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REVIEW

Agriculture in the digital age: organizational challenges for the adoption of AI and Big Data

La agricultura en la era digital: desafíos organizacionales para la adopción de IA y Big Data

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ABSTRACT

Introduction: the article analysed how artificial intelligence (AI) and Big Data became key tools for generating competitive advantage by transforming complex data into useful information for decision-making. It highlighted that, beyond access to technology, organisations needed to adapt their structure and strategy to truly harness its potential. The research focused on the agricultural industry in Extremadura, a region with low GDP per capita and an ageing population that has traditionally been resistant to change.
Development: the Fourth Industrial Revolution, characterised by the rapid expansion of disruptive technologies, profoundly changed the way companies operated. In the agricultural sector, AI and Big Data made it possible to monitor crops, automate machinery and optimise resources. However, their adoption required more than just technological tools: it involved an organisational transformation that included professional training, investment in digital infrastructure and a culture of innovation. In Extremadura, the lack of university education and a preference for traditional methods limited the effective implementation of these technologies.
Conclusion: it was concluded that the incorporation of AI and Big Data was essential to improve the competitiveness, efficiency, and sustainability of the agricultural sector in Extremadura. However, its success depended on a profound change in organisational mindset and institutional support through public policies, training, and incentives. The key was not only in having technology, but in knowing how to integrate it strategically to transform the business model and face future challenges.

Keywords: Big Data; Artificial Intelligence; Agribusiness; Digital Transformation; Competitiveness.

RESUMEN

Introducción: el artículo analizó cómo la inteligencia artificial (IA) y el Big Data se convirtieron en herramientas clave para la generación de ventaja competitiva, al transformar datos complejos en información útil para la toma de decisiones. Se destacó que, más allá del acceso a la tecnología, las organizaciones debían adaptar su estructura y estrategia para aprovechar realmente su potencial. La investigación se enfocó en la industria agropecuaria de Extremadura, una región con bajo PIB per cápita y una población envejecida que tradicionalmente ha mostrado resistencia al cambio.
Desarrollo: la Cuarta Revolución Industrial, caracterizada por la rápida expansión de tecnologías disruptivas, modificó profundamente la forma en que las empresas operaron. En el sector agropecuario, la IA y el Big Data permitieron monitorear cultivos, automatizar maquinaria y optimizar recursos. No obstante, su adopción requirió más que herramientas tecnológicas: implicó una transformación organizacional que incluyó formación profesional, inversión en infraestructura digital y una cultura de innovación. En Extremadura, la falta de formación universitaria y la preferencia por métodos tradicionales limitaron la implementación efectiva de estas tecnologías.

Conclusión: se concluyó que la incorporación de IA y Big Data fue fundamental para mejorar la competitividad, eficiencia y sostenibilidad del sector agropecuario en Extremadura. Sin embargo, su éxito dependió de un cambio profundo en la mentalidad organizacional y del apoyo institucional mediante políticas públicas, formación e incentivos. La clave no estuvo solo en tener tecnología, sino en saber cómo integrarla estratégicamente para transformar el modelo de negocio y enfrentar los retos futuros.

Palabras clave: Big Data; Inteligencia Artificial; Agroindustria; Transformación Digital; Competitividad.

INTRODUCTION

One of the most significant aspects of big data analysis is its ability to transform available data, through statistical and computational methods, into valuable information that generates a competitive advantage for the company and adds value for the customer.[1]

However, generating a competitive advantage does not depend solely on access to complex sources of information, but also on having a structure that leverages it and effectively transforms it. Hill et al.[1], in their understanding of strategy and business, explain that:

To create a successful business model, managers must 1) formulate business strategies that enable their company to attract customers from other companies in the industry (their competitors) and 2) implement those business strategies, which also involves the use of functional strategies to increase responsiveness to customers, as well as efficiency, innovation, and quality.

But sustained with a review and reformulation of the value chain, it is essential to ensure the successful use of information and the effectiveness of strategic, operational, and control decisions.

It is easy to recognize the importance and benefits associated with the implementation of this technology, but how can this technology support the development of the agricultural industry, and specifically of Extremadura (a region that currently has the lowest GDP per capita in Spain)?

In Extremadura, the agricultural industry has traditionally played a crucial role in society and the economy, contributing significantly to Extremadura's GDP, which is more substantial than that of the rest of the autonomous communities. Due to the low rainfall in winter, combined with very warm temperatures in spring and summer, the agricultural sector in the region experienced a negative growth, in real terms, of -1,6 %.

In 2020, these factats added to the situation due to COVID-19, the fall was 9,2 % and although this year an increase of 4,2 % is expected (according to BBVA research) thanks to the measures adopted to alleviate the consequences of the pandemic, climate change together with the announced end of CAP (Common Agricultural Policy) aid continue to affect the agricultural industry negatively.

Considering all this, agricultural organizations in Extremadura must adapt and incorporate new technology with their correct, effective, and efficient administration as an essential part of their existence. However, will the organizations know how to adapt themselves to take advantage of these new resources correctly? This question is especially relevant in "Empty Extremadura" with a highly aged population (the population aging index has reached its historical maximum 144,3 %, almost 20 points above the Spanish index) that is characterized by resisting change and adapting to new technologies, preferring "the traditional".

Thus, the central research question is: Do agricultural companies in Extremadura recognize the need to adapt their organizational systems to incorporate technological tools that handle large volumes of data, thereby generating added value and competitiveness?

DEVELOPMENT

The Fourth Industrial Revolution, a concept developed by Schwab[3], has brought about a convergence of digital, physical, and biological technologies that profoundly impacts all productive sectors, including agriculture and livestock. Unlike previous industrial revolutions, this one is characterized by its exponential speed, its global scale, and its capacity to radically transform business models, value chains, jobs, and society as a whole.

In this context, tools such as artificial intelligence (AI) and Big Data have emerged as key drivers of transformation. Marr[4] conceptualizes Big Data through the "4 Vs": volume, velocity, variety, and veracity, which are fundamental pillars for understanding the strategic potential of this technology in business environments. The ability to capture, process, and analyze large volumes of data in real-time allows organizations to make evidence-based decisions, optimize processes, and generate added value for both the company and its customers.

Particularly in the agricultural sector, these technologies enable tasks such as crop monitoring, disease prediction, machinery automation, and accurate management of natural resources. The integration of IoT, sensors, predictive analytics, and intelligent management systems in agriculture and livestock promotes

sustainable practices, reduces input waste, and improves yields.

Proper implementation of these tools requires not only technology but also organizational redesign. Hill et al.[2] state that companies must align their internal structure, competencies, and strategy to respond to the demands of today's competitive environment. This involves training or hiring skilled personnel, investing in digital infrastructure, and revising production processes to incorporate these innovations effectively.

Porter et al.[5] introduce the concept of smart and connected products, highlighting that the strategic use of data generates competitive advantages by enabling personalized experiences, safer and more efficient processes, and customer-oriented business management.

In the case of regions like Extremadura, characterized by an aging and traditional agricultural sector with limited university education, the challenge is not only technological but also cultural. Resistance to change, a lack of knowledge about the potential of these tools, and the absence of adaptive strategies in small and medium-sized farms limit the adoption of these technologies.[6,7]

Therefore, the successful incorporation of artificial intelligence and Big Data in Extremadura agriculture does not depend only on technological availability, but also on an integral transformation of the organizational system, where training, strategic planning and openness to change play a central role to ensure a competitive, sustainable and adapted development to the new technological paradigm.[8,9]

CONCLUSIONS

The analysis carried out reveals that the Fourth Industrial Revolution has established a new paradigm, where technology, particularly the use of artificial intelligence and Big Data, has become a fundamental tool for transforming and sustaining industries, including agriculture and livestock. These technologies not only enable the optimization of processes but also facilitate the generation of strategic knowledge, reduce costs, and offer differentiated value propositions that enhance organizational competitiveness.

In this context, Big Data stands out as a resource that, if well-managed, offers significant competitive advantages by translating massive amounts of data into valuable and actionable information. The real impact of these technologies lies not only in their technical adoption but in their effective integration within the business model, which implies a deep adaptation of the organizational system: from infrastructure to human capital training. For regions such as Extremadura, where the agricultural industry has a significant structural impact on the economy and where most farms have traditional characteristics, the challenge extends beyond incorporating digital tools. A profound cultural shift is necessary to overcome resistance, bridge generational gaps, and cultivate a mindset focused on innovation and continuous learning. The "Empty Extremadura", with a mostly aging population, faces the double challenge of modernizing its production without losing its identity, but also without being left behind in a rapidly evolving world.

The implementation of technologies such as Big Data and AI should not be seen as a threat to traditional practices, but as an opportunity to complement them, professionalize them, and make them more resilient in the face of global challenges such as climate change, reduced public support (CAP), and market volatility. This will only be possible if agricultural organizations manage to develop flexible structures that are open to change and strategically aligned with new technological scenarios.

Thus, the real advantage lies not only in possessing technology but also in knowing how to utilize it effectively. Farms that understand this point will be the ones that lead the sector's transformation. To this end, the role of the State, cooperatives, and educational institutions in promoting active training, financing, and incentive policies, with a special focus on small and medium-sized farms, will be fundamental.

In short, the future of agriculture in Extremadura will depend on its ability to integrate technology and organizational strategy. Only in this way will it be possible to achieve a more productive, sustainable, and competitive development that will contribute not only to improving the regional GDP, but also to revitalizing the social and economic fabric of one of the most forgotten areas of Spain.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Research: Jesica Tirado.
Writing - original draft: Jesica Tirado.
Writing - proofreading and editing: Jesica Tirado.