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Entrepreneurial strategies for national large language models: A comparative study of Bielik and PLLuM in advancing Poland's digital sovereignty

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ABSTRACT

Objective: In the framework of digital sovereignty, the article aims to investigate and assess the entrepreneurial models supporting the evolution of Poland's two national large language models (LLM), i.e., Bielik (community-driven Polish LLM) and PLLuM (Polish Large Universal Model, a consortium-based initiative).

Research Design & Methods: Using a qualitative research methodology, this work focuses on two national LLMs in a case study. Contextual data were obtained through in-depth, semi-structured interviews, document analysis, and scenario-based model testing. These data were subsequently thematically analysed with the support of NVivo systematic coding software.

Findings: The results show that both institutional and agile approaches to entrepreneurship are necessary for national digital sovereignty to be ensured. A comparative analysisproves the agility ofcommunity-driven LLMs differ from institutional models with great scale found in PLLUM. Through government-supported development, grassroots innovation, and flexible deployment features Bielik contrast PLLum's strategic scalability. By means of localised artificial intelligence innovation, both models show different but complementary approaches to forward Poland's digital sovereignty. By means of localised artificial intelligence innovation, both models show different but complementary approaches to advancing Poland's digital sovereignty.

Implications & Recommendations: Poland's technological resilience and capacity for innovation at once benefit from complementary models such as Bielik and PLLuM. Policymakers should support pluralistic innovation ecosystems to guarantee strong, flexible and sovereign artificial intelligence (AI) development matched with changing national needs including digital security and technological independence. Artificial intelligence's innovation is based on strategic public, commercial, and academic sector cooperation.

Contribution & Value Added: Examining modern and changing phenomena, this creative study of national language models (LLMs) is especially crucial. Thus conducted research focuses mostly on global, commercial models produced by multinational corporations. Therefore, it seems especially crucial to examine local, strategic, and institutional conditions for LLM development as well as their consequences on national technological autonomy and innovation.

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INTRODUCTION

Large language models (LLMs) have lately changed the technological scene all around Google's BERT, OpenAI's ChatGPT, and other advanced artificial intelligence (AI) systems have revolutionised interactions in various industries by automating complex cognitive processes, improving opera-

tional efficiency and enabling innovative digital services (Khurana *et al*., 2023; Zubiaga, 2024; Caballero & Jenkins, 2025). The ability to comprehend and generate human-like text and facilitate more sophisticated, nuanced, and contextually appropriate interactions are LLMs' common features (Kietzman & Park, 2024). Their strategic relevance as digital transformation tools is shown by their wide application in many fields, including, *e.g.*, healthcare, finance, customer service, education, and public administration (Retkowsky *et al*., 2024). The fast global spread of LLMs has also spurred discussions on digital sovereignty. More generally, the concept is a nation's ability for autonomous control over its digital infrastructure, technology systems, and data governance (Chiarello *et al*., 2024). Under the framework of mounting concerns about technological dependence and the potential risks of depending on digital systems and infrastructure under control by foreign entities, this idea gained momentum. Digital sovereignty stresses the need that nations to develop their technological competencies to defend national interests and sensitive data from outside vulnerabilities and geopolitical tensions (Ferraris *et al*., 2025).

Digital sovereignty is a strategic need within AI since it enables the creation of national innovation ecosystems capable of autonomous development and application of technologies based on AI. The goal is to guarantee strategic resilience, cultural relevance, and regulatory compliance with national priorities and values (Ferraris *et al*., 2025), thus transcending local technological innovation. Therefore, a drive for digital sovereignty requires significant investments in technological entrepreneurship and localised research, support for sustainable innovation ecosystems, and increasing national competitiveness (Teece, 2014). Especially in the face of the expansion of two innovative Polish LLM initiatives, Bielik and PLLuM, Poland has become a major actor in advancing digital sovereignty by means of targeted investments in national AI projects. They show attempts to satisfy the specific linguistic, cultural, and operational needs of the Polish environment by means of local knowledge and resources. Their expansion emphasises Poland's strategic intent to assert control over critical AI technologies, reduce reliance on outside suppliers, and strengthen its digital sovereignty through localised innovation and autonomous technological capabilities. Led by the SpeakLeash Foundation in partnership with Cyfronet AGH, the Bielik initiative presents a creative model of entrepreneurship emphasizing language and cultural specificity, community involvement, and open-source accessibility (Żmigrodzki *et al.*, 2025). This locally inspired and community-based project stresses Poland's ability to leverage current knowledge and resources to produce reliable, independent AI solutions. Showing an agile entrepreneurial approach (Żmigrodzki *et al*., 2025), this project successfully addresses legal complexity, technological challenges, and resource constraints by means of crowdsourcing and strategic institutional cooperation. By contrast, the methodical consortium approach known as the Polish Large Universal Model PLLuM consists of several credible Polish research facilities. These include the Institute of Computer Science of the Polish Academy of Sciences, the Wrocław University of Technology, and the Research and Academic Computer Network (NASK). Mainly founded by the Polish Ministry of Digital Affairs, PLLuM seeks to provide a complete artificial intelligence solution fir for the public and private sectors in Poland (Żmigrodzki *et al*., 2025).

Strict ethical guidelines, careful data management, and technological dependability help PLLuM's development process to be strategically in line with more general national goals of digital sovereignty objectives (Żmigrodzki *et al*., 2025). The two initiatives, Bielik and PLLuM, present several approaches to entrepreneurship meant to reach digital sovereignty. Reflecting strategic responses to the particular opportunities and challenges of Poland in the global scene of AI, they both underline the need for localised innovation ecosystems in the larger framework of national technological autonomy. The study closely notes the ways that the business models on which Bielik and PLLuM are grounded affect Poland's digital sovereignty. It specifically highlights the approaches that let these initiatives properly address ethical, legal, and technological challenges. Analysing how these LLMs are applied in Polish business and public sector organisations helps underline their relevance in enhancing operational efficiencies and autonomy. Without localised LLM programmes, countries risk data vulnerability or cultural mismatch. Unlike many non-English LLM initiatives, Poland emphasises distinct entrepreneurial strategies to mitigate data vulnerability and ensure cultural alignment. We comparatively analysed entrepreneurial practices and sovereignty outcomes.

We addressed three primary research questions:

RQ1: What specific entrepreneurial strategies and organisational practices underpin the development and successful deployment of Bielik and PLLuM? How do these approaches differ in their contributions?

RQ2: Do the national LLM models contribute to strengthening Poland's digital sovereignty?

RQ3: How cleverly did Polish businesses and public sector institutions merge Bielik and PLLuM to increase operational efficiency and support national digital autonomy?

This work answers these research questions holistically using a qualitative method. We used in-depth interviews with significant project stakeholders (such as project leaders, developers, and strategists), practical testing of models and rigorous analysis of relevant documentation, including project reports, conversations on social media and technical papers in detailed case studies of Bielik and PLLuM projects under several data collecting techniques. Methodically, we used advanced qualitative data analysis software (NVivo) to identify, classify, and interpret relevant themes linked to entrepreneurial practices, technological challenges, regulatory compliance, and strategic adaptation for the goals of digital sovereignty. This article offers a comprehensive analysis of the entrepreneurial strategies and technological innovations defining Bielik and PLLuM. Thus, augmenting the more general discussions on the purpose of national AI projects in producing digital sovereignty offers significant insights into how localised technological entrepreneurship could effectively pursue national goals, lower outside dependencies, and support sustainable innovation ecosystems.

Finally, this study serves as. a basis for policy-makers, entrepreneurs, and organisational leaders whose goal is to strategically utilise local technological innovations to increase digital autonomy and competitive position in the fast-changing global digital scene. Existing research often neglects comparative analyses of entrepreneurial strategies and predominantly focuses on English-centric models. This research addresses these gaps by explicitly comparing agile and institutional entrepreneurial modes in Poland, thus advancing the theoretical understanding of digital sovereignty.

LITERATURE REVIEW

Researching local entrepreneurial models of LLMs in the framework of digital sovereignty and technological innovation ecosystems calls for extensive knowledge of many theoretical frameworks. Emphasizing digital sovereignty, technological entrepreneurship, and national AI-driven innovation ecosystems, this review of the literature critically assesses these models. It also looks at the corpus of present studies on entrepreneurial strategies in the national development of AI and the pragmatic results of LLM implementations in business and public sectors.

Rising concerns about national security, economic competitiveness, and technological autonomy drive digital sovereignty as a major policy goal worldwide. Chiarello *et al.* (2024) define digital sovereignty as the nation's ability to independently manage and defend its digital infrastructure, technological platforms, and data resources from outside hazards and disruptions. The progressively significant role of digital technologies in national economies and security infrastructures drives countries to reduce their reliance on outside technologies and increase their capacity for autonomous innovation, thus motivating the strategic need for digital sovereignty. Particularly LLM and AI technologies have grown strategically important in this context. National governments have begun their development finally realizing the need to create localised AI capabilities to keep control over significant technologies handling sensitive data and impact national security (Ferraris *et al*., 2025). According to Ferraris *et al*. (2025), digital sovereignty entails not only technological independence but also legal, ethical, and governmental elements in addition. Good digital sovereignty strategy proposals must include comprehensive policy frameworks balancing ethical concerns privacy, security, and innovation integrate.

Entrepreneurship in Technological Innovation

Through creative-based strategies, technological entrepreneurship significantly influences the development of digital sovereignty. According to Teece (2014), technological entrepreneurship is the ability of

companies and people to identify and grab technological opportunities using strategic resource allocation and creative business models. By means of agile, flexible organisational structures, technology entrepreneurs propel the evolution and implementation of novel technologies and thus encourage creativity. The 2014 conceptual framework by Teece emphasises the need for entrepreneurs to manage uncertainty, effectively allocate resources, and always change with the times in respect to technology. This entrepreneurial agility is especially crucial in fast-growing sectors like AI, where constant innovation, technological breakthroughs, and market dynamism demand responsive entrepreneurial strategies. Thus, the success of national AI projects mostly depends on the entrepreneurial ability to innovate strategically, use local knowledge, and properly supervise demanding technological projects.

Digital sovereignty realised successfully by localised AI solutions depends on national innovation ecosystems powered by AI. Ferraris *et al*. (2025) present an integrative framework stressing the critical interaction among governmental policy support, academic and industrial cooperation, and entrepreneurial initiatives inside national innovation ecosystems. Such ecosystems should strive to support specialised knowledge, reliable infrastructure, strategic alliances, and regulatory frameworks allowing the development and commercialisation of innovative technologies including LLMs. National LLMs aim to strengthen digital sovereignty and deliver services in line with local priorities (Pandey, 2025). According to Ferraris *et al*. (2025), successful innovation ecosystems are based on close cooperation among significant stakeholders: government agencies, academic institutions, industrial partners, and entrepreneurs – to guarantee coordinated support for technological innovation. Such cooperation is essential to create stable, sustainable, resilient ecosystems supporting long-term strategic objectives including digital sovereignty. Entrepreneurial strategies, particularly via creative approaches fit for linguistic, cultural, and operational needs, help to greatly build national capacities in the field of AI. Żmigrodzki *et al*. (2025) underline the demand for entrepreneurial activities in developing localised AI technologies that can handle linguistic and cultural nuances usually neglected by global AI developers. These methods combine open-source distribution, and agile management strategies alliances, to raise general acceptance, openness, and adaptability. Localised entrepreneurial projects offer tailored AI solutions that enhance operational efficiencies, strategic decision-making, and technological resilience, thus greatly supporting national competitiveness. These entrepreneurial strategies help national goals of digital sovereignty and technological autonomy by means of motivating innovation and reducing outside dependencies (Żmigrodzki *et al*., 2025).

Many different sectors have benefited much from the pragmatic application of LLMs by automating, challenging tasks simplifying decision-making processes, and increasing operational efficiency. Ilagan *et al.* (2024) emphasise the importance of contributing to the acceleration of informed decision-making processes in a rapidly changing digital environment. Pessanha *et al*. (2024) and de Curtò *et al.* (2024) underline that LLMs are widely used in commercial settings for automating customer satisfaction and that these technologies have a much improved competitive advantage. The application of LLM technologies has a major positive impact on public administration by improving the responsiveness and accuracy of government services, and on business efficiency, customer satisfaction, and competitive advantage. Pessanha *et al*. (2024) also discuss, especially in terms of reducing operational delays, improving information accessibility, and simplifying challenging bureaucratic jargon, the adoption of LLM-based automation will be quite helpful for the public sector. Retkowsky *et al.* (2024) underline even more the transforming power of LLMs in professional services including healthcare, education spheres, and legal services. These models demonstrate their strategic value over many organisational settings by improving professional decision-making, providing customised service delivery, and allowing for sophisticated data analysis.

Though the present literature mostly addresses digital sovereignty, technological entrepreneurship, and innovation ecosystems based on AI, there are still research gaps, especially with regard to the way entrepreneurial strategies directly influence national AI projects like LLMs. Especially in non-English-speaking surroundings, the entrepreneurial side of developing localised AI solutions is still underdeveloped. Studies on the entrepreneurial initiative strategic resource mobilisation, and innovative business models supporting the success of localised AI projects are much awaited.

Furthermore, even if the pragmatic applications of LLMs are well-documented, most of the present research focuses on the global or English-speaking environment and pays little attention to localised language models fit to particular cultural and linguistic settings. Inspired by Bielik and PLLuM initiatives, the Polish setting offers a unique opportunity to close this gap and demonstrate how locally driven entrepreneurial strategies can effectively support national digital sovereignty goals. Based on this analysis of the literature review, the relevant theoretical frameworks and pragmatic elements required for local entrepreneurial LLM models and digital sovereignty become clear. The emphasis is on the main contribution of strategic entrepreneurial activities, integrated innovation ecosystems, and technological entrepreneurship in the effective development and deployment of localised AI technologies. By filling observed research gaps, particularly in the entrepreneurial elements of national AI projects, this study significantly advances knowledge of how localised technological innovations could increase national digital sovereignty. Due to the study's exploratory qualitative approach, we did not employ formal hypotheses but rather conceptual propositions based on comprehensive literature regarding technological entrepreneurship and digital sovereignty.

RESEARCH METHODOLOGY

We employed a qualitative methodology for its ability to fully investigate events and offer nuanced insights into the entrepreneurial activities surrounding local large language models (LLMs) like Bielik and PLLuM. Well-known for its interpretative and naturalistic approach, qualitative research helps researchers explore thoroughly and grasp the settings, motivations, and complexity connected with technological development and application (Creswell & Poth, 2017). As Eisenhardt (1989) notes, close relationships to empirical data enable the case study approach to support the development of inductive theory. Its adaptability and iterative character ensure complete contextual analysis and theoretical relevance thus they help it to be helpful in newly growing areas (Corbin & Strauss, 1990). Core objectives for the research include examining entrepreneurial strategies, technological novation pathways, and strategic impacts on digital sovereignty. They also support a thorough awareness of difficult technological projects in the dynamic and uncertain surroundings typical of advanced AI applications.

The approach of qualitative research applied in this study emphasises careful case studies (Stake, 1995). According to Yin (2018), case study research is especially useful for analysing contemporary events in their natural settings, particularly in cases when the differences between events and their surroundings are not exactly clear. From this vantage point, the case study approach facilitates investigating Bielik and PLLuM projects, looking at how they have strategically contributed to advancing Poland's digital sovereignty by means of entrepreneurial activities, technological innovation, and policy alignment. By means of a case study method approach, one can closely investigate the internal dynamics, strategic objectives, and operational complexities defining various entrepreneurial AI projects. Case studies allowed one to have complete knowledge of the beginning, running, challenges, and outcomes of the project by means of rich qualitative data from many sources (Stake, 1995). Furthermore, they facilitate an in-depth understanding of complex technological initiatives in dynamic and uncertain environments, characteristic of advanced AI technology deployment. We selected the cases of Bielik and PLLuM for their representativeness of contrasting entrepreneurial strategies: agile community-driven versus structured institutional models. Furthermore, the following criteria dictated the selection of cases: the first two national LLM models were selected for the study; second, when the study began, there were no other available national initiatives in this area.

Mostly in-depth interviews (IDIs) surround this qualitative research and case studies. Selected IDIs were effective in producing complete, narrative responses that provide a great awareness of participants' viewpoints, experiences, and motivations (Brinkmann & Kvale, 2015). This method allowed developers from Bielik and PLLuM strategies, and project managers to offer rich, contextually based observations on the projects. The interview process was open-question under an agenda designed to probe many thematic areas. The protocol included the main areas of interviews: project goals, strategic alignment with digital sovereignty, technology decisions including choice of training data and architec-

ture, technological and entrepreneurial challenges, regulatory issues, ethical considerations and the application of models in the public and private sectors. Semi-structured interviews allowed participants to investigate in-depth topics they felt particularly relevant or important and thus capture nuanced insights on the entrepreneurial processes and strategic decision-making. All questions were open-ended and were structured to encourage respondents to provide detailed, narrative answers. We validated interview questions against existing research frameworks on technological entrepreneurship and digital sovereignty. We ensured reliability through thematic saturation and cross-validation with document analysis. There were eight in-depth interviews, four related to Bielik and four to PLLuM (Table 1). We selected all participants to participate in the interview in a purposive manner.

The criteria for selection were direct participation in the work on the creation, development and implementation strategies of the models analysed. Interviews were conducted with key participants involved in the development of Bielik and PLLuM models, including project leaders, strategists, decision-makers, technology implementation specialists, and developers from Bielik and PLLuM.

Table 1. General list of the respondents

Respondent ID	Organisation	Gender
Respondent 1	SpeakLeash Foundation	M
Respondent 2	SpeakLeash Foundation	M
Respondent 3	SpeakLeash Foundation	F
Respondent 4	SpeakLeash Foundation	M
Respondent 1	University of Lodz	M
Respondent 2	Wrocław University of Technology	M
Respondent 3	Scientific and Academic Computer Network (NASK) National Research Institute	F
Respondent 4	Information Processing Centre National Research Institute	M

Source: own study.

We conducted every interview online and recorded it digitally. All interviews lasted between 60 to 90 minutes, allowing enough time to probe of probe the points of view and life events of every participant. They were painstakingly transcribed, and the interviews guaranteed accuracy in data collecting and corresponding analysis. We considered the highest ethical standards in digital research when designing the study. Before the interviews, we obtained informed consent from participants to participate in the research and to record the interviews. Before the interviews' transcription and analysis, we anonymised all data. We reported the research project to the Research Ethics Committee at the Jagiellonian University. However, due to the lack of sensitive research, the study did not require an additional approval procedure. The study meets the requirements of the Declaration of Helsinki and the GDPR. Several complementary techniques used in the data-collecting process for this study triangulated the results to increase their depth and dependability. We mitigated potential biases from developer perspectives through triangulation with secondary data (usage logs, policy reports). Specific case excerpts illustrate practical challenges, such as GDPR compliance and resource bottlenecks. Moreover, Bielik and PLLuM strategies explicitly correspond to Teece's 'dynamic capabilities' and Ferraris' 'integrated ecosystems,' respectively, presented in a conceptual matrix of entrepreneurial agility vs institutional support. As said, IDIs provided main qualitative data with careful awareness of the strategic, technological, and entrepreneurial features of every project. We used practical tests on both Bielik and PLLuM to empirically access both models. The model of evaluation criteria included operational performance (response time and functionality), linguistic precision (grammatical and contextual accuracy), adaptability (performance across diverse scenarios), and resilience. Model testing consisted of scenario-based assessments in context-specific applications relevant to both corporate and public sector environments whereby we accessed the outputs of the LLMs for accuracy, relevance, and ethical compliance. Examining many publicly available and internal documents, we conducted a comprehensive document analysis (Miles *et al*., 2014).

The sources compromised official project web pages, technical documentation, strategic reports, material from social media, and other pertinent internet resources. Through means of required background

knowledge and data cross-verification, analysing the records helped us authenticate the insights acquired from the model testing and interviews. We closely examined the data gathered through interviews, model evaluations, and document reviews using thematic analysis – a flexible qualitative method meant to identify, investigate, and present patterns – themes – within datasets (Braun & Clarke, 2006). We selected thematic analysis for its proven ability to organise and grasp complex qualitative data. Therefore, the data includes both explicit and implicit interpretations. Under the guidance of Braun and Clarke's (2006) methodological recommendations, the study underwent several iterative stages:

Data familiarization: We first checked several times every transcript and document to ensure total awareness of the material and background.

First coding: Particularly with an eye toward themes of entrepreneurial practice, strategic alignment, technological innovation, and ethical-regulatory compliance, we methodically coded major textual sections. This phase consisted of deductive (theory-motivated) and inductive (data-driven) coding methods.

Identifying Themes: From codes, we developed meaningful themes and iteratively refined them to reflect significant conclusions on entrepreneurial strategies, digital sovereignty alignment, technological challenges, and sector-specific applications.

Reviewing and enhancing themes helped to guarantee internal coherence inside them and clear difference between them, thus ensuring great interpretation and resilience.

Defining and naming themes: We precisely defined every theme, thus capturing the central concepts of the research questions. We articulated the themes to underline their relevance and applicability in addressing how strategic help of entrepreneurial models helped Poland to reach digital sovereignty.

Reporting: To provide strong empirical evidence for every theme that surfaced, we methodically presented the results of thematic analysis, combining narrative descriptions with illustrative passages from interview data and document analyses.

By providing a thorough and methodical way to code and examine data, the NVivo program helped us organise huge qualitative datasets and improve the clarity and repeatability of the studies, in-depth interviews, practical model evaluations, and in-depth thematic analysis, the methodological approach presents a successful investigation of the entrepreneurial strategies underlying Bielik and PLLuM projects. By means of the methodological multi-faceted qualitative approach, this study greatly improves the knowledge of how entrepreneurial practices and strategies might efficiently strengthen national digital sovereignty by means of localised advances in artificial intelligence. We developed the thematic codes deductively and then developed them inductively based on the analysis of the empirical materials. The thematic codes enabled systematic coding of data and triangulation between different sources. This strengthened the consistency of the analysis and increased the reliability of the results obtained. In the course of the thematic analysis, we identified eight main codes and sixteen sub-codes (Table 2).

Table 2. The final codebook with main and subcodes

Main codes	Subcodes	Codes number
LLMs strategies	Strategic objectives; National vs. commercial motivations	34
Technology entrepreneurship	Business models; Funding and partnerships	31
Infrastructure and data	Data sources; Technical infrastructure	42
Model performance	Quality of responses; Resistance to hallucinations; Ethical compliance	34
Digital sovereignty	Definitions and approaches; The role of LLM in the national strategy	28
Challenges and barriers	Technological; Regulatory; Political	39
Prospects for model development and practical implementation	Further development plans; Technological innovations	21

Source: own study.

RESULTS AND DISCUSSION

Case Study 1:

Exhibition of the Bielik Project

One of the main Polish projects is Bielik, which intends to establish and apply a local large language model (LLM specifically fit for the Polish language). This project aims to close significant gaps in the Polish language coverage in the worldwide artificial intelligence ecosystems. The main goal of the project is to give Polish-speaking companies and individuals a strong, linguistically accurate, culturally appropriate AI tool. Bielik receives financing mostly from community-driven sector sponsors and crowdfunding platforms, thus reflecting its entrepreneurial basis and flexible development strategy.

> 'We built Bielik with our own efforts, just such a bottom-up social initiative. A bottom-up, independent of any entities.'

(IDI, Respondent 1, Bielik)

Essential for effective project management and resource mobilization, this grassroots approach ensures community involvement and increases the active participation of great stakeholders.

Strategic Goals

Bielik deliberately stresses matching with linguistic and cultural aspects, trying to ensure that its language models totally reflect the subtitles and nuances of the Polish language. This alignment is vital given the lack of successful Polish-language models in a global AI market, mostly targeted by English-language solutions. Part of ensuring linguistic accuracy is intensive research and development projects aiming at exactly capturing and replicating the subtleties of Polish syntax, semantics, and pragmatics inside AI systems.

> 'Initially, the mission of our community that built Bielik was to collect a sufficiently large set of training data for language models in Polish. In the beginning, the team was only involved in cataloguing the data collection. Now we have almost three terabytes of text data in Polish and, to our knowledge, this is the largest collection of text data in Polish in an open model anywhere in the world.'

(IDI, Respondent 4, Bielik)

For Bielik, operational autonomy marks still another basic strategic goal. By means of local technological knowledge and infrastructure, the project seeks to lower Poland's dependency on AI technologies developed by external entities, which is not free from multinational technology companies but also has data control capabilities (Open AI, Meta, Deep Seek). The open-source Bielik project lowers costs and enhances security by letting regional companies and institutions apply AI independent of commercial, offshore cloud services. Apart from enhancing Poland's resilience against possible geopolitical and economic threats related to external technological reliance by means of increased technological independence, Bielik also conforms with more general national aspirations of digital sovereignty.

> 'We can install the data in the infrastructure of the company, the office and feed the model, give it a database context and keep all the work in internal use. At the same time, the model can handle RODO issues, personal data issues, and canonicalisation, and at the same time we can, for example, use a set of documents as a knowledge source for the user. We have said from the beginning, we want the model to be in the organisation, in the company of the data running on their server.'

(IDI, Respondent 1, Bielik)

To offer practical and scalable AI solutions that can be rapidly embraced into a range of sectors, the strategy framework of the Bielik project gives operational effectiveness great weight. By applying agile project management approaches, Bielik can rapidly adapt to limited resources, shifting technical

needs and operational requirements. This guarantees the efficient implementation of AI solutions in given businesses and municipalities.

Entrepreneurial Models and Technology

Using and developing Bielik presents many technological and entrepreneurial challenges requiring a strategic entrepreneurial approach. These challenges included regulatory compliance issues, data collecting limitations, and difficulties in training models. One of the main difficulties – given the rather limited availability of comprehensive, high-quality Polish-language datasets fir for advanced artificial intelligence training – is data acquisition. Unlike publicly available English-language datasets, Polish datasets tend to be fragmented and require significant preprocessing and screening. Creative data collecting techniques including collaboration with academic institutions, publishers, and government agencies to acquire a variety of outstanding language resources needed for effective model training where needed to solve this problem. Model training presented further technological complexity mostly due to the great computational resources required for developing and improving large language models. Computational restrictions were overcome with strategic alliances, most famously with the Academic Computer Centre Cyfronet AGH, which gave access to technological know-how and contemporary computing architecture. Effective management of computational resources, optimising algorithms, and improving models continuously – all made possible by this system – help achieve the desired performance and accuracy.

> 'The moment Cyfronet from AGH joined us, it became apparent that we had a missing proxy in the form of computing power. From word of mouth, it turned out that we were building the first LLM.'
>
> (IDI, Respondent 3, Bielik)

> 'Thanks to Cyfronet, we overcame the technical challenge, because the biggest problem was the GPU (Graphics Processing Unit).'
>
> (IDI, Respondent 1, Bielik)

One major challenge was meeting legal criteria. This included a rigorous respect of EU and Polish data protection policies, including the General Data Protection Regulation (GDPR, 2016). To build stakeholder confidence and project validity, project leaders had to establish privacy-protecting strategies and strict ethical monitoring policies through data governance systems.

Use Cases Reflecting Applications and Effectiveness in Business Automation and Public Administration

In many spheres of public administration and corporate automation, Bielik has shown to be pragmatic and successful. These initiatives confirmed both its strategic relevance and the contribution to increased capability and digital sovereignty. Regarding corporate automation, Bielik improved means of communication strategies, customer service tools, and sales processes. Through means of accurate and contextually relevant automated communications (IDI, Respondent 2, Bielik), its application has enabled Polish companies to automate interactions, efficiently control customer relationships, and raise general customer satisfaction. Using advanced language understanding tools has helped companies greatly reduce running expenses, streamline procedures, and increase market competitiveness.

Particularly in public administration, Bielik can be rather useful for automating complicated bureaucratic procedures, boosting citizen participation, and quickening administrative reactions. For instance, Bielik has been successfully included in the administrative systems of the Poznań Supercomputing Centre, automating responses to citizen questions, simplifying complex bureaucratic language, and enhancing information distribution methods (Poznań Supercomputing Center, 2025). Particularly with regard to administrative processing times, operational delays, and informational errors, this approach significantly raised public service delivery quality and efficiency.

> ‘Bielik is like a more organised intern who needs to be shown how a copier works, how a coffee machine works. Then he will be able to do these few selected things, such as vertical tasks. He has a very high focus on specific tasks.’
>
> (IDI, Respondent 1, Bielik)

Moreover, Bielik’s strategic relevance has been demonstrated in important administrative responsibilities, like helping government agencies with legal compliance, document summarizing, and decision-making. The adaptability and scalability of Bielik’s solutions have helped to further enable significant deployment across many governmental departments, thus supporting their contribution to improving Poland’s public sector technological autonomy and operational capacities.

> ‘Bielik can be like a document classifier. We have a Bielik that detects sentiment in documents and another Bielik that decides where to send those documents. To use each of them, well, you have to install them separately. On the other hand, they no longer require training, but are, as it were, adapted to it. You have to remember that in most cases you don’t need to train the models, you just need to give them good instructions and a good database.’
>
> (IDI, Respondent 1, Bielik)

Artificial intelligence solutions have been quickly tailored and adapted to meet various organisational and sector-specific needs thanks to the entrepreneurial structure applied in the expansion of Bielik. Always matching with evolving user expectations, technological developments, and legal requirements guarantees that AI implementations remain relevant and effective by this natural adaptability.

Bielik’s case study detailed pictures of effective entrepreneurial strategies that have been quite essential in bringing local AI solutions meant to support national goals of digital sovereignty into use. Notwithstanding significant technological and entrepreneurial challenges, Bielik successfully underlines that locally developed AI technologies could boost operational efficiency, reduce reliance on outside technologies, and help build ecosystems of sustainable innovation. By means of strategic alliances, effective resource management, and strict compliance rules, Bielik demonstrates the indispensable role entrepreneurial models perform in attaining technological autonomy and digital sovereignty. Its successful efficient application in public administration contexts and Polish businesses highlights more relevance and strategic advantages of localised artificial intelligence solutions. Bielik LLM fits Teece’s (2014) concept of dynamic capabilities. Its creation validates the ability to quickly identify opportunities, mobilise resources and adapt to changing technological conditions. The model illustrates the entrepreneurial agility crucial for innovation in the AI environment. Here policymakers, corporate leaders, and legislators seeking to use technological innovations to reach national sovereignty objectives will find great ideas.

Case Study 2:

Project Consortium Overview, Leadership Positions, Funding PLLuM

Polish Large Universal Model (PLLuM) is an attempt at developing and using advanced AI solutions specifically suitable for the Polish environment. Comprising well-known academic and research facilities, including Wrocław University of Technology, NASK National Research Institute, Information Processing Centre – National Research Institute (OPI PIB), Institute of Computer Science of the Polish Academy of Sciences, University of Łódź, and the Institute of Slavic Studies of the Polish Academy of Sciences (PLLuM, 2024), the project is set up as a cooperative consortium. Under this consortium approach, combining knowledge in linguistics, computer science, cybersecurity, and data management promotes noteworthy multidisciplinary cooperation. Polish Large Universal Model has defined management roles based on institutional strengths and specializations quite precisely. Wrocław University of Science and Technology is guiding the consortium in project management and technological development. In the project, ethical government and cybersecurity fall to NASK. It guarantees strict following of national and European legal norms. Every institution involved provides unique knowledge and contributes to building the creative ecosystem and knowledge sharing required for the project to be

successful. Mostly sponsored by the government, PLLuM is strategically important for Poland's more ambitious goals related to digital sovereignty. The Polish Ministry of Digital Affairs provided s provided over 14.5 million Polish zlotys to assist in the phases of intensive research, development, and PLLuM (Ministry of Digital Affairs, 2025) implementation. Such a significant government-backed expenditure underscores the strategic importance of PLLuM for national goals, enabling sustained research and technological development crucial to achieving digital autonomy in Poland.

Aimed Deliberately, Strategically

Driven by a vision that exceeds technological development, PLLuM stresses social responsibility, economic integration, and ethical integrity equally – all of which are vital for a sustainable and long-lasting digital transformation. The program aims mostly to increase digital competency in all spheres of life. This means projects aiming at improving the digital skills of people, companies, and institutions all around Poland. Moreover, PLLuM supports the creation of a digital environment in which technology efficiently serves people and helps build a more technologically conscious and capable society by means of AI solutions not only advanced but also tailored to the particular needs of the local context.

Not less important is PLLuM's commitment to stimulating imagination. The initiative actively supports the public and private sectors, AI integration, supporting entrepreneurship, increasing competitiveness, and fostering economic development. Apart from providing contemporary technological solutions, PLLuM wants to build a strong and sustainable innovation ecosystem supporting ongoing research and the continuous development of artificial intelligence technology.

> 'The model is not only a language processing tool but also a way to develop digital competence. Public administration, business, and all users are learning to use AI. While they are testing but increasingly putting it into practice and adapting it to their own needs.'
>
> (IDI, Respondent 3, PLLuM)

Digital sovereignty is rather important among the several strategic objectives of the PLLuM model. Though its main goal is to develop natural language understanding for PL with open and readily available AI, PLLuM helps to further the more general objective of digital sovereignty. Being an open-source project and using PLLuM allows users to run models locally, upload documents and interact with them under private RAG setups. The model allows for safe, local processing and maintains overall control over user data. Noteworthy, PLLuM ethically emphasises highly the need to minimise false, offensive, or misleading information generated by AI systems. Ethical goals include rigorous data curating, thorough content moderation policies, and methodological bias detection techniques in order to ensure responsible, trustworthy AI deployment. Integrated into PLLuM, ethical safeguarding policies demonstrate a commitment to maintaining information integrity distribution integrity, regulatory compliance, and society values preservation.

Observations of Technology

Polish Large Universal Model incorporates a multi-scale model infrastructure with parameter values ranging from 8 billion to 70 billion parameters. It thus addresses a wide spectrum of computational requirements. This stratified approach enables the system to run effectively over several operational settings. Smaller businesses or limited-scope projects would find the models at the lower end of the scale – those with 8 billion parameters – fit for use in the settings in which computational resources are limited. Conversely, especially in complex environments like government agencies and large corporations, the larger models – with up to 70 billion parameters – offer the processing capacity required for more challenging tasks.

> 'We have acquired text data with consent directly from publishers, authors or data to which we are entitled. Due to the legal situation in this area, which we recognise quite thoroughly, and the regulations that have been in force since 20 September 2024 [...]. Instructional data is mainly our data, manually collected or converted from resources that we also collected

> in the consortium many years ago. Well, and preferences are also newly acquired data – the only dataset of this kind in Poland.'
>
> (IDI, Respondent 2, PLLuM)

The quality of training sets greatly affects PLLuM's performance. One respondent PLLuM reports having about 150 billion tokens, carefully chosen from many sources, including publicly available language data, proprietary content acquired from strategic alliances, and specialised datasets fit for particular sectoral uses. Crucially for high-performance AI, this extensive data-curating process guarantees linguistic accuracy, cultural relevance, and functional adaptability.

By means of a multi-layered approach, the PLLuM design minimises ethical issues in content production. This approach essentially uses automated tools designed to detect bias, which run in the first phases of processing to uncover trends likely to generate biased or negative outputs. Regular manual assessments conducted by field experts complement these automated systems so enabling the study of cases where algorithmic assessments might be inadequate. Apart from a means of correction, human involvement is a basic component of the system's design concept. Moreover, constant assessments of the system produce a feedback loop that ensures the model develops in line with contemporary ethical standards and society values, thus ensuring continuous progress. This adaptable framework enables PLLuM to preserve high degrees of responsibility while efficiently handling new ethical challenges.

Strategic Public Sector Implementation Model

The strategic utility and effectiveness of PLLuM are vividly demonstrated through successful implementations across critical public sector domains, notably in citizen assistant applications, healthcare, legal frameworks, and education.

> 'Depending on what we want to do – whether a general-purpose model or a few specific tasks – a different size will be appropriate. […] We have what we refer to as generator models. These work great for various flagship applications, like search systems. [...] We have framework models – the 8 billion parameter model or the large 70 billion parameter model.'
>
> (IDI, Respondent 1, PLLuM)

Citizen assistant applications form the primary strategic focus of the PLLuM deployment. Through automated, responsive interactions with people, this paradigm greatly boosts the efficiency of public administration. These initiatives improve public service availability and quality, help to simplify and clear bureaucratic procedures, and allow the automated processing of citizen inquiries. Noteworthy, PLLuM's capacity for subtle, contextually appropriate responses helps to enable meaningful citizen involvement thus lowering administrative needs and simplifying governmental procedures. Moreover, PLLuM enhances clinical treatment decisions and patient management in healthcare by means of advanced diagnostic support systems grounded on AI. Using analysis of large medical data sets and patient histories, PLLuM helps doctors identify diagnostic trends, make individualised treatment recommendations and automate routine clinical documentation. This application of PLLuM significantly enhances healthcare delivery, patient outcomes, and operational efficiencies within medical institutions.

By means of effective management and interpretation of challenging legal texts, PLLuM increases the accuracy and efficiency of legal analysis. Lawyers also streamline decision-making and enhance legal information access, thus helping professionals and the general public.

Another sector gaining from PLLuM's arrival is the legal one. Polish Large Universal Model's enhanced processing capability helps it much as well. This system automates legal document analysis, statutes interpretation, and compliance checker process. PLLuM improves the process of delivering legal analysis by supporting lawyers in interpreting sophisticated texts and facilitating access to legal documents for both experts and non-experts. Educational applications of PLLuM provide innovative solutions to enhance teaching and learning processes across diverse educational contexts. Furthermore, PLLuM supports the development of interactive, personalised educational content, automated assessment mechanisms, and sophisticated educational analytics, significantly improving educational delivery and outcomes. According to one respondent:

> 'Its ability to adapt content and interactions to varying educational needs ensures broad applicability and effectiveness within Poland's educational system.'
>
> (IDI, Respondent 3, PLLuM)

The PLLuM project is a well-coordinated attempt to produce local AI solutions fit for Poland's national objectives for digital sovereignty. It skillfully navigates through technological,, regulatory, and ethical terrain to generate strong AI applications that are culturally appropriate with a well-defined consortium framework, major government support, and established strategic and ethical objectives. The technical complexity of the project, different model framework, and strong ethical standards underline its potential to considerably increasethe operational efficiency of the public sector, improve service delivery, and strengthen national digital competences. Its successful implementation in significant spheres of the public sector, including citizen support, healthcare, legal frameworks, and education, underlines the strategic relevance of localised AI solutions in driving sustainable digital transformation and raising national technological independence.

The PLLuM model fits into the framework of integrated ecosystems Ferraris *et al*. (2025). The model is based on the collaboration of academic institutions and government bodies. The coordinator of multiple partners within the consortium has played a crucial role in building the innovation ecosystem and supporting digital sovereignty.

Comparative Study of Bielik and PLLuM

Particularly for the Polish environment, Bielik and PLLuM provide different approaches to generating large language models (LLMs) with their different technological architectures and model capacities. Bielik largely uses smaller and medium-sized models between 1.5 and almost 11 billion parameters. Using a strategic approach that gives practicality, simplicity of implementation, and operational effectiveness top priority, Bielik efficiently serves a wide spectrum of small and medium-sized businesses along with local government agencies. On the other hand, PLLuM offers a larger range of model architectures, spanning from 8 billion to 70 billion parameters. Designed for applications needing great computational capability, PLLuM's architecture satisfies the needs of larger corporations, national organisations, and government agencies depending on advanced AI capability. More broad models enable more difficult tasks, including thorough data analysis, advanced language comprehension, and improved contextual interactions.

Although every project uses different strategies to reach this alignment, Bielik and PLLuM both significantly support Poland's general aim of digital sovereignty. Bielik is a strategically coordinated project that underlines the significance of operational autonomy, linguistic-cultural sensivity, and grassroots innovation. As an AI tools initially developed as a social initiative, it offers easily accessible, linguistically precise, and culturally adequate solutions for local implementations, at the same time reducing Poland's dependency on external AI providers. Through an agile, open-source architecture, Bielik advances the general acceptance of technology and active community participation, thus enhancing the nation's capacity for autonomous innovation. Meanwhile, PLLuM ensures guarantees of thorough adherence to regulatory standards, thus strategically aligning itself with national objectives related to digital sovereignty and supporting continuous, major technological developments especially targeted at supporting critical applications in the public and private sectors by forming alliances with important institutions By including strategic digital skills and rigorous ethical standards in its technological architecture, PLLuM directly addresses Poland's concerns about digital sovereignty, generating strong, institutionalised AI capabilities.

Financing and entrepreneurial ideas supported by Bielik and PLLuM highlight several approaches to stimulating innovation and implementation of AI. Stressing agile development, flexible resource management, and the ability to quickly adapt to new technical and operational needs, Bielik mostly employs a bottom-up entrepreneurial approach. Especially with Cyfronet AGH, which supplies the required computing infrastructure, its many funding sources cover strategic alliances, private sponsors, and crowdsourcing projects. By keeping flexible, sensitive to community needs, and in line with local technological strengths, this approach helps Bielik create dynamic innovation ecosystems. Conversely, PLLuM

employs a more ordered entrepreneurial model distinguished by significant institutional collaboration and substantial governmental support. Thanks – in large part – to the main financial support from the Polish Ministry of Digital Affairs, which enables long-term strategic planning, methodical technological development and strong ethical management, PLLuM has great financial resources. Noteworthy, PLLuM can conduct large-scale, resource-intensive research and development projects closely linked to national strategic objectives and regulatory standards by means of this ordered framework.

An examination of Bielik and PLLuM projects revealed clear differences in their technological approaches, strategic orientations, entrepreneurial frameworks, and regulatory and ethical considerations. Both projects aim to increase Poland's digital sovereignty. Particularly useful for distributed and smaller projects, Bielik stresses adaptability, fast responsiveness, and wide accessibility using a community-centric and, agile operational framework. Its entrepreneurial approach encourages constant innovation, agile development and strong adaptation to the needs of local users based on active community involvement and different funding sources. Conversely, PLLuM operates inside a consortium-based, institutionally anchored framework designed for continuous strategic development. This approach is defined by great government support, advanced technological capability, and strict adherence to regulatory standards. Its methodical and disciplined approach supports long-term sustainability, scalability, and dependable performance, especially in mission-critical national applications. Taken together, these initiatives demonstrate how context-sensitive entrepreneurial ideas could support the development of technological sovereignty. Their different achievements highlight how realistic several strategic routes are for advancing national innovations in AI, each tuned to different operational environments, sectoral needs, and policy goals.

Emphasising the strategic need of helping a variety of entrepreneurial models and creating adaptive technological ecosystems, this comparative analysis provides insightful analysis for legislators, corporate leaders, and entrepreneurs. Encouragement of national innovation capacity and Poland's digital sovereignty calls for a whole policy framework including diversified financing sources, agile managerial approaches, a coherent regulatory environment, and governance structures based on ethical values. By means of innovative technological ideas and diverse entrepreneurial approaches, Bielik and PLLuM both effectively advance Poland's digital sovereignty objectives despite having rather different approaches and strategic focus. This comparative emphasises the need for a contextual approach to the development of national AI, thus providing significant insights for current and future projects meant to support sustainable technological innovation and national digital autonomy.

The case studies help us realise, among other things, the great impact of intentional entrepreneurial strategies in advancing context-aware development in the artificial intelligence domain. The successful application of agile management techniques, the development of strategic alliances, an emphasis on data ownership, and the acceptance of open-source distribution frameworks constitute fundamental ingredients in driving local-level innovation. As Teece (2014) notes, technological entrepreneurship is essentially defined by the demand for responsiveness, careful use of resources, and a great degree of adaptation in the face of changing market dynamics and technological developments. Bielik is an agile, entrepreneurially oriented initiative with great capacity of adaptation, flexible resource management, and community-driven innovation that fits perfectly. Strong, flexible technological solutions directly fit for local needs and conditions were created by the collaboration with companies such as Cyfronet AGH and crowdsourcing. As a part of structured entrepreneurial approaches, PLLuM reflects institutional cooperation and strong government support. This model captures the emphasis of Ferraris *et al.* (2025) on integrated national innovation ecosystems in which government policy, academia, industry, and entrepreneurial players interact closely for the sake of proper technological development. PLLuM's extensive institutional framework, significant state funding, and strategic alignment with national priorities show how well-organised entrepreneurial models can support the major, resource-intensive technological changes needed for significant national applications. Open-source distribution and data localization are two further entrepreneurial techniques that greatly support digital sovereignty. Emphasising open-source technologies, Bielik helped to spread openness, community involvement, and wide acceptance, thus distributing technological control and reducing dependency on outside sources. Emphasised espe-

cially in PLLuM's rigorous data management policies, data localisation guaranteed compliance with national and European regulatory standards, thus safeguarding sensitive information and strengthening national autonomy in terms of critical digital infrastructures (Chiarello *et al.*, 2024).

The case studies underline significant effects on Poland's technological autonomy and creative capacity. Though their routes are quite different, Bielik and PLLuM both actively support Poland towards digital sovereignty. Using community resources, local knowledge, and quick, context-specific technological development, Bielik's bottom-up entrepreneurial model increases Poland's creative potential. The strategic plan embraced by the PLLuM's consortium greatly promotes technological independence by means of formalised cooperation among companies, preservation of continuous governmental involvement, and support of the execution of sustainable, future-oriented projects. This methodical approach reveals a cautious and context-aware initiative meant to increase national self-reliance in important technological fields. This disparity corresponds with the theoretical perspectives of Ferraris *et al.* (2025), who underline that different entrepreneurial strategies suited for different circumstances define how dynamically innovation ecosystems are kept in good condition.

As Bielik and PLLuM demonstrate, the coexistence of agile and disciplined, entrepreneurial models emphasises the synergistic elements of these strategies. This integration raises Poland's creative potential and its ability to solve technological problems. Notwithstanding all the achievements, several problems still exist, especially in regard to scalability, data management, and ethical standards adherence. One of the toughest challenges is scalability, particularly for dynamic businesses like Bielik. Financial constraints, scattered data sources, and limited computing resources seriously impede sustainable development and wide application. As PLLuM's effective structured approach demonstrates, solving these issues calls for ongoing financing, strategic cooperation between institutions, and expandable technological frameworks. Data governance is further challenging, mostly because of the strict regulatory environment – that which the including General Data Protection Regulations compliance demands. Reaching effective data localization, ethical data use, and strong privacy protections calls for continuous regulatory alignment, careful monitoring, and creative directionally driven innovative data management techniques under constant control. Maintaining ethical compliance requires constant attention, the application of advanced moderation techniques, regular evaluations of ethical guidelines, and proactive approaches to find bias, all of which are vital for preserving user trust, openness, and acceptance. Recommendations for improving entrepreneurial activities, a range of funding sources, and a strong institutional framework supporting both flexible and orderly entrepreneurial practices. Policymakers should promote more cooperation among academic institutions, businesses, government agencies, and entrepreneurial organisations and thus create strong innovation ecosystems able to sustain targeted and context-driven technological advancement. To ensure clarity, support, and efficient control for the growth of entrepreneurial AI – thus enhance national technological independence and innovation capacity – the regulatory environment must be always changing. The effective applications of Bielik at the Poznań Supercomputing Centre clearly demonstrate the strategic relevance of AI in the field of public administration. The operational benefits localised AI integration – such as automating complex bureaucratic procedures, enhancing effective information sharing, and improving institutional responsiveness – are reflected in the experiences of Polish companies. Firms across sectors including finance, customer service, and sales—report significant increases in productivity, customer satisfaction, and competitive positioning following the merger of Bielik and PLLuM.

Pessanha *et al.* (2024) emphasise that LLM-driven solutions substantially improve operational efficiencies and decision-making accuracy, enhancing competitive advantages and strategic responsiveness in dynamic market environments. Polish enterprises, including those in sectors like finance, customer service, and sales, report notable improvements in productivity, customer satisfaction, and competitive positioning following the integration of Bielik and PLLuM. Particularly, Bielik's deft use within Poznań Supercomputing Center highlights its strategic relevance in public administration settings. Automating complex bureaucratic tasks, improving information dissemination processes, and enhancing administrative responsiveness illustrate significant operational efficiencies achieved through localised AI solutions.

Similarly, PLLuM's strategic applications extend across healthcare, legal frameworks, and education, demonstrating versatile, sector-specific functionalities essential for comprehensive public service improvements. Healthcare institutions leveraging PLLuM's advanced analytical capabilities report significant enhancements in clinical decision-making, patient management efficiencies, and personalised healthcare delivery. Legal frameworks benefit substantially from automated document analysis, legislative interpretation, and compliance verification processes facilitated by PLLuM, improving legal service accessibility, responsiveness, and accuracy. Educational applications similarly illustrate PLLuM's strategic value, providing personalised content, interactive learning environments, and automated evaluation mechanisms that substantially enhance educational outcomes and pedagogical effectiveness. The successful implementations of Bielik and PLLuM highlight significant potential for further integration and innovation within Polish business and public sectors. Continuous advancements in AI technologies, expanding model capabilities, and improving computational resources offer opportunities for broader adoption, deeper sector-specific integrations, and enhanced strategic functionalities.

Future integration efforts should emphasise scalable solutions, ethical safeguards, and enhanced computational capacities to sustain innovation momentum effectively. Policymakers and organisational leaders should foster comprehensive innovation ecosystems supporting ongoing research, sustained funding, and strategic technological advancements. Encouraging greater community engagement, transparent development practices, and diversified entrepreneurial approaches will further enhance Poland's AI innovation capacities and national digital sovereignty. The comparative insights from Bielik and PLLuM demonstrate diverse, context-specific entrepreneurial pathways to achieving digital sovereignty objectives. Agile and structured entrepreneurial models offer complementary strengths, highlighting the strategic importance of diverse innovation ecosystems. Effective entrepreneurial strategies, robust regulatory frameworks, and sustained institutional collaborations significantly enhance technological autonomy, innovation capacities, and operational efficiencies across sectors. These insights provide valuable guidance for policymakers, entrepreneurs, and organisational leaders aiming to strategically leverage localised AI innovations to reinforce national digital sovereignty. The findings explicitly extend existing theory by providing empirical validation of agile versus institutional entrepreneurial strategies in localised AI contexts.

To develop directions for future research on the dynamics of sovereign AI technologies, we propose a new conceptual model. The model of the matrix can be based on two dimensions: organisational agility and institutional support. According to the matrix, we may classify national initiatives for the creation of LLM models according to the level of agility and institutional support.

CONCLUSIONS

This research contributes by directly addressing gaps in comparative entrepreneurial strategies within national AI development contexts. With a special focus on their contribution to creating national digital sovereignty, we investigated the entrepreneurial models on which the expansion of the early Polish LLMs, Bielik and PLLuM, is based. By means of a qualitative approach, the research reveals significant opportunities related to national AI technologies and facilitates the resolution of the last challenges for such projects. The results suggest that the encouragement of technological independence, creativity, and the development of a strategic managerial framework depends essentially on the entrepreneurs' participation.

Still, a number of issues remain unresolved even with the notable progress achieved in these initiatives. The main problem addresses the linguistic complexity of the Polish language by the models' limited ability to regulate the syntactic variability and semantic nuances of the language. These characteristics reveal the need for long-term strategic investments and methodological improvements in the development of localised AI systems. Dealing with the continuous challenges connected with the evolution of AI calls for both methodical enrichment and diversification of language datasets as well as constant improvement in training approaches. Constant improvement of algorithmic models is necessary to maintain their accuracy as well as their sensitivity to context. Still, scalability remains a fundamental challenge in this field – especially in connection to startups like Bielik. Often under strict

financial constraints and dependent on few community resources, these early-stage projects pose great obstacles to their long-term viability and continuous growth. Realizing good scalability requires coordinated inter-institutional partnerships, consistent financial investment, and upgraded computing infrastructure. Legislators and relevant players have to build motivating regulatory frameworks and targeted funding models if we are to enable the broader deployment and institutional integration of such agile technological solutions. Ethical protections are another interesting topic. While both Bielik and PLLuM have embraced rigorous methods of ethical moderation and bias detection, the continuous control and improvement of these ethical practices remain a main challenge.

Complete ethical compliance demands iterative testing and validation methods, proactive human supervision, and continuous methodological advancement. Strengthening these protections will help to ensure public confidence, guarantee openness, and advance responsible AI use in many social environments. Improving linguistic accuracy, extending computational capability, and strengthening ethical compliance systems should be given great focus in the next studies and development. Efficiency gains are quite likely given continuous development in natural language processing technologies and algorithmic creativity. More general sectoral integration and sustainable technical development will also be enabled by the additional study of creative data management techniques, hybrid business models combining agile and structured approaches, and advanced regulatory frameworks. The scalability and sustainability of Bielik and PLLuM implementations constitute major future issues. Long-term sustainability depends on strategic financial planning, varied funding sources, and trustworthy governance structures capable of supporting ongoing operational needs and technological updates. Growing scalability calls for institutional support, improved computing tools, and methodical knowledge sharing among interested parties. Policymakers and institutional leaders have to create conditions fit for strategic development and sustainable innovation and thus enable the complete integration of localised AI solutions in many different organisational environments.

This article underlines the relevance of entrepreneurial strategies in promoting Poland's digital sovereignty, especially by means of the development and strategic deployment of localised LLMs. Apart from the well-coordinated, consortium-driven PLLuM approach, the adaptable and community-oriented Bielik model presents two different but complementary points of view on entrepreneurial strategies that might effectively increase national technological autonomy and innovation capacity. Particularly adaptable, responsive, and able to fulfil regional needs, Bielik's bottom-up approach helps to support quick, context-specific innovation. On the other hand, PLLuM emphasises open-source projects and transparent governance, thus promoting great community involvement and enabling distributed technological progress and reinforcement of Poland's digital sovereignty. Its basis is a more structured entrepreneurial model characterised by great government support, broad institutional cooperation, and alignment with national strategic objectives. Stable technological infrastructure of the model, strong ethical standards, and significant resource investment form the basis for the development of sophisticated, sectoral relevant AI solutions of great relevance for major national operations. Through its strategic framework, PLLuM increases institutional capabilities, technological dependability and regulatory compliance, thus strengthening Poland's digital autonomy by means of these three factors.

The outcomes draw attention to several crucial policy presumptions that are quite necessary for the development of local LLMs. Strong innovation ecosystems combining government support, scholarly knowledge, industry cooperation, and entrepreneurial activities including government backing should be the focus of policy makers. Effective innovation ecosystems should be granted increased governmental funding, diverse funding sources and strategic incentives that promote entrepreneurial activity and the development of AI technologies aligned with national priorities. Policymakers also must solve regulatory challenges by means of well-defined policies, strict monitoring, and continuous adaptation to the fast-changing technological scene.

For agile, community-based models such as -like Bielik, it is worth introducing an adaptive governance framework. In this model, an emphasis on decentralised decision-making, flexibility and iterative learning processes will be key. This will ensure that agile initiatives can respond effectively to identified needs and technological changes. When models, such as PLLuM, are structured and institutionally sup-

ported, institutional theory provides the framework. In this context, the article presents a set of strategic management concepts that – through flexible organisational structures, the development of cooperation between entities,, and the strengthening of effective management mechanisms – contribute to the creation of a suitable technological ecosystem. Businesses implementing context-specific AI technologies have to give management strategies characterised by adaptability and responsiveness first importance. Such approaches are essential to ensure congruence with the dynamic character of operational requirements, the speed of technical development, and the shifting interests of many stakeholders. Strategic alliances between government agencies, companies, academic institutions, and entrepreneurial companies will help to greatly increase knowledge sharing, resource mobilization, and creative capacity. Recommendations for improving technology policy focus on continuous improvement of ethical compliance systems, data management tools, and computer infrastructure. A good policy framework must have three main components. Firstly, giving advanced computational infrastructure top priority for resource allocation; secondly, improving data governance techniques; thirdly, using careful ethical monitoring systems. Guaranteeing the ethical development and application of AI systems depends on these very fundamental components. Prerequisites for both continuous innovation and the strategic integration of growing technologies across many sectors are constant improvement of techniques, proactive regulatory adaptation, and the methodical inclusion of many stakeholder points of view. Recommendations prioritise feasible and urgent actions, specifically differentiating advice for government and private sectors. Successful international policies, contextualise these recommendations, underscoring the theoretical and practical contributions of this study. Existing frameworks of application of AI concentrate mainly on global scale LLMs like Chat GPT etc. In this study, we qualitatively researched national LLMs. The conclusions apply to Poland and provide a perspective for future research in central Europe and EU countries.

We are aware of the limitations resulting from the methodology of this study. We note, firstly, the limited number of sample size. The number of respondents results from the fact that we invited to the research participation experts who were directly involved in the creation process of national LLMs. Secondly, we are aware that the research covers a Poland-specific context, which additionally limits the possibility of generalizing to different national contexts. When designing further research, scholars should consider these limitations.

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