005; Pietrobelli & Rabellotti, 2011	H 2 There is a positive relation between the cluster's position in IVC and its innovation capacity.

(*Continued*)

Table 3.3 (Continued)

Model variable	*Conceptual foundations and description*	*Source*	*Connection with the hypothesis*
Governance form (theoretical independent variable)	TCE and IVC concept – impact of governance form as regulation mechanism affecting operation and effectiveness of a system; cluster governance form as hierarchical form and non-hierarchical form; observable independent variables: export of medium and high technology products (ExpMHtech), export of knowledge intense services (ExpKIBS), level of mobility of people employed in science and technology (JJmob), joint public-private publications (Ppcpub), innovative SMEs cooperating with others (SMEcoop).	Colombelli et al., 2019; Fornahl & Hassink, 2017; Gancarczyk, 2010; Gancarczyk & Konopa, 2021; Gereffi, 2005; Gereffi et al., 2005; Gereffi & Lee, 2016; Giuliani et al., 2017; Pavlínek, 2012; Pietrobelli & Rabellotti, 2011; Rugraff, 2010; T. Sturgeon et al., 2008; Williamson, 2000	H 3 There is a positive relation between the cluster's position in IVC and non-hierarchical cluster governance form.
Public support (theoretical independent variable)	IVC concept – influence of cluster support policy; cluster support policy; observable independent variable: direct and indirect government support for R&D activity in companies (GovSup)	Fornahl & Hassink, 2017; Gancarczyk, 2010; Gancarczyk & Konopa, 2021; Gereffi & Lee, 2016; Giuliani et al., 2017; Pavlínek, 2012; Pietrobelli & Rabellotti, 2011; Rugraff, 2010	H 4 There is a positive relation between the cluster's position in IVC and the cluster support policy implemented by public authorities.

Source: Own elaboration.

Table 3.4 Measurement of variables and sources of data

Variable	*Variable symbol*	*Source of data/base*	*Scope of available data*	*Research*	*Methodology – related approach*
CLUSTER UPGRADING – DEPENDENT VARIABLE					
Cluster's value added in IVC	CU	SBS data by NUTS 2 regions and NACE Rev. 2 (from 2008 onwards)	2009–2020	Franco et al., 2014; Hollanders & Merkelbach, 2020; Ketels & Protsiv, 2016; Naumanen, 2019	Measure of wages and salaries
ABSORPTIVE CAPACITY					
Human capital education level	Edu	Higher education, 25–64 age group by sex and NUTS2 regions (percentage of population)	2011–2022	Carter, 1989; Cohen & Levinthal, 1990; Madgett et al., 2005	PARP methodology
Employment of R&D personnel and scientists	R&D	Research and development personnel and scientists by sector of activity, sex, and NUTS2 regions, calculated with equivalent of full-time work, number of employees and percentage of total employment in enterprises sector (percentage of employed people)	1980–2020	Keller, 1996; Liu & White, 1997; Wang et al., 2013	PARP methodology
IT competencies	CompIT	Individuals with above basic overall digital skills (percentage of population)	2014–2021	Bassellier et al., 2001; Boynton et al., 1994	PARP methodology

(*Continued*)

Table 3.4 (Continued)

Variable	*Variable symbol*	*Source of data/base*	*Scope of available data*	*Research*	*Methodology – related approach*
Employment in knowledge-intense technologies and sectors	EmHKIBS	Employment in technology and knowledge-intensive sectors(percentage of employed people)	2008–2022	Baldoni et al., 2022; Nählinder, 2005; Zieba & Zieba, 2014	PARP methodology
Employed ICT specialists	EmITsp	Employed ICT specialists (percentage of employed people)	2014–2022	Aničić et al., 2017; López-Bassols, 2002	PARP methodology
INNOVATION CAPACITY					
Internal expenditures on research and development	GERD	Internal expenditures on research and development (GERD) by NUTS2 regions(EURO per inhabitant), corrected with inflation rate	2010–2021	Cohen & Levinthal, 1990; De Propris & Driffield, 2006; Liu & White, 1997	PARP methodology
Venture capital expenditures	VCexp	Venture capital expenditures (share in GDP)	2014–2022	Cumming et al., 2005; Devigne et al., 2013; Landström, 2007; Lutz et al., 2013	PARP methodology
PCT patent applications	PCTpatapp	PCT patent applications (per GDP billion according to purchasing parity standards)	2014–2022	Ardito et al., 2018; Pesole, 2016	PARP methodology

Presence of high growth enterprises	HGEpe	Business demography and high growth enterprise by NACE Rev. 2 and NUTS 3 regions; high growth enterprises measured by the number of employees(growth by 10% or more)	2008–2019	Gancarczyk, 2019; Gancarczyk & Konopa, 2021	PARP methodology
Sale of new-to-market and new-to-firm innovations	SalInn	Sales of new-to-market and new-to-firm innovations (share in total turnover)	2014–2022	Aarikka-Stenroos et al., 2014; Slater & Mohr, 2006	Duke methodology
GOVERNANCE FORM					
Exports of medium and high technology products	ExpMHtech	Exports of medium and high technology products	2014–2022	Shearmur et al., 2015	Duke methodology, PARP methodology
Knowledge-intense services exports	ExpKIBS	Knowledge-intensive services exports	2014–2022	Shearmur et al., 2015	Duke methodology, PARP methodology
Level of mobility of people employed in science and technology	JJmob	Job-to-job mobility of HRST (human resource employed in science and technology)	2014–2022	Bienkowska et al., 2011; Casper, 2007; Obukhova, 2022; Saxenian, 2007	PARP methodology

(*Continued*)

Table 3.4 (Continued)

Variable	*Variable symbol*	*Source of data/base*	*Scope of available data*	*Research*	*Methodology – related approach*
Joint public-private publications	Ppcpub	Public-private co-publications	2014–2022	Wojnicka-Sycz et al., 2018	Duke methodology, PARP methodology
Innovative SMEs collaborating with others	SMEcoop	Innovative SMEs collaborating with others (percentage of SMEs compared to EU average)	2014–2022	Masurel & Janszen, 1998; Müller et al., 2017; Raposo et al., 2014	Duke methodology, PARP methodology
PUBLIC SUPPORT					
Direct and indirect government support of business R&D	GovSup	Direct and indirect government support of business R&D	2014–2022	Kuznetsova et al., 2022; Vernay et al., 2018; Wojnicka-Sycz & Sycz, 2016	Duke methodology, PARP methodology

Source: Own elaboration.

Note: All independent variables were transformed into category variables on the ordinal scale.

Absorptive capacity is measured with the human capital education level, understood as the number of people with higher education in the 25–64 age group, according to NUTS2 regions. The AC measure is based on the number of research and development personnel and employed scientists divided into particular industries, wages, and salaries in NUTS2 regions. We used a series of variables representing particular employment indicators and a variable describing IT competencies – individuals with above basic overall digital skills.

Innovation capacity is measured with internal expenditures on research and development, or more precisely gross domestic expenditure on R&D (GERD) according to NUTS2 regions, number of high-growth enterprises, number of PCT patent applications, venture capital expenditures, and sales of new-to-market and new-to-firm innovations.

Governance form will be measured with exports of medium and high technology products, knowledge-intensive services exports, public-private co-publications, as well as percentage of innovative SMEs collaborating with others. On the other hand, public support is measured with direct and indirect government support for business R&D.

As a result of using the CART method of interactive classification trees, we categorized all independent variables within four theoretical variables (Table 3.5).

As presented in Table 3.5, the values of particular observations were divided into relevant classes and each variable was categorized, as a result of which new qualitative variables were created. Further on in the modeling process, some classes which did not show sufficiently differentiated influence on the dependent variable were combined.

What is more, we used some methodologies of identifying cluster position. Table 3.6 shows the elements of methodologies that were used in our research.

Table 3.6 shows which of the independent variables that are used in different methodologies were considered in the research. These were: cluster size measured with the number of full-time jobs in a cluster, productivity measured with the number of the average remuneration per worker and high-growth enterprises, indicators related to human resources, such as the number of employed people in entities in the cluster or number of scientists in cluster entities (HR), as well as variables like identification of governance form and analysis of institutional factors.

Simultaneously, we took into account control variables in regression models. As Helpman-Hanson's research demonstrated, remunerations in a particular region may be higher than in other regions, among others, when the region constitutes part of a large market or is located in its surroundings, which is reflected in GDP (Brakman et al., 2004). Scientists also emphasize positive correlation between nominal pay and GDP per km^2

Table 3.5 Categorization of independent variables for four theoretical variables using the CART method and further categorization changes

Partial independent variable	*Selected classes*	*Changes within classes*
Absorptive capacity		
Human capital education level	'low', 'medium', and 'high' and additionally 'ND' class	No change
Employment of R&D personnel and scientists	'low', 'medium', 'high', and 'very high' and additionally 'ND' class	Combining 'ND', 'medium' and 'high' classes with 'low' class
IT competencies	'ND', 'low', 'medium', and 'high'	No change
Employment in knowledge-intense technologies and sectors	'ND', 'low', 'medium', and 'high'	Combining 'ND' class with 'low' class
Employed ICT specialists	'ND', 'low', 'medium' 'high', and 'very high'	No change
Innovation capacity		
Internal expenditures on research and development	'ND', 'low', 'medium' 'high' and 'very high'	'very high' class was then combined with 'high' class
Venture capital expenditures	'ND', 'low', 'medium' 'high', and 'very high'	'high' class was combined with 'medium' class, whereas 'very high' class was renamed to 'high'
PCT patent applications	'ND', 'low', 'medium', and 'high'	'ND' class was combined with 'medium' class
Sales of new-to-market and new-to-firm innovations	'ND', 'low', and 'high'	No change
Presence of high-growth enterprises	'ND', 'low', 'medium', and 'high'	'ND' class was combined with 'medium' class
Governance form		
Innovative SMEs collaborating with others	'ND', 'low', 'medium' and 'high'	No change
Exports of medium and high technology products	'ND', 'low', 'medium', and 'high'	'ND' class was combined with 'high' class
Knowledge-intensive services exports	'ND', 'low', and 'high'	No change
Joint private-public publications	'ND', 'low', 'medium', and 'high'	No change
Job-to-job mobility of HRST	'ND', 'low', 'medium', and 'high'	No change
Public support		
Direct and indirect government support of business R&D	'ND', 'low', and 'high'	No change

Source: Own elaboration based on research.

Table 3.6 The methodologies of cluster research used for identifying the research subject and operationalization and measurement of variables

Methodology	*Indicators*	*Application for the model*
Methodology of stars	cluster size measured by number of full-time workers in a cluster	+
	specialization measured with location quotient (*LQ*)[a]	within cluster identification
	productivity measured with average remuneration per worker	+
	SME productivity is measured with number of high-growth enterprises, known as gazelles	+
	innovation leaders determined with number of global pioneer companies	–
Measure of remuneration level	average value of remuneration per person employed in sector	+
PARP methodology	indicators related to human resources, number of people employed in cluster entities (HR)	+
	number of scientists in cluster entities (HR)	+
	indicators in other areas of benchmarking	–
Duke methodology	input-output structure	–
	trade flow on particular stages of value chain	–
	governance form – type identification	+
	position within IVC – analysis of location of particular entities or clusters between various stages of IVC	–
	institutional context – describing influence of institutional factors (including social and economic ones) on improving position in IVC	+
	analysis of stakeholders – analysis of cooperation of entities in a cluster	–

Source: Own elaboration.

[a] The indicator is used both for identifying clusters in economy and in analysis of changes in specialization level.

(Brakman et al., 2004). Based on control variables, it is possible to determine whether the relation between the explained variable and the explanatory variables exists, or whether it is due to influence of other factors. Control variables are used to control for their potential impact compared to the research framework's theoretical variables. The relationship between control variables and the dependent variable does not necessarily have to be that of direct dependence. Nevertheless, it should be acknowledged that the control variables may generate external effects, reflecting the power of the economy and the level of its development.

The influence of capability-related and governance factors will be controlled by macroeconomic conditions as well as those related to the cluster's subindustry. The control variables in our research include country-level apparent labor productivity (APL) in an ICT subindustry represented in the cluster and GDP per capita according to purchasing power parity in the country. In addition, HICP inflation rate is another control variable, used for normalizing the dependent variable and independent variables when needed.

Labor productivity is defined as value added at production factor costs divided by the number of employed people. This indicator is usually presented in thousands of Euro per employed person (Eurostat glossary – apparent labor productivity – SBS, 2023). The indicator can be used, for example, for conducting comparative analyses of countries' labor productivity per worker.

Gross domestic product (GDP according to purchasing power parity) is a production indicator for a particular country or region. It reflects the total value of all produced goods and services, subtracting the value of goods and services used directly in the process of their production. GDP in PPS (purchasing power standards) eliminates differences in levels of prices between countries. Calculated per capita, it allows us to compare economies differing significantly in absolute size. GDP per capita in PPS is a key variable in determining the eligibility of NUTS 2 regions in the European Union structural policy. It must be remembered that these indicators have been scaled; that is, the data is expressed in relation to EU27_2020 = 100. Therefore, they cannot be compared to previous publications based on EU25 = 100 and EU27_2007 = 100. GDP per capita describes the measure of domestic economies productivity, compared to the average value in the European Union. If the index of a particular country is higher than 100, the level of GDP per person employed in this country is above the EU average, and vice versa. Basic data are expressed in PPS, that is in common currency, which eliminates differences in levels of prices between countries, allowing us to compare the GDP of such countries. Simultaneously, 'employed people' are not differentiated into those working full-time or part-time.

HICP (or, in other words, general inflation rate of consumer prices) is used in international comparisons of consumer prices inflation. HICP is adopted, for instance, by the European Central Bank for monitoring inflation in the Economic and Monetary Union, and for evaluating inflation convergence in line with the requirements set forth in Article 121 of the Treaty of Amsterdam.

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4 Determinants of Cluster Position and Upgrade in IVCs – Research Findings

4.1 The Characteristics of the Research Sample in the Context of the European ICT Industry

4.1.1 The Characteristics of the Research Sample

Individual years from the adopted period were treated as observations, which gave us the total number of 1521 observations. They refer to 171 clusters in three indicated service subindustries. Table 4.1 presents the number of observations in particular countries and ICT subindustries.

As we can see in Table 4.1, initially the largest number of observations referred to Germany (234), then the United Kingdom (169), Italy (117), Belgium, the Netherlands, and Poland (91 each).

The research sample was then limited due to a lack of data on some independent variables and the necessity to remove their corresponding records in the database, which boiled down to removing some observations. The total number of observations after the necessary model modifications is presented in Table 4.2.

The different number of clusters in the GFGOV (governance form and public support) model can be attributed to the fact that independent variables considered in these models had various levels of missing data. Following the categorization and application of the missing data criterion, we eliminated some observations with the most frequent data deficits from the base. The removal of some observations resulted in the reduction of the initial sample by 13 clusters. In the KD (Key Determinants) aggregate model, we finally analyzed 117 clusters (just like in AC, ACc, IC, and ICc models). This number was determined by the quality of data on independent variables and application of the 'all effects' method, which allowed us to reduce the missing data compared to GFGOV and GFGOVc models.

Table 4.3 presents the number of clusters which reached high positions in IVCs in particular countries in 2009–2020.

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Table 4.1 The number of observations in particular countries and ICT subindustries

Country	*Number of observations in J 61 sector*	*Number of observations in J 62 sector*	*Number of observations in J 63 sector*	*TOTAL number of observations*
GERMANY	39	104	91	234
UNITED KINGDOM	52	65	52	169
ITALY	39	52	26	117
BELGIUM	26	39	26	91
POLAND	13	52	26	91
NETHERLANDS	52	13	26	91
GREECE	26	26	26	78
ROMANIA	13	26	26	65
SWEDEN	26	13	26	65
PORTUGAL	26	13	13	52
DENMARK	13	26	13	52
SPAIN	13	13	26	52
FINLAND	26	13	13	52
SLOVENIA	13	13	13	39
HUNGARY	13	13	13	39
FRANCE	13	13	13	39
BULGARIA	13	13	13	39
CZECH REPUBLIC	13	13	13	39
SLOVAKIA	13	13	13	39
AUSTRIA	13	13	13	39
NORWAY	13	13	13	39
Total number	**468**	**559**	**494**	**1521**

Source: Own elaboration based on research.

Table 4.2 The sizes of the analyzed clusters according to regression models

Model	*Number of observations*	*Number of analyzed clusters*
Absorptive capacity (AC model)	819	117
Innovation capacity (IC model)	819	117
Governance form and public support (GFGOV model)	728	104
Absorptive capacity with control variables (ACc model)	819	117
Innovation capacity with control variables (ICc model)	819	117
Governance form and public support with control variables (GFGOVc model)	728	104
KD aggregated model	806	117 [a]

Source: Own elaboration based on research.

[a] 117 in 2014–2019, 104 in 2020.

Table 4.3 The number of clusters which reached high positions in IVCs in particular countries

Country	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*TOTAL*
GERMANY	11	12	12	13	13	16	16	15	16	15	16	0	155
UNITED KINGDOM	7	8	9	8	8	11	12	10	11	0	0	0	84
BELGIUM	5	6	6	5	5	5	4	4	5	5	5	0	55
NETHERLANDS	4	4	4	4	4	4	4	4	6	7	6	0	51
SWEDEN	3	4	5	5	5	5	5	5	4	4	4	0	49
FINLAND	0	4	4	4	4	4	4	4	4	4	4	0	40
AUSTRIA	3	3	3	3	3	3	3	3	3	3	3	0	33
DENMARK	3	2	2	3	3	3	3	3	3	3	3	0	31
FRANCE		3	3	3	3	3	3	3	3	3	3	0	30
NORWAY	3	3	3	3	3	3	3	3	3	0	0	0	27
SPAIN	1	1	1	1	1	2	1	1	1	3	3	0	16
ITALY	1	2	2	1	1	1	1	1	3	2	0	0	15
GREECE	1	0	0	0	0	0	0	0	0	0	0	0	1
BULGARIA	0	0	0	0	0	0	0	0	0	0	0	0	0
CZECH REPUBLIC	0	0	0	0	0	0	0	0	0	0	0	0	0
POLAND	0	0	0	0	0	0	0	0	0	0	0	0	0
PORTUGAL	0	0	0	0	0	0	0	0	0	0	0	0	0
ROMANIA	0	0	0	0	0	0	0	0	0	0	0	0	0
SLOVAKIA	0	0	0	0	0	0	0	0	0	0	0	0	0
SLOVENIA	0	0	0	0	0	0	0	0	0	0	0	0	0
HUNGARY	0	0	0	0	0	0	0	0	0	0	0	0	0
Total number	**42**	**52**	**54**	**53**	**53**	**60**	**59**	**56**	**62**	**49**	**47**	**0**	**587**

Source: Own elaboration based on research.

As we can see in Table 4.3, the largest number of clusters with high position in IVC in 2009–2020 can be found in Germany (155 observations), followed by the United Kingdom (84) and Belgium (55). The average wages and salaries in the analyzed clusters can be determined by national economy conditions; however, it should be noted that there are also significant differences in the level of development of particular regions in a country. Therefore, subsequent modeling in this book reflects GDP and ALP control variables, which allows us to determine what part of the observed differences can be attributed to the country's development level, and what part can be explained by regional specificity of the cluster environment. In Norway, we obtained only 27 observations in which clusters achieved a high position. There are three ICT clusters, including the one that represents each subindustry (Oslo). On the other hand, in Germany there were 18 clusters, and in the United Kingdom – 13. These results substantiate an assumption that the share of clusters with high position in IVC is linked to the general number of clusters in their domestic economies as well as the size of those economies.

4.1.2 The Characteristics of the Information and Communication Technologies Industry in Europe

The Information and Communication Technologies (ICT) industry comprises producers of a wide range of goods and services using digital and electronic technologies. These products and technologies are characterized by their universal use and impact on productivity in all areas of economy and society, as well as high innovative activity, increasing digitalization of various industries including e.g. finance and progressing transformation, which cause changes in other areas of society and economy (Bartolacci et al., 2022; Gancarczyk, Rodil-Marzábal, 2022; Kutera, 2022; Wan et al., 2015).

The universal use and impact on productivity of economy and society account for the fact that the ICT industry is treated as one of key enabling technologies (KETs), i.e. technological platforms constituting foundations for innovation in other areas of economy. Digital and electronic technologies are the basis of diversification for products and services in other sectors, productivity of these sectors and revitalization of business models in mature industries (Gancarczyk, Rodil-Marzábal, 2022). This influence is also manifested in the way society functions. As Report of Cluster Internationalization and Global Mega Trends (Kergel et al., 2015), published by the European Cluster Observatory, shows, this sector is positioned in the socio-economic awareness as an industry significantly shaping international ties, including origin and development of ICT clusters and their inclusion in global value chain structures (Kergel et al., 2015, p. 4). The ICT industry's influence on society and economy includes such technological megatrends as the Internet of Things, Big Data management, development of social media, progressing consumerization, proliferation and ubiquity of IT, rapid development of artificial intelligence, cryptocurrencies and fintech solutions, shortening of lifetime cycles, as well as carbon footprint reduction, development of cloud computing, and machine learning technologies (Bartolacci et al., 2022; Gancarczyk, Rodil-Marzábal, 2022; Kutera, 2022).

As pointed out by Gereffi and Fernandez-Stark (2011), the ICT industry allows quick data and information transfer. This supports transformation processes in country and regional economies (macro level) (Tandon & Sood, 2023), in industries (mezzo level) (Ciffolilli & Muscio, 2018; Montresor & Quatraro, 2017), as well as individual enterprises (micro level) (Gomez-Sanchez et al., 2023). It also supports and participates in processes of 4.0 economy and society transformation (Małkowska et al., 2021). It often constitutes specific and necessary glue facilitating data and information flow, transformation of thoughts into material effects, often in shape of generated product innovations or business process innovations (Ligthart & Prasad, 2022).

Simultaneously, the ICT sector belongs to highly innovative industries on a global scale or at least in particular markets and is subject to transformation and convergence with related industries, thus building one of the so-called New Emerging Industries, broadly defined as Digital Industry. Digital Industry is a result of ICT transformation, simultaneously influencing development of other emerging industries, such as environmental industry or life science industry, using digital technologies to innovate and manufacture products in their areas.

In 1993, Stan Shih, founder of Acer company, was one of the first to present a graph showing value added on the example of IT industry. According to him, high value added occurs in areas characterized by high entry barriers and high level of capabilities, described then as accumulation capabilities. The ICT industry perfectly meets these requirements. It was assumed that most value added is generated at the beginning of the process of generating goods and services (upstream activities) and at its end (downstream activities) (Aggarwal, 2017; Shin et al., 2012).

For example, a business model based on developing and selling software may assume various forms of sale, such as perpetual licenses, in which a customer becomes a perpetual owner of the product, or subscriptions, or plans with specified renewal periods (for instance annual subscriptions, semi-annual subscriptions, quarterly, or monthly subscriptions). There are also popular SaaS (Software as a Service) models. It should be emphasized here that some production in the ICT industry, or to be more specific, software development, is very often closely related to accompanying services, such as performing audits, conducting implementation processes, consulting services, trainings in how to use software, and offering software as a

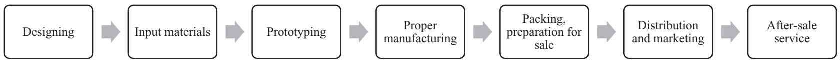

Figure 4.1 Value chain in the ICT industry.

service. That is why particular stages of a value chain in ICT production are closely connected not only with goods, but also with services. Such issues as value chain analysis, sale or export of ICT products (or generally knowledge-intensive products in the ICT industry), or employment in ICT, must always be combined with service activities, without which manufacturing would not function. Figure 4.1 shows an example of a typical value chain in the ICT industry.

The first element of the value chain in the ICT industry is research and development activity, innovation activity, and designing. This scope characterizes activities generating high value added. The research and development stage mostly concerns dominant companies and large corporations, but it may also be conducted by technological start-ups, which conduct innovation activity from initial stages of value-added generation in the chain. This stage comprises preparation of the concept of a product or service, often with adoption of a particular business model, determining the level of revenues, the sources of generated costs (including unit cost of production for material goods and effective hourly rate for services), as well as the value proposed to the customer, distribution channels, key resources, and strategic partners of the venture. At this stage, it is also possible to decide on the product target group and ways of reaching it and maintaining good relations. The project budget and schedule are prepared, often based on the structure of labor division, thus it is necessary to define precisely tasks, project stages, as well as milestones and ways of verifying achieved results and project goals.

Prototyping is not always an obligatory step, though it constitutes a vital element of the chain in a situation when it is necessary to prepare the initial version of software or equipment. Apart from creating a pilot model of the product, the most important element of prototyping consists in making changes and modifications to the product in order to improve it. This stage is often connected with activities aimed at making PCT patent applications. Generated intellectual value, which is closely attributed to the work of research and development staff, including scientists and highly educated people possessing high overall digital skills, needs to be protected. It constitutes the basis for effective commercialization and maintaining competitive advantage in the industry.

In the case of computer equipment, proper manufacturing consists of such stages as assembling and product testing. The component production stage is characterized by higher value added. Then, in the assembling stage, the level of generated value-added decreases, only to grow in the distribution stage. Thus, we can see a direct relation between the level of knowledge intensity, consistent with the degree of complexity of the whole process, lower participation of subcontractors or share of direct costs along with the growth of the value-added level. The higher the level of knowledge intensity and the more complicated and reliant on capabilities, skills, and competencies of staff, the higher level of generated value added can be observed.

Another element of the chain concerns preparing products for sale. In the case of material goods, it will entail proper packaging, storing, and preparing for transport. On the other hand, services in the ICT industry at this stage require preparation of marketing information, sale website (for example, e-commerce platform), and training of future users.

The next element of the value chain comprises transport of products to customers or sale of services, directly or through relevant sale platforms. After-sale service may cover training staff in how to use equipment or software, maintenance, technical and implementation consulting, providing technical support, dealing with claims, and repairing defective products.

Moving to the empirical analysis of value added in ICT sector, it should be observed that the total value added of the ICT industry in the EU was over EUR 631 billion in 2020, accounting for 5.2% of the EU gross domestic product (GDP). As reported by Eurostat (Eurostat – value added in ICT Services, 2023), ICT services constituted an overwhelming majority of ICT activities. Taking into consideration generated value added, they were nearly 15 times bigger than ICT production. The ratio of value added in ICT production to GDP remained stable in 2015–2020, whereas the ratio of value added in ICT services to GDP grew steadily in that period (Eurostat – Value Added in ICT Services, 2023). Figure 4.2 presents value added growth in ICT production and services in the 2015–2020 period.

As we can see from the above graph, there was a stable growth of value added generated by ICT services in the 2015–2020 period. The value added in ICT production, on the other hand, following the 2017–2019 growth, decreased in 2020. Due to the fact that the largest part of value added in ICT is generated by ICT services, it is worth analyzing how value added was generated by particular ICT subindustries in 2020 (Figure 4.3.).

As pointed out by Eurostat (Eurostat – Value Added in ICT Services, 2023), the largest part of value added in the whole structure of ICT services is generated in the computer programming, consulting and related activities subsector (51%), telecommunications (28%), and wholesale of information and communication equipment (10%). As presented further in this book, two out of these three subindustries (computer programming, consulting and related activities, and telecommunications) were taken into consideration in our research.

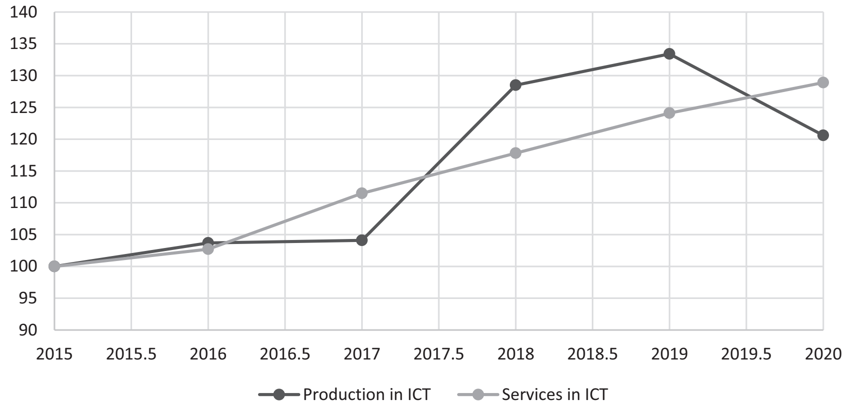

Figure 4.2 Value added growth in ICT production and services in the 2015–2020 period (2015 = 100).

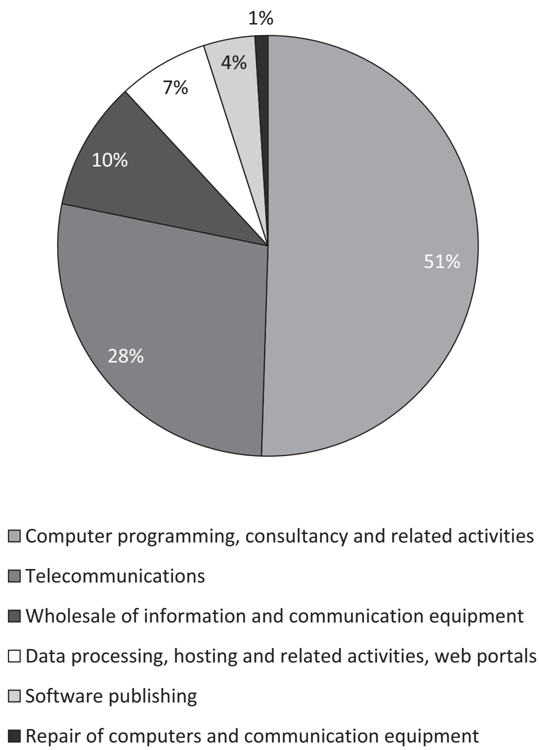

Figure 4.3 Value added generated in ICT services in 2020.

As far as work productivity in the ICT industry in the European Union is concerned, the ratio was nearly EUR 98,500 per worker in 2020. In particular EU countries, the value of the ratio ranged from as much as EUR 125,500 per worker in Belgium and over EUR 100,000 in Finland, Sweden, France, and Austria, to below EUR 40,000 in Hungary, Latvia, Poland, Romania, and Bulgaria (Eurostat – Value Added in ICT Services, 2023).

Although there are various motives and forms of conducting activities on an international scale (Schweizer et al., 2010; Ślepko, 2012; Wach, 2015), in the case of companies and clusters belonging to ICT industry, the global range is most of all manifested in modularity of the process of generating products (Kuan & West, 2021) and services (Schorr & Hvam, 2019), and in technological standards (Blind & Gauch, 2008; Heinrich, 2014). They are globally popularized, which allows international expansion, such as through exports of goods and services. The geographical scope can be supra-continental, nevertheless, this industry is less globalized than, for instance the pharmaceutical industry (Athreye & Godley, 2009), as it provides services in a defined geographical context and location of activities is of considerable importance (Lee & Saxenian, 2008; Saxenian, 1996).

4.2 Absorptive Capacity as a Determinant of the IVC Position of the Clusters

We shall now present the results of the research we conducted, starting from the research model testing the influence of absorptive capacity (AC model) without control variables and with control variables. Then we will show the results of the analysis of associations between Cramer's V variables and the results of single-factor and multi-factor models.

4.2.1 The Analysis of Cramer's V Associations between Variables

We conducted the analysis of the strength of Cramer's V connections between pairs of independent, categorical variables, and between the dependent variable and particular explanatory variables. The results are shown in Table 4.4.

As demonstrated in Table 4.4, the strongest indicators of the strength of associations between independent variables are percentage of persons employed in technology and knowledge-intensive industries (EmHKIBS variable) and percentage of IT specialists (EmiITsp variable) (0.53). Other pairs of independent variables have indicator values below 0.5.

The results of the analysis of the strength of associations between single independent variables and the dependent variable are presented in Table 4.5.

As we can see in Table 4.5, the highest indicators of the strength of associations of single independent variables with the dependent variable were those

Table 4.4 Cramer's V ratios between independent variables in the AC model

Variable	*Cramer's V*				
	Edu	*R&D*	*CompIT*	*EmHKIBS*	*EmITsp*
Edu	1.00	0.44	0.33	0.49	0.48
R&D	0.44	1.00	0.30	0.27	0.38
CompIT	0.33	0.30	1.00	0.21	0.45
EmHKIBS	0.49	0.27	0.21	1.00	0.53
EmITsp	0.48	0.38	0.45	0.53	1.00

Source: Own elaboration based on research.

Table 4.5 Cramer's V indicators for particular independent variables with the dependent variable in the AC model

Variables	*Cramer's V*
Edu and cluster UPGRADING	0.48
R&D and cluster UPGRADING	0.36
CompIT and cluster UPGRADING	0.52
EmHKIBS and cluster UPGRADING	0.42
EmITsp and cluster UPGRADING	0.42

Source: Own elaboration based on research.

of percentage of individuals with above basic overall digital skills (CompIT variable) (0.52) and percentage of population with high education in 25–64 age group (Edu variable) (0.48). Other variables had values below 0.48.

4.2.2 Single-Factor Models

We also developed single-factor models for the AC model. We analyzed the results for single-factor models, taking into account the dependent variable and particular independent variables in the AC model (confidence interval 95%, $p<0.05$). The results show that the highest probability of a cluster's high position in IVC occurs when the values of all observed variables representing the AC theoretical variable are classified in the highest classes ('high' or 'very high' class). This is consistent with the logic behind Hypothesis 1 and proves that these observable variables are appropriate proxies for the AC theoretical variable.

In the model for absorptive capacity (AC model) without control variables, the following observed independent variables were used:

– percentage of population with high education in 25–64 age group – Edu variable (finally 'low', 'medium' and 'high' classes remained in the model),

- percentage of population employed as research and development personnel and scientists – R&D variable ('low' and 'very high' classes remained in the model),
- percentage of population with above basic overall digital skills – CompIT variable ('low', 'medium' and 'high' classes remained in the model),
- percentage of people employed in technology and knowledge-intensive sectors – variable ('low', 'medium' and 'high' classes remained in the model).

Percentage of employed IT specialists, independent variable (EMITsp variable) was rejected in the stage of final selection of observed independent variables for the AC model, as it lowered the quality of this model due to its lack of statistical significance in the multi-factor model. Additionally, its introduction changed the values of the odds ratios of other variables, which resulted in illogical dependencies between explanatory variables and the explained variable.

4.2.3 Multi-Factor Models

The results of the multi-factor model of logistic regression for the 'absorptive capacity' theoretical explanatory variable were presented in Table 4.6.

As we can see in Table 4.6, all independent variables are statistically significant ($p \leq 0{,}05$). The results of the multi-factor model for absorptive capacity should be interpreted in the following way: the probability of a cluster's high position in IVC in the 'high' category in 'percentage of population with above basic overall digital skills' variable (CompIT variable) is 303.5 times higher than in the 'low' category, and nearly 54 times higher than in the 'medium' category. This means that the highest probability of a high position is observed when the percentage of population with above basic overall digital skills is the highest.

Similar dependencies can be observed in percentage of people employed in high technology and knowledge-intensive sectors (EmHKIBS variable): 17 time higher probability of high position in the 'high' category than in the 'low' one, and over 16 times higher probability in the 'medium' category compared to the 'low' category.

Considering the percentage of population with higher education in the 25–64 age group (Edu variable), the probability of a cluster's high position in IVC is over 7 times higher in the 'high' category than in the 'low' one, and over 2.5 times higher in the 'medium' category compared to the 'low' class. Finally, the employment of R&D personnel and scientists (R&D variable) creates the probability of a cluster's high position in IVC over 3.5 times higher for the 'very high' class compared to the 'low' class. The values of odds ratios for other explanatory variables, taking into consideration their

Table 4.6 Results of the multi-factor model for absorptive capacity without control variables (AC model)

Cluster UPGRADING – Evaluation of parameters
Distribution: BINOMINAL, Binding function: LOGIT
Modeled probability Cluster UPGRADING = 1

Result	*Level*	*Evaluation*	*Standard*	*Wald*	*Odds ratio*	*Confidence OR –95%*	*Confidence OR 95%*
Free term		–8.008*	1.114	51.684	0.000	0.000	0.003
Edu	MEDIUM	1.010**	0.333	9.182	2.746	1.429	5.279
Edu	HIGH	2.009*	0.395	25.935	7.456	3.441	16.156
R&D	VERY HIGH	1.322*	0.256	26.698	3.753	2.272	6.197
CompIT	HIGH	5.716*	1.039	30.261	303.650	39.620	2327.215
CompIT	MEDIUM	3.987*	1.016	15.404	53.897	7.359	394.728
EmHKIBS	MEDIUM	2.820*	0.411	47.195	16.785	7.507	37.531
EmHKIBS	HIGH	2.842*	0.401	50.317	17.146	7.819	37.598

Source: Own elaboration based on research.

* $p < 0.001$, ** $p < 0.003$.

Table 4.7 Independent variables in ACc-1 and ACc-2 models

ACc-1 model – model variables	*ACc-2 model – model variables*
R&D	R&D
CompIT	Edu
EmHKIBS	EmHKIBS
GDPpcPPS	GDPpcPPS
ALPpem	ALPpem

Source: Own elaboration based on research.

specific classification, take justified, logical sequence. Obviously, we must remember that particular dependencies described earlier are corrected with the presence of other variables in the model.

We considered various variants in the process of identifying an optimal *model for absorptive capacity with control variables* (ACc model). Finally, when selecting variables, we distinguished two models which meet all valid quality criteria. Table 4.7 presents independent variables which were reflected in the models.

It is worth observing that compared to the AC model without control variables, the ACc-1 model does not contain the 'percentage of population with higher education in 25–64 age group' variable (Edu variable), whereas the ACc-2 model does not contain the 'percentage of population with above basic overall digital skills' variable (CompIT variable). The introduction of both variables: 'percentage of population with higher education in 25–64 age group' (Edu variable) and 'percentage of population with above basic overall digital skills (CompIT variable) as well as control variables to the ACc model, generated a model that could not be accepted due to its lack of significance of variables and poor fit.

Other independent variables of 'absorptive capacity' (meaning for the ACc-1 model: 'percentage of population with higher education in 25–64 age group' (Edu) and 'percentage of employed IT specialists' (EMITsp), and for the ACc-2 model: 'percentage of population with above basic overall digital skills' (CompIT) and 'percentage of employed IT specialists'), deteriorated the quality of the ACc-1 and ACc-2 models. It was due to the fact that it showed too high degree of correlation between variables, too low statistical significance, and changing the values of odds ratios of other variables, which resulted in illogical dependencies between explaining variables and the explained variable. For the above reasons, ultimately, they were not used in the above models and were rejected while selecting variables.

In order to select the optimal ACc model, we checked the Akaike Information Criterion (AIC). The results obtained by these two models are presented in Table 4.8.

Table 4.8 AIC used in order to choose the optimal ACc model

Model	*ACc-1 model*	*ACc-2 model*
Model description	*Model with CompIT variable, but without Edu variable*	*Model with Edu variable, but without CompIT variable*
AIC	453.2	438.6

Source: Own elaboration based on research.

Table 4.9 Analysis of strength of Cramer's V associations in the ACc model

ACc-2 model – model variables	*Cramer's V*
Edu and cluster UPGRADING	0.37
R&D and cluster UPGRADING	0.36
CompIT and cluster UPGRADING	0.21
EmHKIBS and cluster UPGRADING	0.42
GDPpcPPS and cluster UPGRADING	0.72
ALPpem and cluster UPGRADING	0.63

Source: Own elaboration based on research.

Due to the fact that AIC had lower value for the ACc-2 model with the 'percentage of population with higher education in 25–64 age group' (Edu) variable (438.6 compared to 453.2 in the other, ACc-1 model with 'percentage of population with above basic overall digital skills' (CompIT) variable, it was decided to adopt the ACc-2 model as better fitted (the number of variables in ACc-1 and ACc-2 is the same).

Simultaneously, we can observe that the Akaike score co-occurs with the 'percentage of population with higher education in 25–64 age group' (Edu) variable stronger associated with the dependent variable (cluster UPGRADING) than the 'percentage of population with above basic overall digital skills (CompIT) variable (Table 4.9).

Consequently, the ACc-2 model will be treated as optimal for establishing determinants of clusters' position in IVC as far as their absorptive capacity is concerned. In order to achieve consistency of terminology used in this book, we establish that this model shall be hereinafter referred to as the ACc model.

The results for the multi-factor model of logistic regression for the 'absorptive capacity' theoretical variable with control variables (ACc model) were presented in Table 4.10.

As we can see in Table 4.10, all independent variables are statistically significant ($p<=0.05$). The results of the multi-factor model with control

Table 4.10 Results of the multi-factor model for absorptive capacity reflecting control variables (ACc model)

Cluster UPGRADING – Evaluation of parameters
Distribution: BINOMINAL, Binding function: LOGIT
Modeled probability, Cluster UPGRADING = 1

Result	*Level*	*Evaluation*	*Standard*	*Wald*	*Odds ratio*	*Confidence OR –95%*	*Confidence OR 95%*
Free term		–8.724*	0.782	124.473	0.000	0.000	0.001
Edu	HIGH	1.944*	0.458	18.054	6.986	2.850	17.126
R&D	VERY HIGH	1.504*	0.339	19.719	4.498	2.316	8.736
EmHKIBS	MEDIUM	2.407*	0.491	24.023	11.099	4.239	29.059
EmHKIBS	HIGH	3.482*	0.494	49.701	32.533	12.356	85.659
GDPpcPPS	HIGH	3.608*	0.418	74.511	36.899	16.263	83.719
GDPpcPPS	ND	2.372*	0.476	24.838	10.714	4.216	27.227
ALPpem	HIGH	4.685*	0.596	61.788	108.333	33.682	348.434
ALPpem	MEDIUM	1.582**	0.455	12.092	4.866	1.995	11.873

Source: Own elaboration based on research.

* $p < 0.001$, ** $p < 0.002$.

variables should be interpreted in the following way: the probability of a cluster's high position in IVC in the 'high' category concerning apparent labor productivity (ALPpem variable) is over 108 times higher than in the 'low' category, and more than 4 times higher in the 'medium' category than in the 'low' category. Similar dependencies can be observed in 'percentage of population with higher education in 25–64 age group' (Edu variable: nearly 7 times higher probability of a high position in the 'high' category compared to the 'low' category). On the other hand, for the 'percentage of population employed as research and development personnel and scientists' (R&D variable), the probability of a cluster's high position is nearly 4.5 higher in the 'very high' class than in the 'low' class.

As far as the variable of 'GDP per capita according to purchasing power parity in the country' (GDPpcPPS) is concerned, the probability of a cluster's high position is nearly 37 times higher for the 'high' class than for the 'low' class. For the 'percentage of people employed in technology and knowledge-intensive sectors' variable (EmHKIBS), the probability for the 'high' class is 32.5 times higher, and for the 'medium' class – 11 times higher than for the 'low' class. The values of odds ratios for particular explanatory variables take a justified, logical sequence. It should be remembered that particular dependencies described earlier are corrected with the presence of other variables in the model.

4.3 Innovation Capacity as a Determinant of the IVC Position of the Clusters

4.3.1 The Analysis of Cramer's V Associations between Variables

We conducted an analysis of the strength of Cramer's V associations between pairs of independent categorical variables and between the dependent variable and particular explanatory variables ($p < 0.05$ was adopted). The results are presented in Table 4.11.

Table 4.11 The indicators of the strength of Cramer's V associations between independent variables in the IC model

Variables	*Cramer's V*				
	GERD	*VCexp*	*PCTpatapp*	*SalInn*	*HGEpe*
GERD	1.00	0.26	0.42	0.23	0.22
VCexp	0.26	1.00	0.54	0.32	0.19
PCTpatapp	0.42	0.54	1.00	0.46	0.31
SalInn	0.23	0.32	0.46	1.00	0.27
HGEpe	0.22	0.19	0.31	0.27	1.00

Source: Own elaboration based on research.

Table 4.12 The indicators of the strength of Cramer's V associations between particular independent variables and the dependent variable in the IC model

Variables	*Cramer's V*
GERD and cluster UPGRADING	0.51
VCexp and cluster UPGRADING_	0.40
PCTpatapp and cluster UPGRADING_	0.71
SalInn and cluster UPGRADNG_	0.23
HGEpe and cluster UPGRADING_	0.30

Source: Own elaboration based on research.

As we can see in Table 4.11, the strongest associations between independent variables were observed between 'venture capital expenditures' (VCexp) variable and 'PCT patent applications' (PCTpatapp) variable (0.54). Other pairs of explaining variables had values below 0.5.

The results of the analysis of the strength of associations between individual independent variables and the dependent variable are presented in Table 4.12.

As we can see in Table 4.12, the highest indicators of the strength of associations between particular independent variables and the dependent variable were observed for the 'PCT patent applications' (PCTpatapp) variables (0.71) and the 'internal expenditures on research and development (GERD) variables (0.51). Other variables had values below 0.5.

4.3.2 Single-Factor Models

We also prepared single-factor models for the IC model. We analyzed the results for single-factor models, taking into consideration the dependent variable and particular independent variables in the IC model (confidence interval 95%, $p<0.05$). They show that the highest probability of a cluster's high position in IVC occurs when the values of all observed independent variables that stand for the 'innovation capacity' theoretical variable are classified in the highest classes ('high' or 'very high'), which is consistent with logic.

Ultimately, *the regression model for the 'innovation capacity' variable (without control variables)* (IC model) comprised the following independent variables:

- Internal expenditures on research and development – GERD variable (finally the 'ND', 'low' and 'high' classes remained in the model),
- Venture capital expenditures – VCexp variable ('low' and 'high' classes remained in the model),
- PCT patent applications – PCTpatapp variable ('low', 'medium' and 'high' classes remained in the model),

– Business demography and high growth enterprises: presence of high growth enterprises measured with employment variable (growth of 10% or higher) – HGEpe variable ('low', 'medium' and 'high' classes remained in the model).

The 'value of share of total turnover of sales of new-to-market and new-to-firm innovations' independent variable (SalInn variable) was rejected at the stage of final choice of independent variables for the model, as it worsened the quality of the IC model, demonstrating lack of statistical significance in a multi-factor model.

4.3.3 Multi-Factor Models

The results of the *multi-factor model of logistic regression for the 'innovation capacity' theoretical variable without control variables* are presented in Table 4.13.

As we can see in Table 4.13, all independent variables are statistically significant ($p <= 0.05$). The values of odds ratios for particular explanatory variables, taking into account their detailed classification, take a justified and logical sequence. Moving to interpretation of the multi-factor model, it must be stated that the probability of a cluster's high position in IVC in the 'high' category of the 'PCT patent applications' (PCT-patapp) variable is over 95.5 times higher than in the 'low' category, and in the 'medium' category it is over 13.5 times higher than in the 'low' category. This means that the highest probability of a cluster's high position in IVC can be predicted in regions with the highest activity in PCT patent applications per GDP billion according to purchasing power parity.

On the other hand, the probability of a cluster's high position in IVC in the 'high' category of venture capital expenditure is over 13 times higher than in the 'low' category. This means that the higher venture capital expenditure compared to GDP, the higher the probability of a cluster's high position in IVC. The highest probability of a cluster's high position is also achieved when there is the largest percentage of high growth companies in all active ICT companies (more than 22 times higher probability in the case of presence of high growth enterprises (HGEpe variable) classified as 'high' than when it is in the 'low' category, and over 4 times for the 'medium' class compared to the 'low' class.

The value of internal expenditures on research and development (GERD variable) is conducive to the emergence of a cluster's high position in IVC (over 3.5 times more for the 'high' class than for the 'low' class). The values of odds ratios for the explanatory variables take a justified, logical sequence. It should be remembered that particular dependencies described earlier are corrected with the presence of other variables in the model.

Table 4.13 Results of the multi-factor model for innovation capacity without control variables (IC model)

Cluster UPGRADING – Evaluation of parameters
Distribution: BINOMINAL, Binding function: LOGIT
Modeled probability, Cluster UPGRADING = 1

Result	*Level*	*Evaluation*	*Standard*	*Wald*	*Odds ratio*	*Confidence OR −95%*	*Confidence OR 95%*
Free term		−7.424*	1.004	54.694	0.001	0.000	0.004
GERD	ND	0.792***	0.344	5.295	2.207	1.124	4.331
GERD	HIGH	1.288*	0.270	22.754	3.624	2.135	6.151
VCexp	HIGH	2.576*	0.621	17.228	13.146	3.895	44.372
PCTpatapp	HIGH	4.560*	0.514	78.667	95.560	34.887	261.748
PCTpatapp	MEDIUM	2.614*	0.468	31.168	13.655	5.454	34.188
HGEpe	MEDIUM	1.468****	0.741	3.922	4.341	1.015	18.563
HGEpe	HIGH	3.093**	1.069	8.373	22.038	2.713	179.045

Source: Own elaboration based on research.

* $p < 0.001$, ** $p < 0.005$, *** $p < 0.03$, **** $p < 0.05$.

In the process of identifying an optimal *multi-factor model for innovation capacity with control variables* (ICc model), just as in the case of the model with control variables for absorptive capacity (ACc), various variants were considered. Finally, at the stage of variable selection, we developed a model which meets all valid quality criteria. The ICc model comprises the following independent variables:

– PCT patent applications – PCTpatapp variable (all classes from the IC model remained, namely 'low', 'medium' and 'high'),
– Presence of high growth enterprises: companies whose high growth is measured with employment (growth by 10% or more) – HGEpe variable (all classes from the IC model remained, namely 'low', 'medium' and 'high'),
– *GDP per capita according to purchasing power parity – GDPpcPPS control variable* (in this model 'low' and 'high' classes were preserved),
– *Apparent labor productivity – ALPpem control variable* (the model comprises 'low', 'medium' and 'high' classes).

Other independent variables (namely 'internal expenditures on research and development' – GERD variable, 'venture capital expenditures' – VCexp variable, 'share of total turnover of sales of new-to-market and new-to-firm innovations' – SalInn variable) were rejected at the stage of ultimate selection of independent variables for the model. The reason was that as they deteriorated the quality of the ICc model, showing too high correlation between variables, lack of statistical significance or changing odds ratios of other variables, which resulted in illogical dependencies between explanatory variables and the explained variable.

It should be noted that compared to the IC model (i.e., the model without control variables) the ICc model does not include such independent variables as 'internal expenditures on research and development' (GERD) and 'venture capital expenditures' (VCexp). The reason was that the generated model lacked significance of the GERD variable. In the case of the VCexp independent variable, after introducing both control variables to the model, this variable was not significant anymore, which could be seen in the multi-factor model. The results of the multi-factor model of logistic regression for the 'innovation capacity' theoretical variable with control variables (ICc model) are presented in Table 4.14.

As we can see in Table 4.14, all independent variables are statistically significant ($p <= 0.05$). The results of the multi-factor model with control variables for innovation capacity should be interpreted in the following way: the probability of a cluster's high position in IVC in the 'high' category concerning presence of high growth enterprises (HGEpe variable) is over 728 times higher than in the 'low' category, and more than 17 times higher

Table 4.14 Results of the multi-factor model for innovation capacity taking into account control variables (ICc model)

Cluster UPGRADING – Evaluation of parameters
Distribution: BINOMINAL, Binding function: LOGIT
Modeled probability, Cluster UPGRADING = 1

Result	*Level*	*Evaluation*	*Standard*	*Wald*	*Odds ratio*	*Confidence OR –95%*	*Confidence OR 95%*
Free term		–9.243*	1.270	52.980	0.000	0.000	0.001
PCTpatapp	HIGH	4.02*	0.682	51.714	134.575	35.376	511.945
PCTpatapp	MEDIUM	3.253*	0.644	25.494	25.856	7.315	91.388
HGEpe	MEDIUM	2.838**	0.966	8.640	17.089	2.575	113.428
HGEpe	HIGH	6.591*	1.440	20.951	728.785	43.331	12257.326
GDPpcPPS	HIGH	2.179*	0.436	24.922	8.834	3.756	20.779
GDPpcPPS	ND	1.928*	0.474	16.581	6.878	2.719	17.401
ALPpem	HIGH	4.473*	0.646	47.883	87.646	24.686	311.178
ALPpem	MEDIUM	1.424***	0.497	8.210	4.156	1.568	11.011

Source: Own elaboration based on research.

*$p < 0.001$, **$p < 0.004$, *** $p < 0.005$.

in the 'medium' category than in the 'low' one. Similar dependencies can be observed for the 'PCT patent applications' (PCTpatapp) variable: over 135 times higher probability of a cluster's high position in the 'high' category and over 25 times higher in the 'medium' category than in the 'low' one.

On the other hand, in the case of the 'apparent labor productivity' control variable (ALPpem variable), the probability of a cluster's high position is over 87 times higher in the 'high' class than in the 'low' one, and 4 times higher in the 'medium' category than in the 'low' one. With regard to GDP per capita according to purchasing power parity (GDPpcPPS variable), the probability of a high position is nearly 9 times higher for the 'high' class than for the 'low' one. The values of odds ratios for particular explanatory variables, taking into account their detailed classification, takes a justified, logical sequence. Obviously, it must be remembered that the dependencies described above are corrected with the presence of other variables in the model.

4.4 Governance and Public Support as Determinants of Clusters' IVC Position

4.4.1 The Analysis of Cramer's V Associations between Variables

Due to the related nature of governance form and public support determinants, they were included into one model (the GFGOV model without control variables and the GFGOVc model with control variables. Both theoretical determinants perform regulatory functions, creating an ecosystem in which clusters operate. They may perform a function supporting development of clusters and their inclusion in IVCs. They reflect a particular institutional order, composed of both a set of rules and principles governing relations between entities in a cluster and entities connected with it, as well as a set of government support for a particular cluster.

We conducted the analysis of the strength of Cramer's V associations between pairs of independent variables, namely 'governance form' (GF variable) and 'public support' (GOV variable) and between the dependent variable and particular explanatory variables (we assumed $p < 0.05$). The results were presented in Table 4.15.

As we can see in Table 4.15, the strongest associations between independent variables were observed between 'job-to-job mobility of HRST' (JJmob) variable and 'knowledge-intensive services exports' (ExpKIBS) variable (0.82), 'public-private co-publications' (Ppcpub) variable and 'knowledge-intensive services exports' (ExpKIBS) variable (0.62), 'innovative SMEs collaborating with others' (SMEcoop) variable and 'knowledge-intensive services exports' (ExpKIBS) variable (0.61), 'innovative SMEs collaborating with others' (SMEcoop) variable and 'public-private co-publications' (Ppcpub) variable (0.59), 'job-to-job mobility of HRST' (JJmob) variable and 'direct and

Table 4.15 The indicators of the strength of Cramer's V associations between independent variables in the GFGOV model

	Cramer's V					
	ExpMHtech	*ExpKIBS*	*Ppcpub*	*JJmob*	*GovSup*	*SMEcoop*
ExpMHtech	1.00	0.24	0.39	0.28	0.33	0.14
ExpKIBS	0.24	1.00	0.62	0.82	0.46	0.61
Ppcpub	0.39	0.62	1.00	0.45	0.52	0.59
JJmob	0.28	0.82	0.45	1.00	0.56	0.39
GovSup	0.33	0.46	0.52	0.56	1.00	0.46
SMEcoop	0.14	0.61	0.59	0.39	0.46	1.00

Source: Own elaboration based on research.

Table 4.16 The indicators of the strength of Cramer's V associations between particular independent variables and the dependent variable in the GFGOV model

Variables	*Cramer's V*
ExpMHtech and cluster UPGRADING_	0.27
Ppcpub and cluster UPGRADING_	0.63
JJmob and cluster UPGRADING_	0.66
GovSup and cluster UPGRADING_	0.43
SMEcoop and cluster UPGRADING_	0.46
ExpKIBS and cluster UPGRADING_	0.59

Source: Own elaboration based on research.

indirect government support of business R&D (GovSup variable) (0.56) and 'public-private co-publications' (Ppcpub) variable and 'direct and indirect government support of business R&D' (GovSup variable) (0.52). Other pairs of explanatory variables had results below 0.5. The results of the strength of associations between individual independent variables and the dependent variable are presented in Table 4.16.

As we can see in Table 4.16, the highest indicators of strength of associations between individual independent variables and the dependent variable were observed for the 'job-to-job mobility of HRST' (JJmob) variable (0.66), the 'public-private co-publications' (Ppcpub) variable (0.63), as well as for the 'knowledge-intensive services exports' (ExpKIBS) variable (0.59). Other variables had values below 0.5.

4.4.2 Single-Factor Models

We also developed single-factor models for the GFGOV model. We analyzed the results for single-factor models taking into account the dependent variable and particular independent variables in the GFGOV model (confidence interval 95%, p<0.05). This allowed us to conclude that the highest probability of a cluster's high position in IVC occurs when the values of all partial independent variables in the 'governance form and public support' theoretical variable are classified in the highest classes ('high' or 'very high'), which is logical.

The single-factor model for governance form and public support (the GFGOV model) without control variables is ultimately composed of the following independent variables:

- Exports of medium and high technology products – ExpMHtech variable (finally 'low' and 'high' classes were preserved in the model),
- Public-private co-publications – Ppcpub variable ('ND', 'low', 'medium' and 'high' classes were preserved),
- Job-to-job mobility of HRST – JJmob variable ('low', 'medium' and 'high' classes remained in the model),
- Direct and indirect government support of business R&D – GovSup variable ('low' and 'high' classes were preserved in the model).

The 'innovative SMEs collaborating with others' variable (SMEcoop), as well as the 'knowledge-intensive services exports' variable (ExpKIBS) were rejected at the stage of the final selection of independent variables for the model, as they worsened the quality of the GFGOV model in the multi-factor model, showing too high degree of correlation between the variables and lack of statistical significance.

4.4.3 Multi-Factor Models

The results of the model of logistic regression for the 'governance form' and 'public support' theoretical variables without control variables are shown in Table 4.17.

Table 4.17 shows that all independent variables are statistically significant ($p <= 0.05$). The values of odds ratios for particular explaining variables, taking into account their specific classification, adopt a justified and logical sequence. For example, the probability of a cluster's high position inIVC in the 'high' category in 'public-private co-publications' (Ppcpub variable) is nearly 94 times higher than in the 'low' category. This means that the highest probability of a cluster's high position in IVC can be found in places with the largest activity concerning preparation and joint publications by private and public entities.

On the other hand, the probability of a cluster's high position inIVCin the 'high' category in 'exports of medium and high technology products' (ExpMHtech variable) is over 28 times higher than in the 'low' category. This means that the cluster has the best chance to occupy a high position in IVC when export of medium and high-technology goods takes the highest value.

The highest probability of a cluster's high position is also achieved when there is the highest mobility of staff employed on science and technology posts

Table 4.17 The results of the multi-factor model for 'governance form' and 'public support' factors without control variables (GFGOV model)

Cluster UPGRADING – Evaluation of parameters
Distribution: BINOMINAL, Binding function: LOGIT
Modeled probability, Cluster UPGRADING = 1

Result	*Level*	*Evaluation*	*Standard*	*Wald*	*Odds ratio*	*Confidence OR –95%*	*Confidence OR 95%*
Free term		–8.522*	1.030	68.411	0.000	0.000	0.001
ExpMHtech	HIGH	3.357*	0.763	19.363	28.706	6.435	128.051
Ppcpub	MEDIUM	2.022*	0.330	37.498	7.554	3.954	14.429
Ppcpub	HIGH	4.543*	0.649	49.022	93.937	26.337	335.051
Ppcpub	ND	1.730*	0.388	19.883	5.638	2.636	12.059
JJmob	HIGH	2.717*	0.325	69.893	15.141	8.007	28.632
JJmob	MEDIUM	2.581*	0.347	55.242	13.216	6.691	26.107
GovSup	HIGH	1.913**	0.601	10.137	6.776	2.087	22.006

Source: Own elaboration based on research.

* $p < 0.001$, ** $p < 0.002$.

(15 times higher probability of a cluster's high position for the job-to-job mobility of HRST (JJmob variable) classified as 'high' class compared to 'low' class and 13 times higher for the 'medium' class than for the 'low' class).

Public support, consisting in direct and indirect government support of business R&D (GovSup variable), supports the cluster's high position in IVC for the independent variable over 6.5 times more for the 'high' class than for the 'low' one. The dependencies described above are corrected with the presence of other variables in the model.

In the process of identifying *the optimal multi-factor model for 'governance form' and 'public support' factors with control variables* (hereinafter referred to as GFGOVc model), just as for the model with control variables for absorptive capacity (ACc) and for innovation capacity (ICc), various variants were considered. Finally, at the stage of selecting variables, we developed a model which meets all valid quality criteria.

The GFGOVc model consists of the following independent variables:

- Exports of medium and high technology products – ExpMHtech variable (finally, the model comprises 'low' and 'high' classes),
- Public-private co-publications – Ppcpub variable ('ND', 'low', 'medium', and 'high' classes were preserved in the model),
- Job-to-job mobility of HRST – Jjmob variable ('low', 'medium', and 'high' classes remained in the model),
- *GDP per capita according to purchasing power parity – GDPpcPPS control variable* ('low' and 'high' classes were kept),
- *Apparent labor productivity – ALPpem control variable* ('low', 'medium', and 'high' classes were kept in the model).

Other independent variables ((i.e., 'direct and indirect government support of business R&D' (GovSup), 'innovative SMEs collaborating with others' (SMEcoop) and 'knowledge-intensive services exports' (ExpKIBS)) were rejected when finally choosing independent variables for the model, as they deteriorated the quality of the GFGOVc model, showing too high correlation between variables, too low statistical significance or they changed the values of odds ratios of other variables, which led to illogical dependencies between explaining variables and the explained variable.

It should be noted that compared to the GFGOV model (without control variables), the GFGOVc model does not contain the 'direct and indirect government support of business R&D' variable (GovSup). The introduction of control variables to the model generated a faulty model that could not be accepted due to the lack of significance of the GovSup variable. This was observable in the multi-factor model. The results of the multi-factor model of logistic regression for 'governance form' and 'public support' theoretical variables with control variables (GFGOVc model) are presented in Table 4.18.

Table 4.18 The results of the multi-factor model for governance form and public support with control variables (GFGOVc model)

Cluster UPGRADING – Evaluation of parameters
Distribution: BINOMINAL, Binding function: LOGIT
Modeled probability, Cluster UPGRADING = 1

Result	*Level*	*Evaluation*	*Standard*	*Wald*	*Odds ratio*	*Confidence OR –95%*	*Confidence OR 95%*
Free term		–8.958*	0.979	83.780	0.000	0.000	0.001
ExpMHtech	HIGH	3.261*	0.801	16.568	26.068	5.423	125.318
Ppcpub	MEDIUM	2.597*	0.391	44.173	13.420	6.240	28.862
Ppcpub	HI GH	4.297*	0.681	39.797	73.507	19.341	279.373
Ppcpub	ND	2.042*	0.515	15.722	7.704	2.808	21.136
JJmob	HIGH	1.401**	0.422	11.009	4.059	1.774	9.286
GDPpcPPS	HIGH	2.212*	0.454	23.744	9.133	3.752	22.232
ALPpem	HIGH	3.785*	0.567	44.503	44.036	14.483	133.897
ALPpem	MEDIUM	1.162**	0.475	5.981	3.196	1.260	8.111

Source: Own elaboration based on research.

* $p < 0.001$, ** $p < 0.002$.

As we can see in Table 4.18, all independent variables are statistically significant ($p \leq 0.05$).The results of the multi-factor model with control variables for go governance-related factors show that the probability of a cluster's high position in IVC in the 'high' category in 'public-private co-publications' (Ppcpub variable) is 73.5 times higher in the 'high' category and over 13 times higher in the 'medium' category than in the 'low' one.

On the other hand, the probability of a cluster's high position is over 4 times higher for the 'job-to-job mobility of HRST' (JJmob variable) in the 'high' class than in the 'low' class. Similar relations can be observed for the 'exports of medium and high technology products' variable (ExpM-Htech): slightly over a 26 higher probability of the high position for the 'high' category compared to the 'low' one.

As far as the 'apparent labor productivity' (ALPpem) control variable is concerned, the probability of a cluster's high position is over 44 times higher in the 'high' class than in the 'low' one, and over three times higher in the 'medium' class than in the 'low' one. In the case of the other control variable – GDP per capita according to purchasing power parity (GDP-pcPPS variable), the probability of a cluster's high position is over 9 times higher for the 'high' class than for the 'low' one. The values of odds ratios for particular explanatory variables, taking into account their specific classification, adopt a justified and logical sequence. It must be remembered, though, that particular dependencies described above are corrected with the presence of other variables in the model.

4.5 Determinants of Clusters' Upgrade Based on an Aggregate Model

In the process of identifying an optimal *model for all theoretical variables, namely absorptive capacity, innovation capacity, governance form, and public support* (hereinafter referred to as the KD model), various variants were considered. Finally, at the stage of variable selection, we developed a model that meets all valid quality criteria.

The KD model is composed of the following independent variables:

- 'exports of medium and high technology products' – ExpMHtech variable (the model ultimately comprises 'low' and 'high' classes) – the variable appearing in the GFGOV and GFGOVc models,
- 'public-private co-publications' – Ppcpub variable (the model comprises 'ND', 'low', 'medium' and 'high' classes) – the variable appearing also in the GFGOV and GFGOVc models,
- 'PCT patent applications' – PCTpatapp variable ('low', 'medium' and 'high' classes were preserved in the model) – the variable appearing also in IC and ICc models,

– *GDP per capita according to purchasing power parity – GDPpcPPS control variable* ('ND', 'low' and 'high' classes remained in the model),
– *'apparent labor productivity' –ALPpem control variable* ('low' and 'high' classes were preserved in the model).

Other independent variables worsened the quality of the KD model, showing too high correlation between the variables, too low statistical significance or changing the values of odds ratios, which led to illogical dependencies between explaining variables and the explained variable. For these reasons, we did not include them in the KD model and rejected them when selecting independent variables. In particular, we must pay attention to those independent variables which were reflected in partial models with control variables. We compared the variables composing the ACc, ICc, GFGOVc, and KD models, as illustrated in Figure 4.4.

As we can see in Figure 4.4., the aggregate KD model does include the following ACc variables: 'employment of R&D personnel and scientists' (R&D variable), 'percentage of population with higher education, 25–64 age group' (Edu variable) and 'percentage of staff employed in technology and knowledge-intensive sectors' (EmHKIBS variable). Some variables from other models were not included in the KD model, either. In the ICc model it was 'presence of high growth enterprises: companies whose high growth is measured with employment (growth of 10% or more)' (HGEpe variable), and in the GFGOVc model – 'job-to-job mobility of HRST' (JJmob variable).

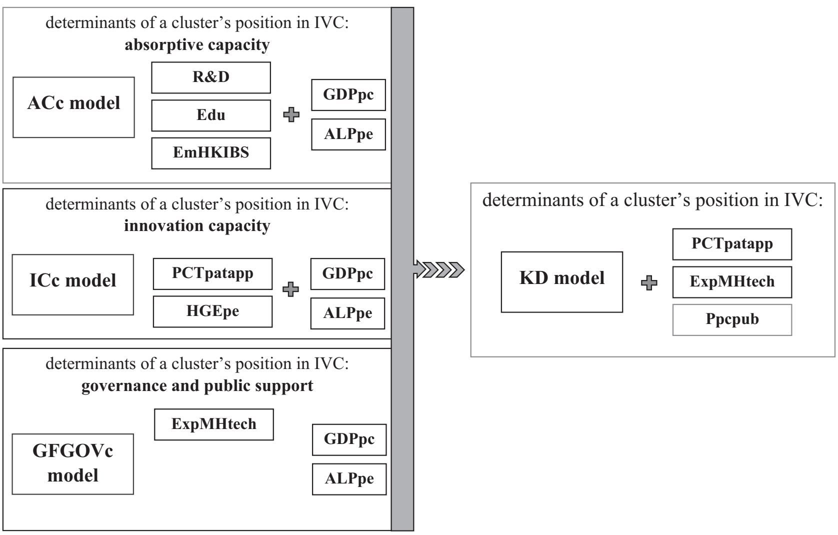

Figure 4.4 The structure of independent variables in the analyzed models.

It should also be noticed that the aggregate KD model does not include any variable from individual variable models concerning absorptive capacity (neither AC nor ACc model). In the modeling process, these variables, when entered into models reflecting control variables, did not gain sufficient statistical significance or power of influence. This was observed in multi-factor models, in which these variables, just like the parameters from the ICc model ('presence of high growth enterprises: companies whose high growth is measured with employment (growth of 10% or more)' – HGEpe) and GFGOVc ('job-to-job mobility of HRST' – JJmob) had values of p exceeding 0.05, and often also values of odds ratios for particular classes. This revealed illogical dependencies between a particular explaining variable of a given class and another class of this variable. For instance, the value of odds ratio for the 'medium' class was higher than the value of the odds ratio for the 'high' class, which would lead to erroneous interpretation of the results of the regression model. The results of the correct KD model with many independent variables are shown in Table 4.19.

As we can see in Table 4.19, all independent variables are statistically significant ($p \leq 0.05$). The results of the multi-factor model with control variables in the KD model should be interpreted in the following way. The probability of a cluster's high position in IVC in the 'high' category in 'PCT patent applications' (PCTpatapp variable) is over 158.5 times higher than in the 'low' category, and over 12 times higher in the 'medium' category than in the 'low' one. Similar dependencies can be observed for the 'exports of medium and high technology products' variable (ExpMHtech): over 60.5 times higher probability of the cluster's high position in the 'high' category than in the 'low' one. For the 'public-private co-publications' (Ppcpub) variable, the probability of a cluster's high position is nearly 66 times higher in the 'high' class and over 16.5 times higher in the 'medium' class than in the 'low' one.

On the other hand, for the 'apparent labor productivity' (ALPpem) control variable, the probability of a cluster's high position is over 37 times higher in the 'high' class than in the 'low' class. For the second control variable – 'GDP per capita according to purchasing power parity (GDPpcPPS) – the probability of the high position is nearly 9 times higher in the 'high' class than in the 'low' one. The values of odds ratios for particular explanatory variables, taking into account their detailed classification, adopt a justified, logical sequence. It needs to be remembered that particular dependencies described above are corrected with the presence of other variables in the model.

4.5.1 Statistical Tests and Analyses Applied in the Models

We conducted the Hosmer-Lemeshow goodness-of-fit test, the analysis of the area under the ROC curve for V-times cross-validation and the training set, as well as the analysis of the forest plot for all models. The aggregated results for the models are shown in Table 4.20.

Table 4.19 The results of the aggregate multi-factor model with control variables (KD model)

Cluster UPGRADING – Evaluation of parameters
Distribution: BINOMINAL, Binding function: LOGIT
Modeled probability, Cluster UPGRADING = 1

Result	*Level*	*Evaluation*	*Standard*	*Wald*	*Odds ratio*	*Confidence OR −95%*	*Confidence OR 95%*
Free term		−11.389*	1.245	83.680	0.000	0.000	0.000
PCTpatapp	HIGH	5.066*	0.751	45.498	158.607	36.388	691.325
PCTpatapp	MEDIUM	2.513*	0.692	13.180	12.343	3.178	47.938
ExpMHtech	HIGH	4.106*	0.870	22.266	60.692	11.027	334.029
Ppcpub	MEDIUM	2.818*	0.481	34.344	16.751	6.526	42.995
Ppcpub	HIGH	4.187*	0.745	31.598	65.850	15.292	283.565
Ppcpub	ND	3.208*	0.587	29.854	24.724	7.823	78.137
GDPpcPPS	HIGH	2.184*	0.388	31.659	8.882	4.150	19.007
GDPpcPPS	ND	2.199*	0.491	20.084	9.015	3.446	23.584
APLpem	HIGH	3.616*	0.575	39.508	37.177	12.040	114.796

Source: Own elaboration based on research.

* $p < 0.001$.

Table 4.20 The Hosmer-Lemeshow (H-L) test and the analysis of the area under the ROC curve for the AC, ACc, IC, ICc, GFGOV, GFGOVc, and KD models

Analysis/model		*AC*	*Acc*	*IC*	*ICc*	*GFGOV*	*GFGOVc*	*KD*
H-L statistical value		3.2302*	10.1464*	14.0336*	7.7309*	3.2105*	6.8186*	13.5512*
AUC	V-times	0.869	0.948	0.906	0.939	0.918	0.956	0.957
AUC error	cross-validation	0.0120	0.0074	0.0103	0.0083	0.0102	0.0073	0.0068
AUC	Training set	0.879	0.954	0.918	0.949	0.932	0.963	0.964
AUC error		0.0114	0.0068	0.0095	0.0072	0.0090	0.0064	0.0059

Source: Own elaboration based on research.

* $p > 0.05$.

As presented in Table 4.20, the Hosmer-Lemeshow goodness-of-fit test for all prepared models of logistic regression does not justify the rejection of the zero hypothesis of the ill fit of particular models. This means that there are no reasons for considering them as ill-fitted. On the other hand, on the basis of the analysis of ROC curves for the V-times cross-validation and for the training set, it must be stated that each time there are slight differences between the curves and their areas, which allows us to conclude that the models are not overfitted. Therefore, we can assume that the prepared models meet the requirements of high quality. Moreover, we checked the shape of the forest plot, in which values of odds ratios and confidence intervals for independent variables are provided for particular models. In each of them, confidence intervals do not have the value of 1.

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5 Discussion and Contribution

5.1 Discussion of the Research Findings

Based on the research findings, we will perform the verification of the research hypotheses concerning the influence of four theoretical variables on cluster upgrading in the ICT service industry. Our assessment will be based on multi-factor models for individual variables with control variables (ACc, ICc, and GFGOVc models) and the aggregate model (KD model). This interpretation will follow a rule that a hypothesis concerning the influence of a particular theoretical variable will be accepted as long as at least two observed variables representing it have shown statistical significance in the models for individual theoretical variables with control variables. Hypothesis 1 contained the following assumption:

H 1. There is a positive relationship between the cluster's position in international value chains and its absorptive capacity.

Taking into account the adopted criteria, Hypothesis 1 was verified positively. The logistic regression model reflecting control variables (ACc model) showed three determinants of ICT clusters' position in IVC: education level of human capital, employment of R&D personnel and scientists, and employment in high-technology and knowledge-intensive sectors.

The assumption in Hypothesis 2 was:

H 2. There is a positive relationship between the cluster's position in international value chains and its innovation capacity.

Hypothesis was confirmed. The model of multi-factor logistic regression reflecting control variables (ICc model) showed that there are two significant IC-related determinants of ICT cluster upgrading, namely PCT patent applications and presence of high-growth companies.

Hypothesis 3 stated that:

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H 3. There is a positive relationship between the cluster's position in international value chains and non-hierarchical form of cluster governance.

This hypothesis was also accepted. The model of logistic regression reflecting control variables (GFGOVc) concerning governance form pointed at three determinants of ICT clusters' position in IVC: export of medium and high technology products, joint private-public publications, and job mobility in science and technology.

Hypothesis 4 assumed that:

H 4. There is a positive relationship between the cluster's position in international value chains and the cluster support by public authorities.

Hypothesis 4 was rejected, as we did not confirm the influence of direct and indirect government support on research and development activities of companies.

The research findings allowed us to reach our main goal and verify research hypotheses, which led to specifying determinants of ICT clusters' position in international value chains. Table 5.1 summarizes hypotheses verification, taking into consideration confirmed and rejected theoretical variables and observable variables reflecting them.

Analyzing the research findings concerning Hypothesis 1, we conclude that absorptive capacity constitutes threshold potential for assimilating and internalizing external knowledge by a cluster as a system comprising companies in their relations with environment organizations and regional resources (Aslesen & Harirchi, 2015; Cusmano et al., 2010; Giuliani et al., 2017; Hervas-Oliver et al., 2012a; Menghinello et al., 2010; Munari et al., 2012; Pietrobelli & Rabellotti, 2011; Sammarra & Belussi, 2006). The determinants which significantly affect the upgrading of ICT service clusters include employment of highly qualified specialists (for instance, research and development personnel, scientists, employees in technology and knowledge-intensive sectors), and higher level of education of regional human resources. This confirms the assumption that absorptive capacity depends on former knowledge resources at the cluster's disposal, as well as sources and specificity of acquired knowledge (Todorova & Durisin, 2007).

The above-listed elements are inextricably connected with the region's human capital available to the cluster. Clusters occupying high positions in IVC are established by organizations employing highly qualified, competent personnel, who can correctly determine the value of the available knowledge resources (Cohen & Levinthal, 1990; Mangematin & Nesta, 1999), decide that it is necessary to continually supplement and update these resources (Jansen et al., 2005; Mowery & Oxley, 1995), and can transform this potential to innovative products or services (Baker et al., 2003; Kim, 1998).

Table 5.1 Summary of models

Theoretical variables	*Model*	*Observable variables*	*Hypotheses verification*	*Identified determinants*
Absorptive capacity	AC model – *model without control variables*	Education level of human capital (Edu), employment of R&D personnel and scientists (R&D), IT competencies (CompIT), employment in knowledge-intensive technologies and sectors (EmHKIBS), employed IT specialists (EmITsp) and control variables in the ACc model: ALPpem and GDPpcPPS	H 1.1. There is a positive relation between the cluster's position in international value chains and its absorptive capacity – confirmed	Education level of human capital (Edu), employment of R&D personnel and scientists (R&D), IT competencies (CompIT), employment in knowledge-intensive technologies and sectors (EmHKIBS)
	ACc model – *model with control variables*			Education level of human capital (Edu), employment of R&D personnel and scientists (R&D), employment in knowledge-intensive technologies and sectors (EmHKIBS), labor productivity (ALPpem) and GDP per capita according to purchasing power parity of the country (GDPpcPPS)
Innovation capacity	IC model – *model without control variables*	internal expenditure on research and development (GERD), venture capital expenditure (VCexp), PCT patent applications (PCTpatapp), presence of high-growth companies (HGEpe), sale of innovations new to the market and new to companies (SalInn) and control variables of the ICc model: ALPpem and GDPpcPPS	H 1.2. There is a positive relation between the cluster's position in international value chains and its innovation capacity – confirmed	internal expenditure on research and development (GERD), venture capital expenditure (VCexp), PCT patent applications (PCTpatapp), presence of high-growth companies (HGEpe)
	ICc model – *model with control variables*			PCT patent applications (PCTpatapp), presence of high-growth companies (HGEpe), labor productivity (ALPpem) and GDP per capita according to purchasing power parity of the country (GDPpcPPS)

Institutional factors	GFGOV model – *model without control variables* GFGOVc model – *model with control variables*	export of medium and high-technology products (ExpMHtech), export of knowledge-intensive services (ExpKIBS), job mobility in science and technology (JJmob), joint private-public publications (Ppcpub), direct and indirect government support for R&D activities in companies (GovSup), innovative SMEs cooperating with others (SMEcoop) and control variables in the GFGOVc model: ALPpem and GDPpcPPS	H 1.3. There is a positive relation between the cluster's position in international value chains and non-hierarchical form of governance – confirmed H 1.4. There is a positive relation between the cluster's position in international value chains and the policy of cluster support by public authorities – rejected	export of medium and high-technology products (ExpMHtech), joint private-public publications (Ppcpub), job mobility in science and technology (JJmob), direct and indirect government support for R&D activities in companies (GovSup) export of medium and high technology products (ExpMHtech), joint private-public publications (Ppcpub), job mobility in science and technology (JJmob), labor productivity (ALPpem) and GDP per capita according to purchasing power parity in the country (GDPPpcPPS)
-	KD model – *model with control variables, identifying the list of key determinants*	observable variables listed above, coming from AC, ACc, IC, ICc, GFGOV, GFGOVc models and control variables: ALPpem and GDPpcPPS	Hypothesis 1. Determinants of the cluster's position in international value chains comprise a set of factors related to the cluster's capacities and institutional factors – confirmed	joint private-public publications (Ppcpub), export of medium and high technology products (ExpMHtech), PCT patent applications(PCTpatapp), labor productivity (ALPpem)and GDP per capita according to purchasing power parity in the country (GDPpcPPS)

Source: Own elaboration based on research.

This may lead to further development of competencies (Keller, 1996) and gaining and maintaining competitive advantage (Zahra & George, 2002), which also positively shape the possibility of achieving a high position in IVC.

At the same time, the factors of the number of people with above-average IT skills (CompIT variable) and employed IT specialists (EmITsp) turned out to be insignificant in the process of achieving a high position in IVC by a cluster. It is worth emphasizing, though, that as we demonstrated in the research finding section, the first model for absorptive capacity, namely the ACc-1 model showed significance of the variable concerning general level of population education (Edu variable) to the variable concerning employed IT specialists (CompIT variable). ACc-1 model was then rejected in the course of its verification by means of the Akaike criterion.

The presented importance of specialist competencies reflects the business practice consisting in offering newly employed staff cycles of trainings and adaptation workshops, which allow them to take specialist jobs. The ICT industry features a high degree of specialization, but this principle can be observed in all clusters – agglomerations with specific activity profile. A particular profile of competencies is reached in the process of continuous education and participation in research and development projects. When recruiting workers from the labor market, cluster participants are determined by a certain initial level of competencies possessed by regional labor resources. The higher the level of competencies – demonstrated in higher education or above-average IT skills – the greater the opportunity of winning a high place in the regional or national perspective as well as in international value chains.

The research findings, especially concerning *AC and ACc models (H 1), allow us to draw a general conclusion that there is a positive relationship between the cluster's position in international value chains and its absorptive capacity.* The cluster's high position in IVC is determined, among others, by the cluster's potential for utilizing the already possessed knowledge resources and continuous accumulation and generation of new knowledge. This, however, will be possible only if the cluster has properly qualified human capital compared to the industry's participants operating outside the cluster. The potential for assimilating and internalizing external knowledge is thus generated by highly competent staff (Mangematin & Nesta, 1999). At the same time, it should be noticed that the significance of control variables in the ACc model is stronger for cluster upgrading opportunities than that of observable variables being proxies for absorptive capacity. External effects connected with the size of the economy (GDP) and labor productivity on the national level (ALP) are better at increasing the probability of upgrading than the theoretical variable and observed variables expressing it. This suggests that the capacities of a cluster as a regional system are weaker than national factors in determining the upgrade in IVC.

The second theoretical variable – innovation capacity – determines the cluster's potential for generating innovations, that is, launching new or significantly improved products and services or implementing new or significantly improved business processes in the organization (OECD-Eurostat, 2018). Innovation capacity is, therefore, the capacity to commercialize knowledge and obtain economic effects on this basis (Giuliani et al., 2017; OECD, 2005; OECD-Eurostat, 2018; Pietrobelli & Rabellotti, 2011). While absorptive capacity determines the possibilities of assimilating or generating knowledge, innovation capacity concerns the utilization of its effects and generating economic value (Cassiman & Veugelers, 2002; Dyer & Singh, 1998; Kim, 1998; Leonard-Barton, 1992).

The results for IC and ICc models (H 2) show that there is a positive relationship between the cluster's innovation capacity and its position in IVC. Unlike in the absorptive capacity model, the IC model with control variables shows greater significance of the theoretical variable, that is observed variables expressing it, than control variables on the national level. The determinants of the ICT cluster's high position in IVC include internal expenditure on research and development (GERD variable), venture capital expenditure (VCexp variable), patent applications (PCTpatapp variable), and the number of high-growth companies (HGEpe). The observed variable concerning sale of new-to-market and new-to-firm innovations (SalInn) was not considered in IC and ICc models due to a lack of significant influence on the cluster's upgrading. Having added control variables to the model, we concluded that significant determinants related to innovation capacity were patent applications and the presence of high-growth companies. Moreover, we could observe greater significance of observable variables than control variables in the cluster's opportunities for upgrading. Both presence of high-growth companies and patent activity, especially if it leads to patent applications, point at effective management of resources and successful accomplishment of goals. High-growth companies are effective in generating economic effects of innovations, expressed in high growth of sale and employment. On the other hand, patents, seen as discoveries concerning products or processes, are a good determinant of effectiveness in research and development activity and innovation activity.

Internal expenditure on R&D (GERD variable) or venture capital expenditure (VCexp variable) do not significantly determine financial results or company competitiveness (Jörn, 2016). As demonstrated in IC and ICc models, the determinants of the cluster's high position are closer to effects than expenditures only. The activity of patenting and discovering in the R&D process is of vital importance, as patents prove the functionality of the discovery and its novelty on a global scale. When a patented solution is implemented as an innovation of a business process or market products and services, its novelty offers opportunities of global expansion. On the other hand, patent protection allows the innovators to claim ownership rights to gain economic benefits, which limits the problem of uncontrolled knowledge spillover and external benefits without incurring costs of such investments. *AC, ACc, IC, and ICc models express a set of determinants of the upgrading, connected with the cluster's capabilities.*

The factors related to governance form and public support were of regulatory nature (GFGOV and GFGOVc models). Both theoretical variables refer to institutional issues, i.e. regulatory mechanisms or sets of rules governing a particular system (Colombo et al., 2019; Gereffi et al., 2005; Gereffi & Lee, 2016; Williamson, 2000). Due to their related nature, we combined the above-mentioned variables into one model and treated them as governance-related factors. The cluster governance form covers the cluster's regulation mechanism in its relations on the regional level and in international value chains. According to the classification of governance forms, there are hierarchical and non-hierarchical structures (Humphrey & Schmitz, 2000, 2002). It should be remembered that hierarchical ties hinder knowledge flow and learning processes regarding chain participants, especially from developing countries (Gereffi et al., 2005; Markusen, 1996; Sturgeon et al., 2008; Williamson, 2000). Our *research confirms that non-hierarchical governance form supports the cluster's high position in IVC (H 3)*. This form positively affects learning processes and knowledge transfer (Markusen, 1996; Pavlínek, 2012; Rugraff, 2010), and consequently, innovative activity and upgrading of the cluster's position in IVC.

The determinants of governance forms include intensity of business cooperation, public-private projects, and position of suppliers resulting from their technical and organizational competencies (Gereffi et al., 2005). According to the results of modeling, significant governance-related determinants of ICT cluster upgrading are high level of joint private-public publications (Ppcpub) and high level of job-to-job mobility in HRST (JJmob). The nature of these factors shows the importance of non-hierarchical governance form (H 3). Participation in IVC dominated by such governance form can be considered as the best environment to support achievement and maintenance of a high position in IVC by a cluster.

Export of medium and high technology products is a form of the cluster's active participation in IVC, where it operates as a supplier or customer. Exporting activity proves intensity of inclusion in global value chains. The more a cluster exports, the less dependent it is on local demand. High export levels prove that the cluster's product range is internationally attractive. Gereffi et al. (2005) point at the risk that may be associated with participation in hierarchical networks. In such a situation, it is easy to observe asymmetry between the buyer and the supplier, and, when it comes to suppliers from less developed countries or clusters at the initial stage of development, this may greatly prevent the cluster from reaching a high position in IVC. In extreme cases, it may even lead to the exclusion of the supplier from the value chain.

The position of a supplier and its competencies are manifested in the type of exported goods. In this vein, export of medium and high-technology products stands for advanced competencies and strengthens the supplier's position in IVC. In this situation, the governance form will be non-hierarchical. This is consistent with the specificity of the ICT industry, in which high levels of export are observed mostly among medium-sized and large entities. Their bargaining power, scale of operations, and impact on the environment allow them to avoid any dependence position in IVC and achieve balanced relationships with other chain participants. High level of technology also allows us to expect that the value chain follows technological standards established by the entities having high competence in those technologically advanced areas.

The findings of our research are consistent with the theory of governance forms, which emphasizes the importance of non-hierarchical structures for upgrading in IVC. Public-private co-publications are an outcome of intellectual cooperation between the scientific and business communities, i.e. inter-sectoral relations. This demonstrates horizontal structures of cooperation and the use of complementary resources from both private and public entities. Private entities contribute to cooperation with public institutes and universities by providing efficiency-oriented incentives, an attitude focused on practical results, and knowledge commercialization. They bring scientific research closer to effects and practical problem solutions. Public entities provide high-quality technology and inventions reflecting the latest scientific knowledge, which is conducive to breakthrough innovations. Relying on public funds, they incur costs of uncertainty related to primary research and development activity.

High job-to-job mobility of HRST characterizes an environment favoring knowledge spillover. As indicated by Grossman and Helpman (1992), this triggers an accumulative process of generating knowledge. Its effects include not only economic growth in the region, but also development of cluster participants (Fallah & Ibrahim, 2004; Glaeser et al., 1992). Staff mobility in a cluster reflects its non-hierarchical structure, when there are no dominant entities attracting better jobs. Staff mobility is usually limited between small and large business entities, or in clusters based on the dominance of public entities (Markusen, 1996). Staff mobility is typical of innovative Marshall's districts (Marshall, 1920) and Italian districts, where balanced relations between cooperating and competing entities prevail.

The GFGOV model also allowed us to test Hypothesis 4, according to which there is a positive relationship between the cluster's high position in international value chains and cluster support offered by public authorities. Although we discovered the significance of the variable describing direct and indirect government support for R&D activities in companies (GovSup) in the GFGOV model, the model with control variables (GFGOVc) and the aggregate model (KD) did not show the significance of this variable.

The lack of significance was also demonstrated for the variables of export of knowledge-intensive services (ExpKIBS) and innovative SMEs collaborating with others (SMEcoop). The lack of significance of the latter variable can be attributed to the essence of the cluster, in which the regulatory mechanism consists of not only coordination of interests and cooperation, but also competition.

The aggregate model (KD) reflects all proxies for four theoretical variables and control variables. *This model revealed key explanatory variables of ICT clusters' upgrading in international value chains, namely value of patent applications per GDP billion according to purchasing power parity, public-private co-publications, and export of medium and high technology products.* This model is characterized by the lack of significance of variables related to absorptive capacity, whose observable variables constitute expenditures and input-related factors, and do not reflect effectiveness of achieving upgrading in IVC. The main conclusion we can draw form the aggregate model is that the cluster's position in IVC mostly depends on outputs, measurable effects of activities on the cluster level, and on cooperation with public sector in generating knowledge.

The conducted modeling allowed us not only to identify determinants of ICT clusters' position in IVC, but also to determine the hierarchy of these factors. Factors related to the governance form on the cluster level in IVC constitute an essential element determining the cluster's position in IVC. Cluster upgrading and their position in IVC are most strongly affected by outcomes of knowledge creation in inter-sectoral partnerships in the form of *joint publications of public and private entities.* Publication effects imply previous joint research and development activities and innovation projects. However, the activities themselves, though they are necessary input, do not always bring success in the form of a discovery which gets positive peer evaluation and can be published. Simultaneously, *export of medium and high technology products* shows that a high position in IVC is achieved by those clusters which participate actively and on a large scale in transactions and ties on the international level, while this activity concentrates on knowledge-intensive and high value-added generating sectors. Knowledge and technology-intensive activity guarantee a stronger bargaining position in international transactions and shape non-hierarchical governance form in IVC.

The value of PCT patent applications in the KD model is a confirmed factor representing the innovation capacity theoretical variable. This determinant concerns globally groundbreaking innovations, therefore, it denotes the global scope of knowledge created in the cluster and the possibility of competing globally rather than on one's own market. Patent applications imply technological standards and terms of contracts, and thus non-hierarchical form of relations in IVC, and also the ability to influence IVC governance. The research findings do not point at expenditure on research and development activity as a factor determining the cluster's high position. On the other hand, pro-innovation activities, confirmed with PCT patent applications, turn out to be significant. The ability to assimilate external knowledge (that is, absorptive capacity) itself was not confirmed as a significant theoretical variable in the model composed of four theoretical variables.

As shown in Table 5.1, of 16 observable variables, aggregated in four theoretical variables, three key determinants of the cluster position (KD model) were identified. In this model we also need to acknowledge the importance of control variables, representing external effects related to power of domestic economies. The impact of these variables on the cluster upgrade is weaker compared to cluster-specific factors, related to governance structure (export of high and medium technology products and joint private-public publications) and innovation capacity (patent applications). Moreover, this impact in aggregate model is weaker than in models with single theoretical variables of absorptive capacity, governance form, and public support.

Impressive bibliography on clusters' operation in the context of international value chains shows that the position of sector concentration in these international structures is determined by both factors related to cluster capabilities and governance-related factors (Caspari, 2003; Gereffi, 2014; Giuliani et al., 2005; Glückler & Panitz, 2016; Kaplinsky et al., 2002). According to the literature on GVCs, clusters' position depends on clusters' capabilities, existing governance form, and public support policy (Fornahl et al., 2015; Gereffi et al., 2005; Gereffi & Lee, 2016; Morgan, 2012; Ravenhill, 2014). Factors related to cluster capabilities determine its potential as an agglomeration. Capabilities stem from relationships and resources available in the regional environment (Gancarczyk & Gancarczyk, 2016; Klepper, 2007; Maskell & Malmberg, 2007; Menzel & Fornahl, 2010; Mossig & Schieber, 2016). As pointed out by Williamson (2000), Sturgeon et al. (2008), Gereffi et al. (2005), Markusen (1996), a cluster is also influenced by the factors of regulatory and institutional nature. Specific rules of the game, regulations, conditions of operation in the regional, national, and international space affect the cluster's position (Colombo et al., 2019; Gereffi et al., 2005; Gereffi & Lee, 2016; Williamson, 2000). *Our research confirms the significance of determinants coming from both spheres – cluster's capabilities and regulatory mechanisms, especially those related to governance form.* On the basis of the models for individual theoretical variables (i.e. AC and ACc models for absorptive capacity, IC and ICc models for innovation capacity, and GFGOV and GFGOVc models for governance-related factors), we can conclude that the cluster's position is determined by absorptive and innovation capacity and governance factors. On the other hand, the aggregate model pointed mostly at the significance of governance factors, related to non-hierarchical governance form, and the ability to effectively generate new knowledge in the form of PCT patent applications.

5.2 A Framework of Industrial Cluster Upgrading

5.2.1 Relationships Among Determinants of Cluster Upgrading

The individual variable models identified a configuration of sufficient factors that reveal interrelations, including causal or mutual (feedback) relationships. Although these interrelations may be specific for each ICT agglomeration, the existing research allows us to distinguish the main directions of influence. One of the basic relationships emphasized in this research points at absorptive capacity as the threshold determinant, which does not directly affect the cluster's upgrading, since innovation capacity operates as a mediator in this causality (Apa et al., 2021; Chang et al., 2024; Duan et al., 2020, 2021; Karlsen et al., 2023). Some research points at absorptive capacity as a fundamental condition to achieve innovation capacity and to generate innovations (Pradana et al., 2020). Absorptive capacity may be treated as a determinant of innovation capacity or act as a moderator for innovation capacity or innovation output (Apa et al., 2021; Chang et al., 2024; Duan et al., 2021; Hervas-Oliver et al., 2012b). On the other hand, innovation capacity represents factors directly translating into commercialization of knowledge assimilated or developed on the basis of absorptive capacity (Broadstock et al., 2020; Fan, 2011; Forsman, 2011). Therefore, innovation capacity as a source of new products, services, and processes constitutes a factor directly stimulating growth of value added and growth of the comparative position in IVC (Fan, 2011; Timeus & Gascó, 2018).

Some scientists point at static nature of the idea of absorptive capacity, as it expresses a certain state in particular conditions of time and territory. Considering environment dynamics, in the long run, absorptive capacity calls for changing, reconfiguring, and adapting, which is expressed in the concept of dynamic capabilities (Teece, 2007). Dynamic capabilities represent the potential for transforming the existing competencies. This happens in a proactive way, through shaping standards of technological knowledge and ability to commercialize it, and also as a reaction to changing environmental conditions and market competition. Absorptive capacity, therefore, should not be treated as astatic asset, but a value requiring development and adaptation (Karlsen et al., 2023).

An essential factor in cluster upgrading is the institutional framework, especially cluster governance form on the regional level and in international relations. Within these regulatory mechanisms, financial support and government expenditure on R&D activities in companies do not translate into comparative growth of the cluster's value added in IVC. Non-hierarchical governance form, determined by partnership of public and private entities in generating knowledge and technological advantage due to export of knowledge-intensive goods, is conducive to learning, knowledge transfer, and innovations (Broadstock et al., 2020; Howell, 2020; Qi et al., 2021; Shen & Li, 2022; Timeus & Gascó, 2018; Yoruk et al., 2023).

If a cluster is subject to hierarchical, dependent relations, it may suffer from lock-in. Then we need an external stimulus, in shape of private or public investment (De Marchi & Alford, 2022a). Potential public support should not, however, be passive and rely only on spending particular funds (Gancarczyk & Konopa, 2021). It should consist in active participation of the public party, based on projects and partnership. Such cooperation should produce effects such as patent applications – legal protection of discoveries which are new on a global scale.

Governance form, however, is not the only determinant of upgrading, as it depends on technology and capabilities. Therefore, AC and IC affect the development of hierarchical or non-hierarchical relations. Moreover, AC – ability to assimilate and apply knowledge – is not only a requirement for technological development and business innovations, but also for assimilating and shaping regulatory mechanisms and the ability to cooperate, i.e. for governance structures (Howell, 2020). To summarize the analyzed interdependencies, capabilities (AC and IC) determine the governance form and cluster upgrading. However, the form of governance also stimulates or blocks the development of capabilities and innovations (Duan et al., 2021; Fritsch & Kublina, 2018; Howell, 2020; Naqshbandi & Jasimuddin, 2022). Cluster upgrading is thus a result of mutual influences between AC, IC, and GF.

For the indicated interrelations to affect the cluster environment, institutional and economic mechanisms on the country level are also needed. Country-level technological profiles and development trajectories, as well as crucial economic variables (GDP, ALP) also prove its impact in the findings of our research, as control variables (De Marchi & Alford, 2022b; Ye et al., 2020; Zhu & He, 2018).

5.2.2 Higher-Order Constructs Based on the Aggregate Model of Cluster Upgrading2

The models with individual theoretical variables and the aggregate model both indicate a hierarchy of importance of identified determinants for cluster upgrading. *The models with four individual explanatory variables and control variables point at sufficient factors, constituting the foundation for the growth of value added and the position in IVC, though not necessary ones.* According to the logic of causality, a cause is sufficient but not necessary if it is capable of producing the outcome but is not the only cause with this capability (Ragin, 2009). This is the nature of theoretical variables: absorptive capacity, innovation capacity, and governance form (as the public support variable was not confirmed). Each of the listed variables may lead to upgrading, but none of them constitutes the only cause. As a result, nearly all observed proxies of theoretical variables may be treated as a set of factors supporting relative growth of value added of a particular cluster compared to other clusters in IVC (Table 5.1). Following the assumptions of the research model (Figure 3.1), the above-listed theoretical variables include both cluster capabilities, namely its absorptive and innovation capacity, and governance-related factors, such as mechanisms regulating its operations. The referred mechanisms are reflected as governance form, i.e. a set of rules directing relationships between cluster participants and their ties in international exchange. Overall, based on the results of the individual variable models, we propose *a higher-order construct of Framework Conditions* as a set of individually sufficient but not necessary determinants of the cluster's upgrade (Figure 5.1).

The aggregate model points at key determinants related to characteristics of governance form. This model demonstrates strong influence of conditions coming from research framework, typical of clusters, in relation to control variables, representing conditions on the country level. The latter, in the aggregate model, are characterized by weaker influence than in models with single theoretical variables of absorptive capacity, governance form, and public support. The specificity of conditions connected with regional and international environments becomes more significant in this model than control variables on the national level.

Consequently, the aggregate model identified a set of factors that directly affect cluster upgrading. Among 16 formerly analyzed factors in models with individual theoretical variables, the aggregate model distinguished three factors coming from the research model (Figure 3.1) and two control variables demonstrating positive connection with cluster upgrading. Using the previously applied criterion of at least two significantly influencing observable variables as a condition for confirming the influence of a theoretical variable, it must be stated that this model only confirms the importance of non-hierarchical governance form. The variable concerning patent applications expresses innovation capacity, however, it remains the only variable confirming this construct. Following the earlier stated criteria, we cannot assume that the innovation capacity theoretical variable was confirmed in the aggregate model.

In the models with individual variables, we identified the determinants that were sufficient but not necessary for cluster upgrading to take place. Therefore, they do not constitute key factors or direct stimuli for this phenomenon. These factors were identified on the basis of the aggregate model, and we theorize the key determinants derived from this model as another, higher-order construct, a cause that is *both necessary and sufficient* to accomplish upgrading. A cause is both necessary and sufficient if it is the only cause that produces an outcome and it is singular (that is, not a combination of causes) (Ragin, 2009).

Taking into consideration the significant reduction of the research model proposed in Chapter 3, we will now perform its re-theorizing and will identify a new, higher-order construct based on the final set of observed variables. The three valid observed variables can be presented according to causal relationships. Namely, public-private co-publications (Ppcpub) demonstrate effectiveness of joint inter-sectoral research in terms of the positive evaluation and recognition in the peer-review process, and dissemination. The referred publications can lead to further applied research and development activities that result in new-to-world inventions. These inventions can be legally protected as PCT application (PCTpatapp), which means the appropriation of economic value from the potential innovation, that is, from productive use of these inventions turned to products, services, and business processes. The innovative outcomes and revenues from licensing the patented inventions are conducive for high-technology and high-value-added exports (ExpMHtech), and an ultimate upgrade in IVC. Based on these causal inferences, we propose a *new construct of Public-Private Governance for Knowledge Creation and Appropriation*, as a necessary and sufficient condition for higher value-added and new-to-world innovations leading to the upgrade of the cluster's IVC position.

5.2.3 An Empirically Corroborated Framework of Cluster Upgrading

The analysis of our research findings will be summarized in the form of an empirically corroborated framework of cluster upgrading. This framework is derived as an integration of the results from the models with individual theoretical variables and the aggregate model (Figure 5.1). Based on the individual-variable models, we theorized *a set of sufficient but not necessary Framework Conditions for cluster upgrading as the first higher-order construct.* These are interrelated absorptive capacity and innovation capacity (cluster capabilities) and a non-hierarchical governance in the cluster's internal and IVC relationships. Based on the aggregate model, we derived *a set of sufficient and necessary conditions for cluster upgrading.* Consequently, were-theorized the initial research framework and its theoretical variables and proposed *another higher-order construct of Public-Private Governance for Knowledge Creation and Appropriation,* as a source of higher value-added and new-to-world innovations leading to the upgrade of the cluster's IVC position.

The framework resulting from our research confirms the importance of the ecosystem approach to developing clusters and regional communities (Brown & Mason, 2017; Gancarczyk, 2019; Stam & Van de Ven, 2021). The ecosystem approach promotes the interrelations among actors, institutions, and regional resources and capabilities in accomplishing sustainable growth and IVC position based on high value added (Spigel, 2017, 2022). Although our framework emphasizes the regional context and its capacity to

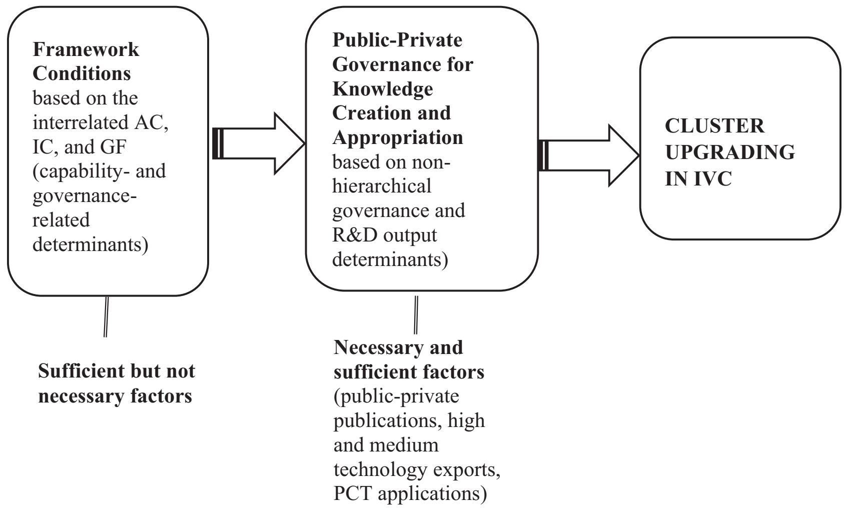

Figure 5.1 A framework of cluster upgrading.

compete internationally, this research also acknowledges the importance of the country-level economic context in providing external benefits to regional industries (Acs et al., 2017). Moreover, we need to recognize a feedback loop from the cluster position in IVC. Namely a favorable position enhances learning from international collaboration and competition, and further upgrading. This stems from both bottom-up learning and development by the cluster and its regional resources, and from top-down innovation networks of the local enterprises to transform the cluster (Expósito-Langa et al., 2011; Karlsen et al., 2023; Shakib, 2020; Ye et al., 2020).

The framework (Figure 5.1) is a generalization from this empirical research and we need to determine the level of this generalization. The ICT services industry is specific and belongs to a relatively narrow group of industries defined as high-technology services and knowledge-intensive services. These types of activity differ in required conditions of development from low or medium-low technologies and services of lower knowledge intensity. However, since the beginning of the 2000s, there have been opinions that digitization is changing the geography of production and innovation (Sturgeon, 2002). Geographical proximity and spatial concentration will lose importance in places with standard and highly formalized technologies (Saxenian, 2007). After earning a master's degree in electrical engineering at Texas Tech University, Jimmy Lee, like thousands of other immigrant engineers, was drawn to Silicon Valley in the late 1970s. Lee worked for nearly a decade at established companies such as Signetics and National Semiconductor as well as at a start-up, International CMOS Technology, before joining a classmate from National Taiwan University, K. Y. Han, to start their own semiconductor firm, Integrated Silicon Solutions, Inc. (ISSI). After bootstrapping the start-up with their own funds and those of Taiwanborn colleagues, they raised over $9 million, mainly from Asian venture capital funds managed by overseas Chinese engineers. Lee and Han exploited their connections in both Silicon Valley and Taiwan to grow ISSI. They recruited former colleagues and classmates in the United States to the R&D center in Santa Clara, and they lined up a manufacturing partnership with the recently established foundry, Taiwan Semiconductor Manufacturing Corp (TSMC). They also incorporated a subsidiary in Taiwan's Hsinchu Science Park to oversee assembly, packaging, and testing. In the firm's early years, Han traveled to Taiwan monthly to monitor its manufacturing operations. He soon moved his family home to run ISSI-Taiwan. Lee remained in the Silicon Valley as CEO and Chairman. ISSI grew rapidly in the early 1990s by selling high-speed SRAMs to motherboard firms that were supplying Taiwan's fast-growing personal computer (PC) industry (Ponte & Sturgeon, 2014; Saxenian, 2007; Sturgeon, 2002; Sturgeon et al., 2008). Production based on them will be easily movable to low-cost locations. Spatial proximity and direct interaction will be needed only in the case of breakthrough technologies and in the initial stage of development, which means low formalization and standardization (Saxenian, 2007). In this case, spatial proximity ensures direct and frequent interactions. Clusters will still be needed in breakthrough research and development and innovation activity on a global scale. If we assume this scenario of cluster transformation, our research can be more broadly generalized than concerning ICT clusters as economically significant (a key enabling technology, and emerging industry) but specific industry, or as an industry representative of knowledge-intensive activities. Assuming the prospective transformation of clusters into kernels of advanced knowledge and innovation, our research contributes to the understanding of upgrading and international position of a wide range of clusters (Ponte & Sturgeon, 2014; Sturgeon, 2002).

5.3 Theoretical and Methodological Contribution

5.3.1 Theoretical Contribution

Firstly, the major contribution and unique theoretical value of this monograph rests in proposing an empirically corroborated framework of industrial cluster upgrading. This research (i) identified the determinants of upgrading among European ICT clusters, (ii) revealed a hierarchy of those determinants, as well as (iii) synthesized higher-order constructs and relationships for an ultimate, empirically corroborated framework of cluster upgrading. This constitutes a major contribution to the theory of localized industry, the concept of clusters, and knowledge of factors determining their position in IVC. Previous research did not include any theory-driven and quantitative analyses of regional agglomerations in a particular industry regarding their position in international value chains. The existing research on cluster upgrading is predominantly based on individual case studies and their upgrading determinants were not confirmed based on the deductive and quantitative approach. Instead, case-specific success factors were distinguished (Klofsten et al., 2015; Tavassoli & Tsagdis, 2014; Wolfe & Gertler, 2004). The theory-driven and quantitative identification and presentation of these determinants addresses a research gap. The book provides an original and evidence-based approach that integrates the earlier dispersed knowledge and advances the research in cluster upgrading (Blažek, 2016; Gancarczyk & Bohatkiewicz, 2018; Humphrey & Schmitz, 2002).

Furthermore, based on the results obtained in the aggregate model (KD), including all theoretical variables and control variables, *we developed a hierarchy of identified determinants of ICT clusters' position in IVC.* It should be stated that the conclusions from our research are important in the context of the ICT industry, which has global influence on transformation of practically all industries, as it represents Key Enabling Technologies. The identification and development of the conditions for the upgrade of the ICT clusters will have direct influence on other areas of regional and country's economies since ICT accelerates processes of transformation and development in other sectors.

Our book is the first quantitative verification of the IVC concept assumptions concerning clusters. Based on the models with individual theoretical variables, this theory was positively verified regarding cluster capabilities and governance as determinants of the clusters' high position in IVC. The aggregate model, however, demonstrated that governance-related determinants influence the possibility of a cluster's high position in IVC. The novelty of our work rests in distinguishing four theoretical variables connected with the cluster's capabilities, namely absorptive capacity and innovation capacity, and regulatory factors of governance form and government support. The book, therefore, offers a valuable contribution to the theory of cluster capabilities and assumptions of new institutional economics, with particular emphasis on the influence of institutions on industrial agglomerations.

We analyzed clusters belonging to one industry only, nevertheless, the methodology can be replicated and applied to clusters in other industries. Moreover, our analysis covered various, polarized economic environments, i.e. clusters located in countries with the lowest and the highest development levels. The data considered here does not refer to examples of the most competitive regions or clusters which have moved from a very low position to the top of the IVC. The conducted research contains independent variables which can be described as universal variables.

Thirdly, the monograph broadens the empirical evidence on the determinants of CU (Giuliani et al., 2005; Grondeau, 2007), *based on the European regional agglomerations of the ICT industry.* Our research confirms the influence of a set of theory-driven variables on cluster upgrading. These are variables with a long tradition in regional research, such as the resource-based view, IVC governance, and the institutional approach. On the other hand, our results allow us to conceptualize these key theoretical variables into higher-order and new theoretical constructs relevant in the context of knowledge-intensive industries. In our research we do not perform any validation of the measurement of theoretical variables or confirmation of the constructs of these variables by a set of proxies. Nevertheless, the distinguished factors may become a starting point for the selection of variables expressing these constructs and for the validation of the AC, IC, and GF measurements. The proxies of the theoretical determinants are widely available in databases, therefore, they can be monitored by a wide range of stakeholders, such as business politicians on various levels, the scientific community, independent analysts and consultants, enterprises, and cluster organizations.

Finally, the book contributes to the methodology of cluster identification for quantitative analyses of this phenomenon. It is based on the known and applied theory and methodology of cluster identification, such as stars methodology, in which all key indicators of the methodology were used, namely both the size of the cluster, the analysis of cluster specialization based on the location quotient, as well as its productivity. We also took into account one of the new indicators from the 'stars' methodology – SMEs productivity determined by high-growth companies. Our book also includes some elements of methodology adopted by PARP, namely the analysis of cluster resources, or, to be more precise, human capital in the context of employment structure and level of its competencies. We also considered another aspect accounted for in this methodology, that is cluster internationalization from the perspective of its export activities. We followed Duke's methodology regarding the influence of the institutional context on clusters and their position, as well as elements related to governance form.

Moreover, the activity of such organizations as European Secretariat for Cluster Analysis, European Cluster Observatory, European Foundation for Cluster Excellence, European Cluster Excellence Initiative (ECEI), European Cluster Collaboration Platform (ECCP), or International Cluster Matchmaking Events points at concentrating efforts and directing projects toward cluster initiatives and cluster organizations rather than clusters as such. That is why research published by the above organizations focuses generally on the analysis of cluster organizations (or possibly cluster initiatives), not on clusters themselves (Dziedzic et al., 2021). The methodology of researching these industrial structures often does not reflect the understanding of clusters as geographical concentrations of companies from the same or related industries, which maintain coopetition relations and develop ties with regional environment organizations and resources, as discussed in this book. Our work emphasizes the delimitation of the concept of a cluster from a cluster initiative, a cluster organization, and the network. However, it also can enhance further research in the area of these cluster-related policy concepts.

5.4 Recommendations for Business and Policy

Our book also provides a contribution to the development of economic policy. This research can be useful in designing policies for knowledge-intensive services in both developed economies, and those aiming to change their industrial structure. The knowledge of determinants of a high position in IVC enhances the planning of regional and country-level policy. The aim of such a policy should be to support processes of emergence and development of clusters, which will enable countries to abandon the policy of basing their international competitiveness on low costs, including low salaries. If economic policy is based on clusters' advantages, it will trigger transformation in the knowledge-intensive direction and facilitate generating high value added through high-quality jobs to accomplish wealth of communities and regions.

Close proximity of the public environment and the business environment is important for the synergy effect. This effect is based on partner, non-hierarchical ties between public administration units and cluster enterprises. As the research findings show, it is not financial expenditure that supports the cluster's high position in international value chains, but the outcome-oriented cooperation between the public and the private sectors.

The empirical base for this research is useful in planning and monitoring regional development and economic policy evaluation. The observed variables we adopted can be found in widely available, public databases. This provides a possibility of ongoing monitoring for policymakers, independent analysts and consultants, as well as enterprises and cluster organizations.

5.5 Limitations and Future Research

5.5.1 Limitations and Proposed Directions for Further Research

The basic limitation of this research was an insufficient number of complete statistical databases for the regional (NUTS 2) level. This not only determined the choice of independent variables, but also the selection of the dependent variable. The dependent variable created on the basis of wages and salaries per employed person, corrected with inflation rate (HICP) constitutes a *proxy* of the value added generated by a given cluster. What is more, available databases often contained significant data deficits, which required such steps as data imputation and limitation of the research sample by choosing variables for 2014–2020 (instead of the originally planned 2008–2020). In spite of the efforts, it was impossible to determine the changes to the industry profile of identified clusters based on available statistical data. This was mainly due to the lack of data on the regional level, and to the fact that we analyzed clusters, not cluster organizations. It should also be observed that the research was not biased by such phenomena as, e.g. the financial crisis of 2007–2009 or the COVID-19 pandemic (2020), which exerted long-term influence on the results of clusters and economies, or the war in Ukraine since 2022. Determinants of clusters' position are subject to change along with transformations on the level of clusters and whole economies, therefore, the adoption of a shorter period of time seems well justified in this case. Therefore, the adopted time period allows us to appropriately understand the current nature of clusters in the context of their inclusion into international value chains.

Another limitation can be found in the use of secondary data rather than primary data that would stem from own measurement designed especially to reflect theoretical variables. It is justified with rational use of the existing databases and access to a broad range of data in the long period of time for many economic regions. Primary research on this scale would not be possible for one research team, therefore, it is conducted by international institutions, such as the European Commission, Eurostat, and OECD.

The determination of the level of cluster inclusion in IVC is difficult to examine empirically, especially if we take into account a large and heterogeneous research sample and due to the lacking data on the regional level. However, this research proved that it is possible to use quantitative methods in analyzing these economic phenomena. The quantitative research was based on clusters coming from economies on various levels of development, wealth, and industrial structure. Moreover, our approach was original and theory-driven in its methodology.

This study relied on empirical data in the long term in order to discover specific patterns of upgrading determinants and interdependencies between the variables defined in the research model. Unfortunately, the lack of data did not allow us to use the panel approach, which would reveal the dynamics of the observed phenomena – both concerning the explained variable and the explanatory variables. Further research should aim at capturing the dynamics of the upgrading process and determining relations between variables, their mutual influence in co-evolutionary development processes. Along with improvement in quality of databases, we recommend techniques of process analysis, causality, mediation, and moderation. The design of variables in such research could be based on prior qualitative analyses, based on single and multiple case studies. Qualitative analyses will also allow for analytical generalization about mechanisms and interdependencies, and consequently, to formulate propositions and testable hypotheses.

In spite of the above limitations, our research contributes to the current research on economic clusters and international value chains. The proposed models concerning absorptive capacity, innovation capacity and governance factors constitute a good starting point for further investigations, thus advancing the findings on clusters' promotion in international value chains.

An important direction of research would be the quantitative and qualitative analysis of the dynamics of clusters' position in IVC (e.g., the change of a cluster's position from low to high value added or from high to low). In order to do this, the dependent variable would have to be dynamic, i.e. it would have to reflect, for instance, the growth of the cluster's productivity. At the same time, independent variables should also reflect the change in time. It should be emphasized, though, that in such research a focus should be not only on interdependencies between particular conditions, but also on causalities. To perform such research, a complete base of regional data for sufficiently long time series is conducive. Based on such research, it would be possible to propose recommendations for advancement of clusters, their individual participants, potential cluster initiatives or organizations, and public policy. This would enable the development of guidelines, good practices, and strategies for regions and clusters.

We recommend continuous *monitoring of cluster upgrading on a regional scale, such as the European cross-border region, and on a global scale.* Such monitoring should be conducted from the bottom-up perspective, as applied in our research, and from the top-down perspective of value chains of international corporations. To perform these investigations, a dedicated methodology for cluster ranking should be developed. Possible criteria for monitoring the cluster upgrading processes can include the degree of inclusion into international chains, position in relation to other chain participants, the cluster's potential for upgrading, or the diagnosis of threats like the lock-in effect, stagnation, or decline in the cluster's lifecycle.

The above-mentioned research on the national economy scale would let us *identify determinants of clusters' position in IVC in particular countries, based on primary research and data.* This research should be theory-driven to ensure high-quality methodology and measurements, and consequently, the findings and conclusions. An advantage of such research would lie in measurement tailored to specificity of variables and the national context. The findings would accurately identify the determinants of clusters' IVC position and its dynamics in a variety of industries. On the one hand, independent variables would reflect the conditions of a particular economy; on the other hand, there would be better access to data on the regional level.

An important direction of research would also lead to the *determination of the degree of a cluster's inclusion in international value chains.*

This would call for the adoption of a specific method of grading and a relevant measurement. Findings provided by the resulting research would help to develop strategies for cluster initiatives and policies for clusters' integration in IVC.

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Conclusion

This monograph has accomplished the aim to develop a theoretical framework for regional cluster upgrading based on the integration of the cluster and IVC concepts and based on the empirical evidence from European ICT clusters. The proposed theoretical framework is the major contribution from this research and represents a conceptual advancement in the area of cluster upgrading in international exchange. The referred conceptual advancement is evidence-based, whereby the evidence stems not only from the existing theoretical and empirical studies that formed an intellectual background for our research. It is also supported by the original empirical study on the European ICT clusters, one of the most crucial industries in terms of the socio-economic impact. The general aim of the monograph was addressed on conceptual and empirical grounds. Namely, it was preceded by the completion of such detailed objectives as (i) developing a research framework based on the governance- and capability-based approaches to the upgrade of clusters in IVCs; (ii) identifying the determinants of upgrading among European ICT clusters, (iii) determining a hierarchy of the identified determinants, as well as (iv) synthesizing the results into higher-order construct and relationships for an ultimate, empirically corroborated framework of cluster upgrading.

Our book responds to a research problem of what factors determine clusters' position in international value chains. The referred research problem stems from the economic and social importance of cluster upgrading (Coe, 2021; Coe & Yeung, 2019; Gereffi, 2018). This significance is associated with the phenomenon of shortening IVCs and the need for delivering a diversified product and service offer in closer geographical proximity than before (Hollanders & Merkelbach, 2020). At the same time, the expected direction of regional and clusters' development consists in increasing value added offered in international trade by establishing knowledge-intensive and highly paid jobs (Coe, 2021; Coe & Yeung, 2019; Gereffi, 2018; Götz, 2021). Cluster upgrading is thus an important phenomenon in increasing the wealth of the societies in regions and countries and limiting inequalities

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between territorial units. Clusters are economic and social systems, understood as specialist agglomerations of networked companies that also establish relationships with business environment organizations and regional resources. Consequently, clusters constitute a type of ecosystem for progressive industrial transformation that raises benefits for the entire territory.

In response to the research problem of determinants of cluster upgrading, we identified factors affecting the clusters' position in IVC based on the example of the information and communication technologies industry. We developed several models of logistic regression. These were the models testing the impact of individual theoretical variables of absorptive capacity and innovation capacity (capability-related factors) and governance form and public support (governance-related factors). We also developed the aggregate model, taking into account all the determinants confirmed in the earlier preceding models with individual theoretical variables. This model allowed us to determine a hierarchy of the analyzed factors and revealed particular importance of governance mode. As a result, we identified higher-order constructs of (i) *Framework Conditions* as sufficient but not necessary factors for cluster upgrading, and (ii) *Public-Private Governance for Knowledge Creation and Appropriation,* as a necessary and sufficient condition for higher value-added and new-to-world innovations leading to the upgrade of the cluster's IVC position.

Based on the research findings, we established that observable determinants of the cluster's position in IVC connected with the theoretical variable of absorptive capacity include employment of R&D personnel and scientists, employment in technologies and knowledge-intensive sectors, and education level of human capital. Considering the individual influence of these factors on the cluster's position, we found that there is a positive relationship between the cluster's position in international value chains and the cluster's absorptive capacity, which confirms Hypothesis 1.

With regard to innovation capacity, the most significant observable factors include PCT patent applications and the presence of high-growth companies. Therefore, Hypothesis 2 assuming a positive relationship between the cluster's position in international value chains and the cluster's innovative capacity, was positively verified.

The analysis of factors related to governance allowed us to conclude that the observable determinants of the cluster's position in IVC are the export of medium and high technology products, public-private co-publications, and job-to-job mobility of HRST. The above determinants point at non-hierarchical governance within a cluster and in its international relationships as improving the cluster's chances to reach a high position in IVC. Thus Hypothesis 3, assuming a positive relation between the cluster's position in international value chains and non-hierarchical form of governance, was confirmed. At the same time, however, Hypothesis 4, claiming that there is a positive relationship between the cluster's position in international value chains and cluster support from public authorities, was rejected. Considering external effects represented by control variables, we were unable to prove a significant relation between public support and the cluster's position in IVC.

On the basis of the aggregate regression model (KD model), we identified key determinants of the cluster's upgrading. The model allowed us to conclude that non-hierarchical governance form exerts the greatest influence on the probability of achieving a high position in IVC by a cluster. This finding also indicates the hierarchy of determinants of cluster upgrading in IVC, where governance is a leading condition. The identified form of governance is characterized by specific configuration of observable variables, including value of patent applications, public-private co-publications, and export of medium- and high-technology products. We theorized this configuration of factors as a new, higher-order construct of *Public-Private Governance for Knowledge Creation and Appropriation*.

Our study addresses research gaps in the area of cluster upgrading. *First*, the research on upgrading predominantly focuses on the regions and countries of the Global South, while the cases of the Global North and developed countries are much less explored (De Marchi et al., 2018; Gereffi, 2018; Gereffi & Lee, 2016a; Karlsen et al., 2023; Ponte et al., 2019). We address this gap by choosing European ICT clusters as an empirical basis. Our findings reveal differences in terms of VC positions and potential to upgrade among these clusters and identify the determinants of their upgrading in this territorial context (Hollanders & Merkelbach, 2020).

Second, the conceptual lens of industrial upgrading is strongly based on the GVC perspective that demands a re-theorizing toward the ongoing VC shortening and transformation to international rather than global perspective only (Coe, 2021; Kano et al., 2020; Ponte et al., 2019; Zahoor et al., 2023; Zhan et al., 2020). In response to this gap, we conceptualize cluster upgrading in IVCs as embracing both global VCs and regional cross-country VCs. Moreover, we propose the theoretical advancement of cluster upgrading that integrates the theory of clusters with global governance perspectives, such as GVC, GPN, and GCC, and capability-based perspectives of absorptive and innovation capacities.

Third, the global governance perspectives are deterministic in emphasizing initial contract conditions and distribution of power in IVCs (Belussi & Sammarra, 2009; Colombelli et al., 2019; Gereffi et al., 2005; Gereffi & Lee, 2016b; Humphrey & Schmitz, 2000; Ponte & Sturgeon, 2014; Schmitz, 2004). Capability-based determinants that we investigate are under-researched and require a clear definition, delimitation, and recognition of their structure (Expósito-Langa et al., 2011; Fritsch & Kublina, 2018; Hervas-Oliver et al., 2012; Howell, 2020; Karlsen et al., 2023). In this research, the constructs of absorptive capacity and innovation capacity were explained according to their theoretical origins and scope. Moreover, their importance and influence in regional development was discussed. Ultimately, we provided their transparent definition as concepts describing the cluster's potential and proposed their operationalization and measurement. Our findings identified the impact of these variables on cluster upgrading. Furthermore, we clarified these theoretical constructs in the context of cluster upgrading, by pointing to the observed variables that proved significant as their proxies.

Fourth, the research on upgrading is predominantly focused on the industrial upgrading of regions and countries, while the antecedents of cluster upgrading are less explored (Karlsen et al., 2023). Our research fills this gap by theoretical advancement and empirical evidence on the upgrade of clusters in a clearly defined industry of crucial socio-economic importance. We acknowledge the specificity of clusters in synthesizing and advancing the theoretical background, design of research methodology, and in deriving conclusions and recommendations.

Fifth, comparative and quantitative research in cluster upgrading remains scarce, and qualitative, case-based methodologies predominate. In response to this gap, we adopted an original, deductive, and quantitative method that enabled statistical generalization, supported by broad comparative evidence. The models of logistic regression (AC, ACc, IC, ICc, GFGOV, GFGOVc, and KD models) included three groups of factors which approximated theoretical variables in our book, that is, absorptive capacity, innovation capacity, governance form, and public support. It was also possible to determine the hierarchy between these factors and identify higher-order constructs and a proposal of the ultimate theoretical framework. *Our main research methods* included literature review and analysis of secondary data on the sample of clusters representing the ICT services in Europe, using logistic regression. To evaluate the models of logistic regression, we applied the Hosmer-Lemeshow goodness-of-fit test, the analysis of Cramer's V associations, the analysis of the area below the ROC curve, the AIC, and the CART method of interactive classification trees. In order to identify clusters in European economies, we used the location quotient (LQ), based on employment in ICT services.

Our work contributes to the current research on clusters and their integration with international value chains. In the quantitative way, we identified determinants of clusters' positions, verifying assumptions of the IVC concept concerning industrial agglomerations. This accounts for the novelty of our approach, as we rely on deductive conceptual framework and quantitative results. This approach distinguishes our research from the dominant qualitative approach prevailing in the existing analyses.

The contribution made by our book consists in identification of determinants of the clusters' positions in IVC, their hierarchy, and ultimately, in the development of a theoretical framework of cluster upgrading. Our findings are important for the ICT industry, which globally affects transformation of all social and economic activities and belongs to the so-called key enabling technologies. They are also relevant for high-technology and knowledge-intensive industries, and a wider range of clusters transforming to knowledge-based innovation centers. The research method and outcomes provide the possibility of replication, adaptation, and advancement for clusters with other industrial specializations as well.

Our book is the first quantitative verification of the assumptions behind the IVC concept referring to clusters. The above concept was positively verified concerning cluster capabilities and governance factors in individual variable models. However, the integrative, aggregate model showed that governance-related factors affect the cluster's high position in IVC, as necessary and sufficient conditions.

Our research contributes to the methodology of cluster identification for quantitative analyses of this phenomenon. We propose an original method of cluster identification, acknowledging also the existing theories and methodologies, notably, the 'stars' methodology of Eurostat and Duke's methodology.

Apart from scientific importance and contribution to research on clusters and global value chains, the upgrading determinants identified *are relevant for economic policy focused on clusters,* indicating areas of support which may lead to high position in IVC. It should be assumed that such a support policy will also affect the development of the region and other industries through external effects.

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