

**THE BUCHAREST UNIVERSITY OF ECONOMIC
STUDIES**

Council for Doctoral University Studies

Doctoral School of International Business and Economics

**THE DEVELOPMENT OF ARTIFICIAL INTELLIGENCE IN
THE EUROPEAN UNION: CLUSTERS AS MECHANISMS FOR
COORDINATING INNOVATION IN ROMANIA AND THE
BALTIC STATES**

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Bucharest, 2026

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KEYWORDS: artificial intelligence; European Union; Romania; the Baltic States; clusters; DESI; economic performance; digital maturity; innovation.

SUMMARY

The rapid technological transformations of recent years have led to a reconfiguration of contemporary economies. Artificial intelligence — known as “AI” in English — has emerged as one of the emerging technologies with the greatest potential to transform economic, organizational, and institutional processes. In the European Union, the development of artificial intelligence is supported by dedicated public policies, strategies, and funding instruments, and is integrated into the European Union’s strategic objectives regarding digitalization, innovation, and competitiveness.

Within this framework, the topic of this doctoral research, “The Development of Artificial Intelligence in the European Union: Clusters as Mechanisms for Coordinating Innovation in Romania and the Baltic States,” is relevant because it allows for an analysis of the relationship between AI adoption, sectoral economic performance, and the role of innovation ecosystems in facilitating digital transformation. The relevance of the topic stems both from the central role that artificial intelligence plays in digital transformation processes and from the need to understand the conditions under which this technology is adopted and integrated into the economy. At the European Union level, differences among member states regarding the level of digitization, infrastructure, skills, and innovation capacity influence the pace and depth of AI adoption. Thus, clusters are analyzed in the thesis as intermediary structures that can facilitate coordination among economic, institutional, and academic actors and can contribute to the diffusion of emerging technologies within regional innovation ecosystems.

The literature addresses the three main dimensions of the research — artificial intelligence, economic performance, and clusters — but, in most cases, these components are analyzed separately. Much of the literature on artificial intelligence focuses on the technological dimension, with an emphasis on algorithms, machine learning, and neural networks, while other studies analyze the ethical, social, and regulatory implications of using artificial intelligence. In parallel, the literature on clusters and innovation ecosystems highlights their role in stimulating innovation, facilitating knowledge transfer, and increasing regional competitiveness. However, the relationship between AI adoption, sectoral economic performance, and the role of clusters is rarely integrated into a common analytical framework.

The review of the literature revealed a number of gaps relevant to the topic of this research. First, studies analyzing artificial intelligence often focus on the technological or institutional level and do not sufficiently integrate the organizational and relational dimensions of this technology’s adoption. Second, the literature on clusters addresses their role in innovation and competitiveness

but rarely investigates their contribution to the adoption of artificial intelligence. Third, for the economies of Central and Eastern Europe, including Romania and the Baltic States, there is a limited number of studies that comprehensively analyze the relationship between AI, sectoral economic performance, and the role of clusters as mechanisms for coordinating innovation. Thus, the research problem of this doctoral thesis lies in the absence of an integrated analysis that connects two levels of analysis: on the one hand, the relationship between the degree of artificial intelligence adoption and sectoral economic performance at the European Union level; on the other hand, the mechanisms through which digitalization/AI-oriented clusters contribute to the adoption of artificial intelligence applications among member firms in Romania and the Baltic States.

The research niche of the thesis is represented by the integrated analysis of the relationship between the use of artificial intelligence, sectoral economic performance, and the role of digitalization/AI-oriented clusters in the adoption and dissemination of AI applications. The research focuses on the economies of Central and Eastern Europe, specifically Romania and the Baltic States. In this doctoral research, the term “digitalization/AI-oriented clusters” refers to clusters that prioritize digitalization as an area of smart specialization, including artificial intelligence, according to the thematic classification of the European Commission’s Smart Specialization Platform (S3).

The choice of Romania and the Baltic States is justified by the fact that these countries operate within the same European strategic and institutional framework but exhibit different levels of digital development and innovation capacity. This comparative analysis highlights how similar structures, such as digitalization/AI-oriented clusters, can generate different outcomes depending on the national and institutional context.

The aim of the doctoral research is to analyze the relationship between the use of artificial intelligence and sectoral economic performance at the European Union level and to assess the role of digitalization/AI-oriented clusters in facilitating the adoption of this technology among member firms, with a focus on Romania and the Baltic States. To achieve this goal, the research is structured around two major axes: a macroeconomic axis, which examines the relationship between the use of artificial intelligence and sectoral economic performance, and a meso-microeconomic axis, which analyzes the role of clusters in facilitating the adoption of artificial intelligence applications.

In this context, the following research questions are formulated:

RQ1: What is the relationship between the degree of artificial intelligence use and sectoral economic performance in the European Union, with a focus on Romania and the Baltic States?

RQ2: To what extent and through what mechanisms are digitalization/AI-oriented clusters associated with the adoption of artificial intelligence applications in member firms in Romania and the Baltic States?

In relation to these questions, the research formulates two main hypotheses. H1 posits the existence of a positive association between the degree of artificial intelligence use and sectoral economic performance in European Union member states. H2 posits that clusters characterized by a higher level of organizational maturity and integration into European networks are associated with a higher level of adoption of artificial intelligence applications among member firms.

The specific objectives of the research are as follows:

- to analyze the relationship between the degree of artificial intelligence use and the economic performance of sectors, measured by hourly labor productivity, employment, and gross value added, in the European Union, with a focus on Romania and the Baltic States;
- to analyze the territorial distribution of digitalization/AI-oriented clusters in the European Union through mapping and the identification of relevant regional patterns;
- to analyze how digitalization/AI-oriented clusters in Romania and the Baltic States are associated with the adoption of artificial intelligence applications among member firms, by identifying support mechanisms, governance mechanisms, and collaboration mechanisms.

The doctoral research aims to identify patterns of association between the use of artificial intelligence and sectoral economic performance, highlight the territorial distribution of digitalization/AI-oriented clusters, and analyze the mechanisms through which they facilitate the adoption of AI applications at the firm level. Furthermore, the research highlights the differences between Romania and the Baltic States regarding the adoption of artificial intelligence and the functioning of innovation ecosystems.

The relevance of the research is both theoretical and practical. From a theoretical perspective, the study contributes to integrating the relationship between artificial intelligence, sectoral economic performance, and the role of clusters into a common analytical framework. From a practical perspective, the results can support the development of public policies and the strategies of organizations involved in innovation ecosystems.

The originality of the research lies in its integrated approach to the relationship between artificial intelligence and sectoral economic performance, the use of digitalization/AI-oriented clusters as a unit of analysis, and the conduct of a comparative analysis between Romania and the Baltic States.

Methodologically, the research adopts a mixed-methods approach, combining quantitative analysis at the macroeconomic level, based on European statistical data (Eurostat, Digital

Economy and Society Index — DESI), with a qualitative comparative analysis of selected clusters in Romania and the Baltic States.

The quantitative component uses descriptive and correlational analyses to highlight the association between the use of artificial intelligence and sectoral economic performance indicators. DESI indicators are used to contextualize the level of AI adoption and to support the analysis of the association between digitalization and economic performance.

The qualitative component is based on a documentary and comparative analysis of the clusters and their member firms, aiming to identify the mechanisms through which they facilitate the adoption of AI applications. Additionally, maps are created using the RStudio program to highlight the territorial distribution of the clusters.

The analysis of national AI strategies provides the institutional and public policy framework within which the analyzed clusters operate, contributing to an understanding of the contextual differences between Romania and the Baltic States. The assessment of cluster maturity is conducted indirectly by analyzing participation in European projects, the existence of digital infrastructure or centers of excellence, integration into international collaboration networks, the types of services offered to cluster members, and the degree of sectoral specialization, based on publicly available information.

Regarding the results obtained, the quantitative analysis revealed a positive association, though structurally conditioned and sectorally differentiated, between the degree of artificial intelligence use and economic performance, with hypothesis H1 being partially confirmed. This relationship is more pronounced in knowledge-intensive sectors, such as information and communications and professional, scientific, and technical activities. The results suggest that, in many sectors, the digital transformation process is in a transitional phase, in which the expansion of AI use precedes the full realization of economic benefits.

Regarding the meso-microeconomic dimension, the comparative analysis showed that Hypothesis H2 is validated, with clusters oriented toward digitalization/AI functioning as mechanisms for coordinating innovation and facilitating the adoption of artificial intelligence applications among member firms. This association is supported by mechanisms such as inter-organizational collaboration, access to innovation infrastructure, participation in European projects, and integration into international networks. The level of organizational maturity of clusters influences their ability to support the development and implementation of AI applications.

The original contributions of the research consist of integrating the relationship between the use of artificial intelligence, sectoral economic performance, and the role of clusters into a common

analytical framework, as well as using digitalization/AI-oriented clusters as a unit of comparative analysis between Romania and the Baltic States.

Therefore, the research highlights that the adoption of artificial intelligence and its impact on economic performance cannot be explained exclusively from a technological perspective and are not sufficient in themselves, but require an integrated approach that includes the organizational and institutional dimensions. In this context, clusters oriented toward digitalization/AI play an important role in transforming technological potential into economic value, particularly in the economies of Central and Eastern Europe.

The structure of the thesis reflects the logic of the research approach and allows for a progressive approach, from theoretical grounding to empirical analysis and interpretation of results.

The first chapter establishes the theoretical framework of the thesis. Within this chapter, artificial intelligence is analyzed as a process of systemic innovation, clarifying the basic concepts, typologies, evolution, main applications, as well as the opportunities and challenges associated with its use. The chapter also addresses cluster theory, their typologies, governance, and their role in the context of digital transformation, as well as the relationship between clusters, regional competitiveness, and innovation ecosystems. Additionally, it analyzes the legislative and institutional framework for artificial intelligence in the European Union, including relevant policies and strategies, existing regulations, and institutional architecture. The chapter concludes by identifying the research niche, highlighting the limitations of the existing literature and arguing for the need for an integrated analysis.

The second chapter presents the methodological framework of the study and the approach to investigating the analyzed relationships. The research questions, objectives, and formulated hypotheses are defined, and the conceptual structure of the research is described. It presents the methods used, the analytical tools, the selected indicators, and the data sources utilized, particularly Eurostat databases, DESI indicators, and information on clusters. It also discusses the methodological limitations of the research and how these are addressed within the analysis.

The third chapter comprises the empirical analysis and interpretation of the research results. The chapter begins with an analysis of the national strategic context of AI development in the European Union (the EU), specifically an analysis of national strategies on artificial intelligence, and continues with a comparative analysis of digital maturity, based on DESI indicators and Eurostat data, in Romania and the Baltic States. The chapter examines clusters oriented toward digitalization/AI, including their territorial distribution, an assessment of organizational maturity, and a comparative analysis of selected clusters in Romania and the Baltic States. The third chapter

also includes an analysis of the main applications of artificial intelligence in representative firms within these clusters and highlights regional patterns. Finally, the results are interpreted in relation to the research hypotheses and questions formulated within the methodological framework, highlighting the association between the clusters' level of organizational maturity and the adoption of artificial intelligence applications.

The conclusions section summarizes the main findings of the research. It also describes the theoretical and practical contributions, taking into account the limitations of the research, and proposes directions for future research.