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KEY DRIVERS AND CHALLENGES IN IMPLEMENTING THE DIGITAL PRODUCT PASSPORT

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Abstract

The article examines the digital product passport (DPP) as a strategic digital infrastructure for enterprises under modern digital and circular economy conditions, and provides a systematic analysis of the internal and external factors driving its implementation, as well as the main barriers and risks. Based on the analysis of the European Union's regulatory and legal documents, as well as consulting and industry reports, the paper highlights the impact of DPP on digitalization, operational efficiency, competitive advantage, corporate reputation, and circular economy objectives. At the same time, it classifies key barriers such as problems of data interoperability and standardization, digitalization costs, shortages of technical and managerial skills, concerns related to data collection and security, and resistance to organizational change. The research findings show that DPP should be viewed as a core mechanism for transitioning to sustainability, transparency, and innovative business models, while its successful implementation requires the development of standardization, strengthening human capacity, and enhancing cooperation among stakeholders.

Keywords: Digital product passport (DPP), circular economy, digital identification, sustainability, digital transformation, Industry 4.0, blockchain, supply chain transparency.

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КЛЮЧЕВЫЕ ДВИЖУЩИЕ ФАКТОРЫ И ВЫЗОВЫ ПРИ ВНЕДРЕНИИ ЦИФРОВОГО ПАСПОРТА ПРОДУКТА

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Аннотация

В статье рассматривается цифровой паспорт продукта (DPP) как стратегическая цифровая инфраструктура для предприятий в условиях современной цифровой и циркулярной экономики, а также проводится системный анализ внутренних и внешних факторов, стимулирующих его внедрение, и основных барьеров и рисков. На основе анализа нормативно-правовых документов Европейского союза, а также консалтинговых и отраслевых отчетов в работе выделено влияние DPP на цифровизацию, операционную эффективность, конкурентные преимущества, корпоративную репутацию и цели циркулярной экономики. Одновременно классифицируются ключевые препятствия, такие как проблемы интероперабельности данных и стандартизации, затраты на цифровизацию, дефицит технических и управленческих компетенций, риски и опасения, связанные со сбором и безопасностью данных, а также сопротивление организационным изменениям. Результаты исследования показывают, что DPP следует рассматривать как базовый механизм перехода к устойчивости, прозрачности и инновационным бизнес-моделям, тогда как его успешная реализация требует развития стандартизации, укрепления человеческого потенциала и расширения сотрудничества между заинтересованными сторонами.

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Ключевые слова: цифровой паспорт продукта (DPP), циркулярная экономика, цифровая идентификация, устойчивое развитие, цифровая трансформация, Индустрия 4.0, блокчейн, прозрачность цепочек поставок.

INTRODUCTION

The digital product passport (DPP) is one of the key and distinctive tools in the European Union's sustainable development agenda to ensure the transition to a circular and climate-neutral economy. For this reason, it is envisaged as an integral part of the *Circular Economy Action Plan* (CEAP) and the *European Green Deal* initiative. The DPP approach implies a shift away from the traditional linear economic model toward a circular model in which every product is designed with a minimal environmental footprint and, at the end of its use phase, is conceived so that each component used in its production can be recovered.

CEAP notes that over the next 40 years, the consumption of materials such as fossil fuels, metals, and minerals is expected to double, while the volume of annual waste is projected to increase by 70 percent by 2050. Up to 80 percent of a product's environmental impact is determined at the design stage. However, the traditional linear model does not provide producers with incentives to make products suitable for reuse¹.

Thus, the DPP is designed to bridge this gap by enabling the collection and sharing of precise data throughout the entire lifecycle of a product, supporting the monitoring and optimization of its sustainability.

In a period of rapid change driven by digital transformation, the digital product passport is regarded as one of the key instruments. With the help of the DPP, technological and operational data on the entire lifecycle of a product are continuously tracked and consolidated into a single digital unit. Through integration with supply chain traceability systems, the DPP provides full visibility

¹ Digital Product Passports: A Complete Guide. (2024, Agosto 23). <https://root.sustainability.com/blogs/digitalproduct-passport/>

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over the product's origin and characteristics, makes operational processes more transparent, and contributes to the formation of a responsible supply chain.

LITERATURE REVIEW

In international research, the digital product passport (DPP) is interpreted as a central infrastructural element of digital transformation and the circular economy. Studies by Cikis Studio emphasize that the DPP, by integrating material and product flows into a single digital environment, helps to build a modern and competitive supply chain, optimize operational processes, and enable rapid adaptation to market changes².

Analyses by Deloitte, meanwhile, consider the introduction of the DPP as a strategic source of competitive advantage for companies: it not only strengthens corporate image and brand trust, but also helps attract customer segments that prioritize transparency and sustainability, and opens up new growth opportunities by facilitating access to market segments regulated or incentivized by sustainability standards. Thus, foreign sources assess the DPP as a comprehensive digital mechanism that unites transparency, sustainability, and competitiveness³.

METHODOLOGY

To analyze the drivers and barriers to implementing the digital product passport, a systematic literature review and content analysis were employed. Scientific articles, European Union documents, and reports from organizations such as Deloitte, McKinsey, GS1, and Cikis Studio were compared. Based on the obtained information, internal and external factors were grouped conceptually, and the impact of the DPP on digitalization, sustainability, and competitiveness, as well as the main implementation risks, were briefly synthesized.

² Digital product passport: Cos'è e perchè implementarlo. (s.d.). urly.it/3141n2

³ Digital Product Passports are just around the corner | Deloitte UK. (s.d.). <https://www.deloitte.com/uk/en/services/riskadvisory/perspectives/digital-product-passports-are-just-around-the-corner.html>

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ANALYSIS AND RESULTS

Strengthening cooperation between enterprises within the supply chain is one of the important dimensions of the DPP. Another advantage of the DPP is that it enhances transparency by providing accurate and verifiable information on the materials and production processes used by different actors. This, in turn, reduces uncertainties in resource use. Thanks to the detailed traceability it ensures, companies can optimize end-of-life product management, making it easier to channel products into recycling and material re-use.

The DPP is not merely a data collection system, but a catalyst that promotes corporate sustainability. Access to detailed information enables companies to continuously monitor the environmental impact of their products and to take measures to reduce greenhouse gas emissions and the use of non-renewable resources. With the help of the DPP, firms can calculate the carbon footprint for each product and implement corrective actions aimed at improving the energy efficiency of production processes. Such analysis also facilitates compliance with EU sustainability regulations, such as the European Green Deal and the Circular Economy Action Plan, which require responsible resource use and emission reduction.

In the context of globalization and an increasingly interconnected economy, the role of the DPP becomes even more strategically important. The ability to track products in detail and maintain reliable, verifiable information about them is crucial for ensuring the quality and safety of goods circulating at the international level. For example, in sectors such as electronics or textiles, where supply chains are highly complex, the DPP helps ensure that products meet the quality and sustainability standards required by different markets.

The DPP is integrated with Industry 4.0 technologies such as blockchain and decentralized identifiers (DID), which ensures data security and operational efficiency. When applied to supply chains, blockchain makes it possible to create tamper-proof chains of certificates in which product information can be verified

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and exchanged among supply chain participants. This system not only reduces the likelihood of fraud, but also guarantees the integrity and immutability of data over time. Owing to these characteristics, the DPP proves to be an indispensable tool for ensuring sustainability, transparency, and competitiveness for companies operating in an Industry 4.0 environment.

The figure 1 illustrates how a garment is linked to its DPP. The QR code on the product label is scanned with a smartphone, giving the consumer access to detailed information on the product's origin, composition, production process, and environmental indicators.



Figure 1. QR-enabled access to DPP.

In recent years, due to new environmental requirements that make sustainable operations mandatory, sustainability has become a strategic priority for businesses. Europe is leading this transformation and, through the Circular Economy Action Plan, is encouraging companies to introduce digital product passports to increase product transparency and sustainability.

The Eco-design for Sustainable Products Regulation (ESPR) is a key pillar of this regulatory framework. While other directives merely recommended the introduction of digital product passports, the ESPR makes the DPP mandatory for certain categories of products. Therefore, for companies dealing with regulated products, the digital product passport becomes a critical instrument for complying

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with regulatory requirements. By providing structured data, companies not only meet legal obligations, but also position themselves as responsible and competitive brands.

The introduction of the digital product passport is determined by a set of strategic factors that demonstrate how important this system is for enterprises and organizations. These factors represent the main motivations for implementing this digital tool aimed at promoting transparency, sustainability, and innovation. They can be grouped into two broad categories:

1. Internal factors – related to in-company processes and objectives, including improving operational efficiency, enhancing internal management, and building competitive advantage.
2. External factors – stemming from regulatory requirements, consumer expectations, and market trends.

Identifying and understanding these factors in depth is crucial for designing a successful transition strategy toward the DPP. By taking into account internal and external needs and pressures, organizations can develop strategies that not only meet regulatory requirements but also generate significant economic and environmental benefits. This, in turn, allows enterprises to remain competitive and profitable in a rapidly evolving global economy. An expanded analysis of these factors makes it possible to view the DPP as a strong catalyst for long-term innovation and growth.

The digital product passport is one of the main pillars of digital transformation for companies. By implementing the DPP, enterprises can simplify information management throughout the entire supply chain, increase operational efficiency, and enhance transparency. The DPP creates a unified and standardized database of information on materials, processes, and products, to which different supply chain participants can gain access. At the same time, it reduces errors and system interruptions and helps integrate new technologies such as artificial intelligence and predictive analytics into the organization.



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Companies that implement the DPP position themselves as actors committed to sustainability, which today has become a more important factor in consumer purchasing decisions than ever before. As the importance of sustainable practices grows – especially in product selection – the DPP serves as a key source of competitive differentiation. It not only strengthens corporate image but also builds trust among customer segments that prioritize transparency and sustainability. In addition, the DPP facilitates access to market segments that are regulated or incentivized on the basis of sustainability standards, thereby expanding growth opportunities in strategic sectors. In markets where sustainability has become a primary selection criterion, the DPP remains a strategic tool for attracting new customer groups and strengthening the loyalty of existing customers.

Introducing the DPP demonstrates a company's strong commitment to sustainability and transparency and significantly improves its brand image. This tool provides tangible evidence of corporate social responsibility. Such an approach is increasingly valued not only by consumers but also by investors and other stakeholders. The use of DPP increases transparency and trust among strategic partners and customers, contributing to a positive perception of the company within the industry. Moreover, firms that implement DPP can obtain various sustainability certificates and awards, further enhancing their visibility and attractiveness in the marketplace. A strengthened image can, in the long term, turn into a sustainable competitive advantage, positively affecting brand value and customer loyalty.

EU documents such as the European Green Deal are accelerating the transition toward a sustainable economic model. These regulations require firms to comply with increasingly stringent standards and are turning the digital product passport into a necessary tool for ensuring regulatory compliance and anticipating future requirements. At the same time, the DPP provides a significant competitive advantage in a rapidly changing market environment. Companies that follow

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sustainability standards present themselves as forward-looking and sustainability-oriented actors and thus become particularly attractive to environmentally conscious consumers and investors. The DPP simplifies the integration of sustainability requirements into operational processes and creates a clear information system for tracking and fulfilling environmental obligations. Growing consumer demand for clear and understandable information on product origin, composition, and sustainability is one of the main external drivers of DPP implementation. Sectors such as fashion and electronics are especially affected by this trend. Consumers increasingly prefer brands that provide transparency and regard it as one of the main criteria in their purchasing decisions. The DPP enables companies to present detailed information on the entire life cycle of a product, including its environmental footprint. Such transparency strengthens customer loyalty and helps brands stand out in highly competitive markets. By implementing DPP, companies can build trust, create more personalized and engaging consumer experiences, and align themselves with broader sustainability goals.

The digital product passport plays a central role in the transition to a circular economy by promoting recycling, re-use, and repairability. According to the European Circular Economy Platform, the introduction of DPP improves end-of-life product management, reduces disposal costs, and optimizes the use of raw materials. This approach directly contributes to emission reductions.

By providing detailed information on materials and components, the DPP enables stakeholders to consciously choose the most appropriate ways to re-use or recycle products. It also supports the development of innovative business models such as “product-as-a-service”, in which companies retain ownership of materials and ensure their efficient recovery. Such alignment with circular economy principles not only benefits the environment but also enhances resource efficiency and opens new market opportunities, helping enterprises succeed in a sustainability-oriented economy.

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The factors driving the implementation of DPP show that the system's innovation and improvement potential covers various dimensions of business and market development. Companies that actively adopt DPP not only adapt to sustainability requirements but also consolidate their position as leaders in innovation, transparency, and circular economy practices. In the current context of intensifying environmental and social challenges, DPP acts as a "bridging link" for future business models, enabling greener and more resource-efficient approaches in certain industries, revisiting production cycles, and contributing to a more sustainable and resilient global economy.

At the implementation stage, the DPP as a strategic tool faces a number of initial challenges. These barriers are linked to both internal and external factors, and their combined impact significantly complicates the process of adopting the DPP (Figure 2). In the internal context, enterprises may encounter obstacles related to their level of preparedness to adopt the solution, as well as the adequacy of technical infrastructure and available resources. On the external side, relationships with suppliers, legal and regulatory requirements, and customer resistance emerge as key constraining factors. Effectively addressing these issues is essential for the gradual and full integration of the DPP into the business environment and for aligning it with future sustainability objectives, new regulations, and market expectations. Overcoming these barriers not only supports compliance with formal requirements, but also helps transform enterprises into exemplars of transparency and innovation in a globally competitive landscape.

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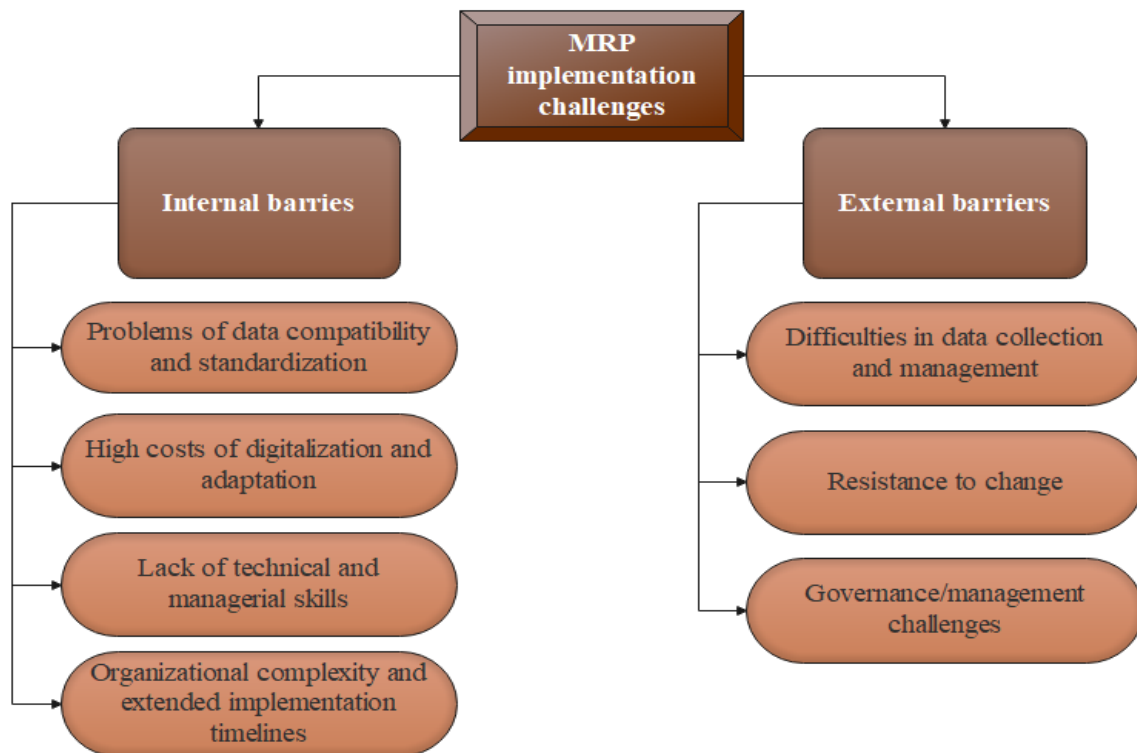


Figure 2. Challenges in implementing the digital product passport.

The lack of unified international standards seriously limits large-scale implementation of the DPP. Organizations face difficulties in ensuring data compatibility between different systems and industries. This challenge requires significant investment in standardization initiatives, including the development of protocols that harmonize data formats and communication interfaces. The EU's Digital Transformation Framework shows that the absence of agreement on data standards complicates cross-border operations and restricts collaboration along supply chains. If this gap is not closed, companies risk creating fragmented and poorly connected systems, which ultimately reduces the effectiveness of the DPP.

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Transitioning to the DPP requires investment in advanced digital tools such as blockchain, IoT, and traceability systems. These technologies involve costs for software, hardware, and qualified personnel, which can become a substantial financial burden, especially for small and medium-sized enterprises. The need to integrate new systems and adapt existing infrastructure further increases economic pressure on companies. Finding a balance between long-term benefits and short-term costs is a serious challenge, particularly in sectors with narrow profit margins.

Effective implementation of the DPP is highly dependent on the availability of staff with sufficient expertise in data management, IT systems, and supply chain coordination. However, many organizations report skill gaps precisely in these areas. This shortcoming limits their ability to manage complex digital systems and fully exploit the potential of the DPP. Training programmes and capacity-building initiatives are needed, but they require both time and resources, which further complicates the process. Bridging this gap demands attention not only to technical training but also to organizational change management.

Integrating the DPP requires broad organizational change, including stronger internal coordination, redesign of business processes, expanded cross-departmental collaboration, and staff training. For companies with global or deeply networked supply chains, such adaptation can require considerable time and resources. Prolonged implementation periods may lead to strategic misalignment and a loss of pace and motivation in the project. According to the World Economic Forum, many companies underestimate the complexity of such transformation processes, which results in delays and suboptimal execution⁴.

The extensive data required by the DPP – detailed information on raw materials, components, and production processes – is challenging to collect and manage on a unified platform. Gathering accurate and complete data from suppliers around the world is particularly difficult when working with supply chains located in

⁴ The World Economic Forum. (s.d.), da <https://www.weforum.org/>

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developing countries. Research by GS1 shows that upstream suppliers are often insufficiently transparent, which raises concerns about the completeness and accuracy of the data⁵.

Internal resistance – including employee scepticism and reluctance to share confidential product information – is one of the major barriers to DPP implementation. Concerns about data security, protection of intellectual property, and the potential misuse of shared information intensify this resistance. Building a culture of openness, demonstrating the strategic value of the DPP with practical examples, and clearly explaining its benefits to stakeholders are crucial to overcoming these issues. Otherwise, the implementation process may be prolonged and stakeholder engagement may decline.

Conclusion

These challenges associated with implementing the DPP clearly reflect the complexity of transitioning to a more transparent and sustainable operational environment. Enterprises must address skill shortages, internal resistance to change, and issues of interoperability and data collection gradually and systematically. If these barriers are ignored, the potential benefits of the DPP across the entire value chain will not be fully realized. Conversely, overcoming them through targeted training, standardization, and active engagement with stakeholders will allow companies not only to adapt to new requirements and standards, but also to become leading actors that reshape the market in the direction of sustainability and innovation.

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