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STRUCTURAL LIMITATIONS AND COMPETITIVENESS CHALLENGES OF THE EUROPEAN UNION'S AI MODEL

Abstract

This article examines the European Union's (EU) artificial intelligence (AI) development model, through the lens of institutional economics and endogenous growth theory, and incorporates a comparative analysis of systemic strategies pursued by the United States and China. It argues that the EU's limited competitiveness in AI is driven primarily by structural and investment – related constraints, while the EU normative – regulatory model constitutes a distinctive asset, whose competitive effects depend on complementary conditions. Despite its strong scientific base and capacity to shape global ethical and legal standards, the EU continues to struggle with fragmented data markets, underdeveloped commercialisation pathways, insufficient computing infrastructure and limited access to private capital. The results of the analysis suggest, that strengthening the European AI ecosystem requires a coherent investment strategy, deeper capital-market integration, improved coordination of public policies and institutional reforms that would enable Europe to translate its scientific and normative resources into durable technological and economic advantages.

Keywords: *European Union, Artificial Intelligence, Competitiveness, Endogenous Growth, Institutional Economics, Investment, Comparative Capitalism, AI Governance (Regulations)*

Streszczenie

Artykuł analizuje model rozwoju sztucznej inteligencji (AI) w Unii Europejskiej (UE) przez pryzmat ekonomii instytucjonalnej oraz teorii wzrostu endogenicznego, uzupełniając rozważania o porównanie strategii systemowych realizowanych przez Stany Zjednoczone i Chiny. W opracowaniu argumentuje się, że ograniczona konkurencyjność UE w obszarze AI wynika przede wszystkim z barier strukturalnych i inwestycyjnych, natomiast unijny model normatywno regulacyjny stanowi wyróżniający się zasób, którego efekty konkurencyjne zależą od warunków komplementarnych. Pomimo silnej bazy naukowej i zdolności kształtowania globalnych standardów etycznych i prawnych UE wciąż zmaga się z fragmentacją rynków danych, słabo rozwiniętymi ścieżkami komercjalizacji, niewystarczającą infrastrukturą obliczeniową oraz ograniczonym dostępem do kapitału prywatnego. Wyniki analizy sugerują, że wzmocnienie europejskiego ekosystemu AI wymaga spójnej strategii inwestycyjnej, głębszej integracji rynków kapitałowych, lepszej koordynacji polityk publicznych oraz reform instytucjonalnych, które pozwolą Europie przełożyć zasoby naukowe i normatywne na trwałe przewagi technologiczne i gospodarcze.

Słowa kluczowe: *Unia Europejska, Sztuczna Inteligencja, Konkurencyjność, Wzrost Endogeniczny, Ekonomia Instytucjonalna, Inwestycje, Kapitalizm Porównawczy, Zarządzanie SI (Regulacje)*

Introduction

In the context of intensifying global competition for technological and innovation advantages, driven in particular by accelerating progress in artificial intelligence (AI), the European Union (EU) faces an imperative to strengthen its competitiveness. This challenge goes beyond technological advancement as such and entails profound shifts in institutional architecture, economic structures, and geopolitical interdependencies. AI is increasingly regarded as a strategic resource, shaping not only trajectories of economic growth but also social relations, the principles of civic participation, the functioning of democratic institutions, welfare standards, and the frameworks of human – technology coexistence.

Against the backdrop of capital – intensive AI development strategies pursued by the United States (US) and China, the EU faces not only a shortage of capital but also a widening gap in innovation capacity, productivity, and the market deployment of emerging technologies. Despite a highly developed scientific base, a relatively stable internal market, and a leading role in shaping the normative – regulatory order of AI governance (as exemplified, i.a.by the AI Act), the EU's competitive position in AI remains constrained by persistent structural deficits.

Key developmental barriers include: a low level of private investment in research and development (R&D) and insufficient collaboration between academia and industry; fragmentation of the data market and the absence of a trusted and secure Union – level data and compute infrastructure; uneven distribution and outflows of AI talent; limited engagement of private capital in strategic sectors and high – risk investments; and inconsistencies and gaps in the regulatory and implementation environment that may deter investors and hinder the scaling of innovation. High energy costs and fragmented AI strategies across Member States further weaken the EU's capacity to compete with leading actors in the global race for technological leadership.

Accordingly, the aim of this article is to demonstrate that persistent structural and investment-related constraints fundamentally weaken the EU's AI ecosystem, and to specify the conditions under which the EU's normative – regulatory potential can be translated into durable technological and market

advantages, drawing on a comparative political – economy analysis of systemic strategies pursued by the US and China.

The article advances the main hypothesis that the EU's normative – regulatory model constitutes a key comparative advantage. Its impact on competitiveness, however, depends on enabling conditions. In particular, it requires coherent investment mobilisation, stronger institutional integration, and effective scaling mechanisms. Without these conditions, structural and capital constraints prevent this advantage from being realised.

A subsidiary hypothesis holds that, under favourable conditions, the EU can leverage the *Brussels effect* to diffuse AI standards beyond its borders and strengthen its role in global AI governance. In this way, the EU could articulate a *third way* in the digital sphere, situated between the market – oriented American approach and China's state – led model (Tycner, 2023).

The research problem addressed in this article is to explain the economic and institutional sources of the EU's gap vis-a – vis the USA and China in, inter alia, AI scaling and commercialisation, with particular attention to the relationship between structural and investment constraints and the capacity to harness the EU's normative – regulatory model. The analysis is guided by the following research questions:

1. under what structural and investment conditions can the EU's normative – regulatory model become a developmental asset in AI?;
2. which structural and investment – related problems constrain the EU's capacity to scale and commercialise AI relative to the US and China, and through what economic mechanisms do they operate?;
3. under what institutional and political conditions can the EU translate its scientific and normative resources into durable technological and economic benefits, including a stronger role in global AI governance?.

The analytical framework integrates institutional economics and endogenous growth theory with insights from comparative institutional political economy. The analysis is conducted using a qualitative approach.

Data sources and methodology

To address the research problem, the article employs a qualitative, comparative approach grounded in institutional economics and endogenous growth theory, interpreted through the lens of comparative institutional political economy. The analysis develops a mechanism oriented explanation of the EU's AI competitiveness gap by linking observed outcomes to institutional complementarities, patterns of investment mobilisation, and scaling dynamics, rather than estimating causal effects econometrically.

Conceptually, the analysis links AI – related competitiveness to institutions, incentives, and knowledge accumulation, drawing on institutional economics and endogenous growth theory. It also engages with scholarship on comparative capitalism regarding state – market coordination and investment mobilisation (Hall, Soskice, 2001; Grossman, Helpman, 1990), as well as with the literature on the EU's regulatory power and transnational standard setting, including the so – called *Brussels effect* (Bradford, 2023). More recent theoretical work additionally highlights the role of knowledge-spillover entrepreneurship in commercialising uncertain knowledge (Audretsch, Belitski, 2021) and formalises data as a nonrival input in fully endogenous growth models of the data economy (Cong et al., 2022).

The comparative logic is organised around three cases: the EU, the United States, and China, which represent distinct configurations of state – market relations and AI governance: the United States as a predominantly market – led, investment – driven model; China as a state – led, strategically coordinated model; and the EU as a normative – regulatory model whose competitive effects depend on complementary structural and investment conditions. This case selection enables a structured comparison of how capital, data and compute infrastructure, and commercialisation pathways translate into AI capabilities under different institutional arrangements. Sources were therefore selected to ensure comparability across these three models and to relate directly to the article's key analytical variables (capital mobilisation, compute and data infrastructure, commercialisation dynamics, and governance).

Empirically, the article relies on secondary source analysis as well as document and data analysis. It draws on public policy documents and legal texts

(including EU legal acts and digital policy documents, regulations relating to data, and documents linked to the AI Act), statistical data and indicator datasets (e.g., private AI investment, R&D expenditure, adoption rates, publication and patent activity), and scholarly literature in innovation economics, institutional economics, comparative capitalism, and AI governance, complemented by high quality analytical reports.

Source materials, namely data/indicators, public policy documents, and scholarly literature, were selected so that key findings could be corroborated through their mutual comparison. As a result, the conclusions do not rest on a single report or interpretation but on the consistency of information drawn from different types of materials.

A COMPARATIVE ECONOMIC PERSPECTIVE ON SYSTEMIC AI DEVELOPMENT MODELS IN THE UNITED STATES AND CHINA

The ongoing expansion of AI cannot be examined solely through the lens of technological progress, as it not only redefines the relationship between labour and capital but also fundamentally transforms the human – technology coexistence. AI has become a strategic asset (Ulnicane, 2022: 265) around which the interests of nation states, firms and transnational actors are increasingly concentrated. Its diffusion affects productivity, reshapes the rules of participation in international markets and reconfigures the architecture of global value chains. Competitive advantage is therefore determined not only by technical capabilities but above all by institutional design, policy effectiveness, access to data and the speed of innovation commercialisation. In this context, despite its strong scientific base and normative – regulatory capacities, the EU operates under conditions of growing asymmetry vis – a – vis the USA and China; two economies that have developed integrated, capital intensive and dynamic national AI innovation regimes, underpinned by industrial and investment policies.

The United States has adopted an investment – driven approach in which the private sector performs the primary allocative role, while the state acts as a coordinator through targeted fiscal, infrastructural, and regulatory support.

The strategic objective is to achieve technological dominance within global digital value chains.

This market – oriented strategy, coupled with deep venture capital markets and rapid commercialisation pathways, has enabled the US to establish the world's most effective, capital intensive AI innovation ecosystem. According to the *AI Index Report 2025*, private investment in the USA AI sector reached USD 109,1 billion in 2024; almost twelve times the level recorded in China (USD 9,3 billion) and more than twenty four times that in the United Kingdom (USD 4,5 billion). In the same year, generative AI further strengthened its position as one of the fastest growing segments within the wider technology ecosystem, attracting USD 33,9 billion in private investment, representing an 18,7% increase compared to 2023 (Artificial Intelligence Index Report, 2025: 3 and 249). This inflow of capital, alongside its accelerating growth trajectory, reflects deepening market confidence in the commercial viability of AI technologies, while simultaneously underscoring their role within cross border innovation flows. The same report indicates, that already in 2023, 78% of companies in the USA reported using AI based solutions in their operational activities, compared to 55% the previous year. Such a significant level of implementation, should be interpreted not merely, as an expression of interest in the technology, but as a clear indication that AI is becoming a permanent component of corporate strategy, organisational design and the functioning of production processes (Artificial Intelligence Index Report, 2025: 3).

In economic terms, AI is increasingly emerging as a structural vector of transformation, within advanced capitalist systems, influencing resource allocation mechanisms, business model innovation, and labour market configurations. Competitiveness depends not only on access to advanced, frontier technologies, but also on the capacity to integrate AI into decision making processes, production systems and organisational routines. In this regard, the US based firms exhibit high technological maturity and absorptive capacity, as evidenced by the development of forty state – of – the – art AI models in 2024 alone, compared to fifteen in China and only three in Europe (Artificial Intelligence Index Report, 2025: 27).

Across Asia, different forms of developmental capitalism coexist. The most institutionalised model of state – led technological capitalism is represented

by China, where AI is embedded in strategic industrial planning, reflected in initiatives and documents such as the *Made in China 2025* and successive Five Year Plans. In this model, the state acts as investor, data steward, infrastructure provider and architect of the innovation ecosystem. By contrast, Japan's approach, aligned with the objectives of the *Society 5.0* strategy, focuses on social cohesion. Digital development is framed as a tool for fostering digital inclusiveness and social innovation, and is explicitly intended to address structural challenges (A Nation's Drive Towards a Data-first Digital Society Future, 2022). This orientation is consistent with the tradition of coordinated capitalism, as extensively described by Hall and Soskice (Hall, Soskice, 2001: 34 – 36).

China's AI strategy is embedded in a broader model of capitalism, characterised by what Mariana Mazzucato has termed the *entrepreneurial state* or *developmental state*, in which the government assumes the role of investor, coordinator, and regulator. It goes beyond the Keynesian logic of demand management by actively steering industrialisation, technological transformation, and the cultivation of innovation capacity (Mazzucato, 2011: 69). Furthermore, as argued by Qiaoyu Cai and Mazzucato, AI functions as an ideological mechanism, that reinforces the state's capacity for social oversight and facilitates the implementation of digital forms of social governance. It is perceived not only as a driver of economic growth, but also as a tool for institutional consolidation and the promotion of a digital order that presents an alternative to Western norms (Cai, 2025: 21 – 40). The integration of AI into key sectors such as public administration, healthcare, education, and smart city infrastructure reflects a policy orientation in which innovation is designed less to serve free market competition and more, to strengthen the internal coherence of China's industrial, social and ideological agendas.

The Chinese government emphasise competitive advantage through strategic support for scientific research and the expansion of computational infrastructure, which has translated into a significant increase in the number of research and development centres, as well as an impressive volume of publications in breakthrough technologies. However, the system of tax incentives and subsidies typical of developmental capitalism can weaken market – based selection mechanisms, leading to uneven quality in both selected research projects and scientific publications. The *Nature Index 2024*, ranked China first

globally in the volume of scientific publications in the natural and physical sciences, underscoring its growing knowledge capacity in frontier technologies (Greeven, 2024; Ganpatsingh, 2025). Similarly, the report *China Leads on Generative AI Patents, but What Does That Mean?* notes, that China leads in the number of patent filings related to generative AI, particularly in the domain of environmental technologies (He, 2024). Between 2014 and 2023, Chinese entities filed over 38,000 patents, six times more than the US during the same period. However, the report's authors emphasise, that a substantial share of these Chinese applications is characterised by lower substantive quality, reduced novelty, and limited international reach, as evidenced by a comparatively low number of Patent Cooperation Treaty (PCT) filings (He, 2024). This observation lends support to the argument that the American trajectory of AI development remains more effective at the system level. The US model, rooted in a synergy between fundamental research, venture capital financing, rapid commercialisation capacity and globally scalable products, appears to be more balanced in fostering long term innovation capacity.

Analytically, the US and China illustrate two distinct but scale – oriented AI development regimes: one relies on market selection and venture capital depth, the other on state – led coordination and infrastructure building. In both cases, rapid scaling is enabled by complementarities between capital mobilisation, compute and data access, and institutional capacity to translate research into deployment. The comparison therefore highlights the functional prerequisites of scale that the EU must strengthen, investment mobilisation, shared compute and data infrastructure and coordinated scaling mechanisms, so that its normative – regulatory model can translate into durable technological and market advantages. Against this benchmark, the EU's competitiveness gap can be traced to structural and investment – related constraints, that weaken scaling capacity and mediate whether its normative-regulatory model translates into durable technological and market outcomes.

Structural constraints on innovation and competitiveness of AI in the European Union

In contrast to the USA's market – driven AI development model and China's state – planned model, the EU has adopted a regulatory approach grounded in democratic values, ethics, and technological safety. While this normative trajectory undoubtedly constitutes a hallmark of the EU's AI strategy, it has yet to result in the establishment of an integrated and globally competitive innovation ecosystem, capable of matching the scale of investment and commercialisation achieved by its global counterparts. As noted in the analysis of the European Court of Auditors, since 2018 the European Commission (EC) has launched a series of initiatives to support the development of the EU's AI innovation system. These include regulatory frameworks, digital infrastructure projects, research programmes, and funding instruments. Despite their systemic character, the overall effectiveness of these efforts remains limited due to fragmented competences and the absence of a unified coordination and investment monitoring mechanism between EU and national levels (European Court of Auditors, 2024a). From an institutional economics perspective, this suggests a low level of both horizontal (among member states) and vertical integration (between the EU and national levels), resulting in inconsistencies in resource allocation and hindering the development of effective incentives for private investors and research actors in the AI sector. The lack of robust coordination mechanisms constitutes a major obstacle to the emergence of a cohesive and resilient innovation market, as well as to the effective formation of public – private partnerships, considered *crucial if the EU is to achieve its ambitions in the field of AI* (European Court of Auditors, 2024a). In the absence of stable innovation support mechanisms, that are both embedded within institutional frameworks and effectively coordinated, private capital tends to display a lower propensity to engage in high risk undertakings, a trend that has been clearly evident within the EU. Since 2015, venture capital investment in European technology firms, operating in the field of AI, has remained relatively limited. This was particularly noticeable between 2018 and 2020, leading to more than a twofold increase in the investment gap between the EU and the USA. The value of this disparity now exceeds EUR 10 billion, pointing to

persistent structural limitations in scaling innovation and deploying advanced technologies across Europe (European Court of Auditors, 2024a).

Structural constraints on the development of AI within the EU are further evidenced by data concerning global activity in the field of generative AI.

According to the European Commission's Joint Research Centre, the EU accounts for merely 7% of global activity in this domain, compared to 12% in the US and as much as 60% in China, indicating a pronounced dominance of these two economies in AI advancement. While Europe remains strong in generative AI research, producing approximately 21% of papers worldwide in 2023, EU patent filings represent only 2% of the global amount, underscoring the gap between research output and innovation commercialisation (European Commission, Joint Research Centre, 2025). For comparison, in 2021, North America accounted for nearly 17% of global AI patent filings, while the East Asia and Pacific region generated as much as 62% (European Court of Auditors, 2024b).

The data presented above highlight the EU innovation system's limited capacity to convert its considerable academic and scientific potential into market value. This gap is largely attributable to the low adoption rate of AI technologies among European enterprises. In 2021, only 8% of firms within the EU reported the use of at least one AI technology, with significant variation among Member States (European Court of Auditors, 2024b). Member States with advanced levels of digitalisation and economic development, such as Denmark, Sweden, Finland, Portugal, Luxembourg, the Netherlands and Germany, exhibited relatively high levels of AI implementation. In contrast, in Central and Eastern European economies such as Poland, Romania and Bulgaria, the adoption rate remained markedly lower, frequently below 5%. Moreover, a persistent structural gap exists across the EU between large enterprises and SMEs. This disparity is driven primarily by structural barriers, including limited access to capital, insufficient cross sectoral collaboration, and underdeveloped mechanisms for technology transfer. The contrast with competing innovation systems is reinforced by the scale of public AI support outside the EU; by comparison, US federal spending on AI reached USD 3,3 billion in 2022 (European Court of Auditors, 2024b).

These patterns reflect a narrower AI specific version of the so – called *European paradox*: strong research performance coexists with weaker downstream adoption, technology transfer, and scale – up finance (Argyropoulou, Soderquist, Ioannou, 2019: 1 – 5). The relevant mechanism is therefore not primarily a lack of knowledge production, but the insufficient development of institutional, financial and market channels that connect research excellence with entrepreneurial experimentation, growth stage capital and EU wide market deployment.

A major structural bottleneck lies in the shortage of human capital in strategic technologies, including AI, and the absence of effective mechanisms to retain talent within the internal market. The training and development environment remains insufficiently attractive to offer competitive career pathways or enable collaboration with the private sector at a level comparable to Silicon Valley or South Korea's leading technology hubs.

According to the 2023 report *Where is Europe's AI Workforce Coming From?*, as many as 43% of AI professionals currently working in Europe received their education outside the EU, primarily in India, China, Iran, and the USA. In Germany and the United Kingdom, this share stands at 45% and 47% respectively, significantly exceeding the overall proportion of foreign degrees among the general population with higher education, approximately 13% (Pal, 2024). These figures point to a pronounced dependency of the European labour market on the inflow of foreign talent and to a lack of coordinated measures, aimed at developing a robust internal supply of highly skilled professionals across the EU. Moreover, structural imbalances across EU member states are becoming increasingly pronounced, as talented professionals increasingly migrate to more innovation driven countries, offering stronger science, industry collaboration frameworks, such as Switzerland, France, Germany, the Nordic states, and the Netherlands. This trend is contributing to what may be described as an *internal brain drain*. As Siddhi Pal, the author of the report notes, Southern and Eastern Europe are currently functioning as *suppliers of human capital,* exposing the Union to deeper fragmentation and diminishing its internal cohesion, necessary for building a sustainable and competitive AI ecosystem (Pal, 2024). This interpretation is supported by OECD evidence based on LinkedIn data for 2019 – 2024, which shows that although most EU

Member States are net attractors of AI talent, Greece, Hungary and Italy record a net outflow of AI expertise, confirming that the European AI labour market remains spatially uneven rather than fully integrated (OECD, 2025: 82 – 84). Challenges in cultivating and retaining specialised human capital also stem from the insufficient involvement of the private sector, both in terms of financing skill development and supporting long term, future oriented investment. In 2023, private R&D expenditure in the EU accounted for only 1,2% of GDP, compared to 2,3% in the USA (Sandbu, 2024). The stronger engagement of US private investors in innovation is also evident in the sectoral structure of the economy. Approximately 60% of the investment gap is attributed to the high concentration of the US economy in advanced technology sectors such as software, biotechnology, aerospace, pharmaceuticals, and defence. By contrast, Europe remains predominantly reliant on medium-technology industries, including automotive, chemicals, construction and heavy manufacturing.

Taken together, these indicators point to a consistent mechanism: fragmented markets and weak investment mobilisation depress the expected returns to innovation and increase perceived scaling risk, which in turn discourages private capital, firm level adoption and entrepreneurial experimentation. In institutional economics terms, the EU's binding constraint is not its normative – regulatory orientation per se, but the insufficient development and fragmentation of complementary institutions that lower scaling costs and uncertainty. The most important gaps concern integrated capital markets, interoperable data and compute infrastructures, and stable coordination frameworks for investment and public – private partnership formation. This interpretation is consistent with the knowledge – spillover perspective, which emphasises that the commercialisation of new knowledge under uncertainty depends on entrepreneurial channels and an institutional context that reduces uncertainty and lowers the costs of accessing and processing knowledge (Audretsch, Belitski, 2021: 6 – 7). Seen through this lens, the EU's regulatory pathway is not a substitute for scaling capacity but a potential advantage whose competitiveness effects depend on complementary structural and investment conditions.

The EU's regulatory pathway to growth and technological advantage

In line with endogenous growth theory (P. Romer) and the concept of dynamic comparative advantage (G. M. Grossman and E. Helpman), both the USA and China have focused their AI strategies on the intensification of investment in digital infrastructure, data, human capital and knowledge – intensive innovation. In these contexts, sustained growth and international positioning derive from the capacity to generate and implement breakthrough technologies (Krasodomski, 2025; Grossman, Helpman, 1990; 796 – 814). By contrast, the EU grounds its approach to AI development in normative values and ethics, following the logic of regulatory institutional capitalism. Its objective is to build competitive advantage on democratic principles, human – centric design, and social responsibility, rather than on pure market efficiency (Cancela – Outeda, 2024: 4). Drawing on instruments such as the Charter of Fundamental Rights, the EU aims to minimise negative externalities, such as algorithmic discrimination and lack of transparency by establishing a framework, for safe AI development, that enhances rather than replaces human capabilities (Carriço, 2018: 29). In this perspective, a comprehensive institutional and legal order is positioned as a counterweight to the more market – led and state – led scaling trajectories pursued by the USA and China.

The EU's AI governance framework developed gradually, beginning with the 2017 European Parliament resolution and the Commission's 2018 initiatives, *Artificial Intelligence for Europe* and the *Coordinated Plan on Artificial Intelligence*, later updated in 2021. These documents established the strategic foundations of the EU approach: increasing R&D investment, supporting technology transfer, coordinating Member State action, and developing a unified digital market (European Commission, 2018a; European Commission, 2018b; European Commission, 2025a). The 2020 White Paper introduced the risk-based regulatory logic that formed the basis for the 2021 proposal and, after negotiations, the adoption of the AI Act in 2024 (van der Heijden, 2021: 1 – 10).

The AI Act is therefore relevant primarily through its regulatory and implementation effects. It introduces a risk-classification framework based on the potential impact of AI systems on the public interest, particularly in the

areas of safety, health, fundamental rights, and the stability of socio-institutional structures (Pirozzoli, 2024: 107 – 108). In line with the principle of proportionality and the functional orientation of the framework, the scope of regulatory obligations is determined not by the technological architecture of a system, but by its function and potential societal consequences. The strictest requirements apply to high risk systems, while related obligations for providers and deployers concern, depending on the role and use context, data quality, technical documentation, human oversight, and fundamental rights impact assessments. These mechanisms operate as ex ante safeguards designed to identify risks before deployment and limit negative externalities (Wallenberg, 2025). In institutional economic terms, the AI Act can reduce uncertainty and standardise compliance expectations across the Single Market, thereby lowering coordination frictions for cross border deployment. At the same time, if implementation remains complex and uneven, these obligations may increase compliance costs, especially for SMEs, and reinforce the very scaling constraints analysed in this article.

The EU's regulatory framework extends beyond the AI Act, forming a layered legal structure grounded in human – centric digital governance (Pirozzoli, 2024: 14 – 16). The framework is underpinned by the European Declaration on Digital Rights (2022), complemented by key legislative acts such as the Digital Services Act and the Data Governance Act, which regulate digital platform accountability and govern access to non – personal data (Bogucki, Engler, Perarnaud, 2022: 11 – 13, 27). At the sectoral level, the Data Act (2023) functions as a framework for data integration, supporting the development of the European Data Space (Bogucki, Engler, Perarnaud, 2022: 13 – 14). Unlike the American model, the EU conceptualises data not merely as an economic asset, but also as a common good, to be utilised across diverse socio – economic sectors. The investment dimension of this approach is operationalised through the Digital Europe Programme (2021 – 2027), with a dedicated budget of EUR 7,5 billion. In parallel, Horizon Europe supports the development of strategic infrastructure and funds projects focused on transparent and ethical AI (Group of Chief Scientific, 2024: 24 – 26, 66 – 68). Since 2024, institutional coordination has been strengthened by the European AI Office, tasked with supporting the implementation of the AI Act, enforcing

rules for general purpose AI models and promoting harmonised governance standards in the public interest (European Commission, 2025b).

In general, the EU's holistic approach reflects the principles of socially embedded institutional capitalism, in which competitive advantages arise not from market – driven expansion, but from the integration of democratic values, a robust regulatory framework, and long term coordination of public policies. This regulatory pathway addresses a core element of the article's research problem; it explains why the EU can plausibly lead on governance and standard setting even while lagging on scale and commercialisation.

From an economic perspective, the EU normative – regulatory model can be interpreted as an attempt to supply an institutional public good in the form of trust, legal certainty, and interoperable standards, thereby reducing transaction costs and uncertainty in markets characterised by high information asymmetries and technological uncertainty. However, these benefits translate into competitive advantage only at scale. This requires adequate financing, compute capacity and access to data. In fully endogenous growth models of the data economy, data are formalised as a nonrival input used across innovation and production (Cong, Wei, et al., 2022: 1 – 2). Under these conditions, compliance and safety – by – design can become a differentiating feature rather than a fixed cost borne disproportionately by small and undercapitalised actors. Put differently, the EU's regulatory strength is most likely to operate as an advantage when it is coupled with the complementary structural and investment conditions that enable firms to scale under common rules.

This mechanism directly reflects the article's main hypothesis: without complementary structural and investment conditions, regulatory strength alone is unlikely to translate into scalable deployment and durable market outcomes. It also helps explain why transnational standard setting power is economically reinforced when the internal market supports scaling and diffusion of compliant AI, rather than treating compliance as an entry barrier. This provides an analytical bridge to the subsequent sections on systemic fragmentation and the EU's digital competitiveness, where these complementary conditions are shown to be uneven and institutionally constrained.

Systemic fragmentation and the digital competitiveness of the European Union

From the perspective of endogenous growth theory, the EU's research strength becomes economically consequential only when knowledge diffusion is connected to market formation, growth stage finance, and cross border deployment. The evidence below shows that this conversion mechanism remains weak. Data from 2022 confirm the structural constraints facing the EU in the field of innovation development. As shown in Table 1, EU R&D expenditure remained substantially lower than in the USA and China, while the structure of financing revealed a particularly important weakness: the comparatively low level of private capital involvement. In 2022, private R&D investment in the EU amounted to just 1,3% of GDP, compared with 2,5% in the US and 2.0% in China (European Commission, 2025c: 6 – 11). This investment composition matters for scaling. Public funding supports research breadth, but private capital, especially growth stage financing, is typically decisive for rapid commercialisation, platform expansion and international deployment.

Table 1. *R&D expenditure and private investment intensity in the EU, the USA and China, 2022*

INDICATOR	EUROPEAN UNION	UNITED STATES	CHINA
Total R&D expenditure	EUR 357 billion	EUR 877 billion	EUR 435 billion
Public funding as share of total R&D expenditure	32%	18%	18%
Private R&D investment as share of GDP	1,3%	2,5%	2,0%

Source: Own elaboration based on European Commission (2025c, pp. 6–11).

In this context, capital market integration should be understood not merely as a financial policy objective, but as a competitiveness instrument directly linked to the AI scale – up gap. Its relevance lies in three complementary channels. The Savings and Investments Union seeks to mobilise dispersed European savings, reduce cross – border barriers and make EU capital markets more attractive for firms and investors (European Commission, 2025e).

The Listing Act and the European Single Access Point address the exit and information dimensions of the same problem by lowering the costs of public market access and improving investor visibility, including for firms from smaller or less developed capital markets (Council of the European Union, 2024; Council of the European Union, 2023). Finally, public – private scale – up instruments, especially the planned Scaleup Europe Fund, can help crowd in late stage equity where European AI firms most often face financing constraints (European Commission, 2025f). These instruments are directly relevant to the AI venture capital investment gap with the USA discussed in the previous section, whose value exceeds EUR 10 billion (European Court of Auditors, 2024a). Their role should be understood as catalytic rather than substitutive: they can mobilise savings, improve exit prospects, reduce information asymmetries and provide late stage co investment capable of crowding in private venture capital. Taken together, these instruments lower transaction costs, broaden the investor base and increase the availability of risk capital needed to finance compute, data infrastructure, talent acquisition and cross border deployment. They therefore connect the EU's research and regulatory strengths with the financial conditions required for AI scale – up.

Another key limitation affecting the EU's digital competitiveness is the limited availability of hig quality data and the absence of an integrated computational infrastructure, which, in the current context, function as core inputs of production alongside labour, capital, and land. In endogenous growth theory, data function as intangible assets, that underpin knowledge creation and utilisation, thereby driving innovation. From the perspective of institutional economics and Elinor Ostrom's theory of common goods, data constitute a social resource, whose value generation requires clearly defined property rights and robust information governance frameworks (Viljoen, 2021: 638 – 639). The effective use of data hinges on collective governance structures at the EU level, aimed at broadening accessibility and ensuring a fair distribution of value, particularly for smaller stakeholders. However, as Bertin Martens points out, the fragmented and nationally segmented nature of the EU data market hampers both the interoperability and scalability of informational resources. As a consequence, it constrains their broad application in innovation processes and undermines potential network effects (Martens, 2025). Despite regulatory

initiatives such as the Data Governance Act and the Digital Markets Act, persistent inequalities in data access remain both, between the EU level and individual Member States, and between the public and private sectors. The lack of harmonised standards and an integrated technical infrastructure limits the capacity to train advanced AI models and weakens the EU's long term competitiveness in the digital domain. Even with a high level of research activity and significant public investment in R&D, European firms continue to lag behind, primarily due to limited access to large, high quality datasets (Martens, 2025). In an analysis for Bruegel, Bertin Martens argues that the EU's regulatory approach to data remains overly cautious, particularly in relation to information generated by devices controlled by their producers (Martens, 2023: 7). While the EU's legal framework aims to safeguard property rights, privacy and promote collective data governance, the potential of data as a democratic public good remains largely untapped. From the perspective of institutional economics, current arrangements favour the concentration of data in the hands of dominant actors, leading to informational asymmetries, market distortions, and reduced allocative efficiency. The privileged position of device manufacturers constrains user rights and undermines the notion of data as a shared resource. This underscores the need, for regulatory refinement, common standards for data access, and interoperable technical infrastructures, that can support a unified European data space as a pillar of sustained digital competitiveness (Martens, 2023: 5 – 12).

Analytically, this is where systemic fragmentation becomes economically consequential. It effectively converts data, an inherently scalable resource, into a nationally fragmented input, thereby raising coordination and compliance costs and weakening incentives for EU wide scaling.

These conclusions align with those presented by Mario Draghi in his 2024 report, *The Future of European Competitiveness – A Competitiveness Strategy for Europe*. Draghi emphasises that regulatory fragmentation and heterogeneous requirements raise compliance costs and hinder the creation of large, integrated datasets needed to train advanced AI models (Draghi, 2024: 30).

He also notes that Europe's fragmented market structure contributes to emerging digital bottlenecks and that innovation diffusion is impeded by weak coordination of standards and infrastructure investment (Draghi, 2024: 31).

Similar observations appear in the McKinsey Global Institute report, which points to fragmented AI initiatives and an investment gap vis – a-vis the US and China (McKinsey Global Institute, 2019: 9). The report also documents a persistent perception among European deep tech entrepreneurs that regulation can act as a barrier to scaling (McKinsey Global Institute, 2019: 46).

Both documents acknowledge the importance of regulation, but emphasise the need for simplification, refinement, increased flexibility of the existing legal framework, and stronger alignment with proactive investment policies and coherent institutional frameworks (Lisinska, 2024).

In this view, regulation remains important, but must evolve to become more adaptive, coherent, and embedded within a supportive structural context. For the article's second research question, these assessments converge on a common mechanism: fragmentation and underinvestment jointly weaken the EU's ability to build shared infrastructures and to generate scale effects, thereby limiting both adoption and commercialisation.

The principal constraint on the EU's digital competitiveness does not lie in its regulatory orientation per se, which in fact enhances its international reputation as a global leader in promoting a safe, value – driven, and ethically grounded digital order, but rather in its limited institutional capacity to respond swiftly to market shifts, the absence of a coordinated investment strategy and persistent structural deficits. An additional, highly cost sensitive factor is energy pricing. According to 2023 data from Bruegel, electricity and natural gas prices in the EU were respectively 158% and 345% higher than in the USA (Heussaff, 2024). This implies, that European firms, on average, paid over 2,5 times more for electricity and 4,5 times more for gas, than their American counterparts. For the AI sector, heavily reliant on compute intensive infrastructure, this imposes significant cost pressures on operations. As reported by *Scientific American*, data centres currently account for 1 – 1,5% of global electricity consumption, with projections from the International Energy Agency estimating this share will rise to 2 – 3% by 2030, driven largely by AI expansion (Leffer, 2023). High energy prices in Europe therefore constitute a significant impediment to the development of energy intensive digital technologies. In functional terms, energy costs operate as a *shadow tax* on compute, reinforcing the scaling gap identified earlier in the USA – China benchmark.

This burden is asymmetric: large technology firms can partly absorb energy price volatility through long term power purchase agreements, dedicated cloud or data centre contracts and capital intensive efficiency investments, whereas SMEs usually face energy and cloud compute prices as operating costs that directly reduce experimentation budgets. As a result, high energy prices can delay AI adoption among smaller firms even when regulatory conditions and public support instruments are formally available.

In response to mounting pressure to enhance competitiveness, the EU's AI regulatory agenda entered a phase of recalibration in 2025, shifting towards more pragmatic and flexible solutions. Early legal analyses pointed to discussions concerning a possible postponement of the application and enforcement of selected AI Act provisions not yet in force, particularly those related to high – risk AI systems, together with broader simplification proposals aimed at reducing compliance burdens for SMEs and improving regulatory coherence (Tobey, Stokes, Carr, 2025). This direction was subsequently reflected in the Commission's Digital Omnibus Regulation Proposal, published in November 2025, which proposed technical amendments to the EU digital rulebook aimed at reducing compliance costs and stimulating competitiveness (European Commission, 2025d).

From an economic standpoint, such adjustments may, in the short term, reduce compliance burdens, particularly for SMEs, by improving legal clarity, expanding market access, accelerating technology adoption, and increasing capital inflows. However, excessive regulatory relaxation entails the risk of undermining the institutional foundations of the European AI model. Such a shift could *weaken the EU's bargaining position on global platforms, concede regulatory leadership to more geopolitically assertive rivals* (Csernatoni, 2025: 8), and lead to the erosion of a model based on accountability and institutional oversight, in favour of risk assessments left to private-sector discretion (Lazaro Cabrera, 2025). This trade – off speaks directly to the article's first research question: the EU normative – regulatory model can become a developmental asset only if regulatory credibility is preserved while scaling conditions are improved, rather than by trading away legitimacy for marginal short term compliance relief.

In light of endogenous growth theory and institutional economics, well – designed regulation can act, as a catalyst for innovation and investment, provided it operates within a stable and transparent institutional environment. Regulatory frameworks, that are attuned to the dynamic evolution of AI, and coupled with real time risk monitoring, can enhance investor confidence and reinforce systemic security. From this perspective, regulation ceases to be a constraint and instead becomes a strategic instrument for upholding democratic governance and protecting individual rights. As Anu Bradford argues, the so – called *Brussels effect* equips EU norms with the capacity to shape global standards, particularly due to the influence of the Single Market (Bradford, 2023: 324 – 326).

Crucially, however, the economic reach of such standard setting is reinforced when the internal market enables diffusion at scale, so that compliance becomes a widely adopted baseline rather than an entry barrier borne mainly by smaller actors.

Taken together, the EU case suggests that regulation is necessary for legitimacy and cross – border trust, but it is not sufficient for competitiveness. The binding constraint is the inability to mobilise and coordinate scale, as capital, compute, data, and demand, at the level required for frontier innovation. This closes the logic of the article's main hypothesis: Europe's normative – regulatory model is a comparative advantage, but its competitiveness effects depend on complementary structural integration and investment capacity that allow firms to scale under common rules.

Conclusion

AI has emerged as a decisive force reshaping the global architecture of economic competitiveness. Despite its advanced scientific base and a strong normative – regulatory position in AI governance, the EU remains behind the USA and China in scaling and commercialising AI. The analysis shows that Europe's most binding constraints are structural and investment – related: fragmented data and capital markets, insufficient compute infrastructure, uneven AI talent flows, high energy costs, slow commercialisation pathways

and limited scale – up financing. In line with the article's aim and central research problem, the analysis identifies these constraints as the primary bottlenecks and clarifies the conditions under which the EU's normative – regulatory capacity can translate into competitive outcomes.

Drawing on institutional economics and endogenous growth theory, the article explains, that these constraints operate as a self – reinforcing mechanism: fragmentation raises scaling costs and uncertainty, which depresses private investment, weakens feedback from deployment to learning, and slows productivity gains. Addressing this mechanism requires deeper capital market integration, public – private scale – up finances, coordinated public investment in compute and data infrastructures, and EU level instruments, that reduce coordination failures and accelerate diffusion and commercialisation across the Single Market. In practical terms, this includes instruments that mobilise savings, improve exit channels and investor information, and crowd in late stage equity, such as the Savings and Investments Union, the Listing Act, the European Single Access Point and the Scaleup Europe Fund. This directly answers the second research question by specifying how fragmentation and underinvestment jointly constrain scaling and, in turn, adoption and commercialisation.

At the same time, the EU normative – regulatory model should be treated as a strategic asset, rather than a constraint in itself. By supplying trust, safety and legal certainty, it can lower transaction costs and support market formation, provided that compliance is matched by financing and scale. This is the sense in which regulation must be adaptive and risk – calibrated; not to dilute rights protection, but to ensure that governance and innovation co – evolve. This addresses the first research question and supports the main hypothesis: regulatory credibility becomes economically enabling when firms have access to the investment, compute, and data needed to scale compliant AI under common rules. The analysis also shows that high energy prices operate as a *shadow tax* on compute, with particularly adverse effects for SMEs, which are less able than large firms to absorb energy price volatility or secure favourable infrastructure conditions. Under these enabling conditions, the EU can strengthen the *Brussels effect* and shape international AI standards through both market access and normative influence.

The conclusions therefore respond to the research problem and support the article's hypotheses: Europe's regulatory capacity is a comparative advantage, but it produces competitive outcomes only when embedded in a broader configuration of investment mobilisation, institutional coordination and scaling mechanisms.

This corresponds to the subsidiary hypothesis and speaks to the third research question: standard setting power is reinforced when the internal market enables diffusion at scale, so that compliance becomes a widely adopted baseline rather than an entry barrier.

In sum, the EU has the institutional foundations to articulate a distinct path for AI governance between the market – driven model of the US and the state – centric paradigm of China. Realising this potential requires a systemic transformation that aligns the EU normative – regulatory model with the material capabilities of innovation, capital, compute, data, talent and commercialisation, so that Europe can convert scientific and normative strengths into durable technological and economic advantages. Overall, the analysis indicates that the article's aim has been achieved and the hypotheses are corroborated: Europe's competitiveness challenge is primarily structural and investment related, while regulation functions as an advantage whose effects depend on complementary scaling conditions.

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