Impact of Sustainability, Globalisation and Digitalisation on Romanian Footwear Manufacturing

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Abstract. Globalisation, digitalisation, and sustainability are powerful forces currently reshaping all industries, including industrial footwear manufacturing. These megatrends bring significant changes, highlighting the need to adapt vocational education and higher education programs to meet emerging demands. This study explores how the potential dimensions of these megatrends impact Romania's industrial footwear sector, using data gathered from three expert workshops held with representatives from industry, education, associations and freelancers. The workshops analysed the key dimensions affecting the sector, assessed their impact on work processes, and determined the implications for skills development and training. The findings offer valuable insights into the evolving skill requirements in industrial footwear production, providing recommendations for updating curricula, training materials and national qualification frameworks. The research was conducted within the framework of the ISOV project, Innovative Skills for an Old Vocation, which supports the modernisation of training programs in the footwear industry.

Keywords: Footwear Industry, Sustainability, Digitalisation, Globalisation, Education.

1 Introduction

The megatrends of globalisation, digitalisation, and sustainability are currently influencing all sectors, including footwear manufacturing. It is essential to consider the resulting changes in work processes by reflecting on their implications for vocational training and higher education.

These megatrends are reshaping work processes, material flows, and institutional frameworks across the European footwear industry [1]. For example, the European Green Deal, the Circular Economy Action Plan, and the Corporate Sustainability Due Diligence Directive outline new regulatory expectations regarding product traceability,

eco-design, and social compliance, which directly affect product innovation and supply chain governance in footwear manufacturing [2-5].

At the same time, digitalisation is playing an increasingly strategic role in the sector. The European Parliament's Industrial Strategy emphasises digital technologies—such as robotics, data analytics, and AI—as critical levers for industrial competitiveness, circularity, and innovation [6]. Simultaneously, the European Digital Single Market and Green Digital Agenda strive to unify digital ecosystems across member states, while ensuring digital platforms contribute to climate neutrality and resource efficiency [7].

While these trends affect all sectors, there remains limited insight into how they specifically manifest in each one. Even when forecasts are available concerning a sector's future role, the implications for skilled labour across various spheres of activity can differ significantly. Consequently, the training needs within these domains may vary considerably.

This paper presents the impact of sustainability, globalisation, and digitalisation on Romanian industrial footwear production based on three expert workshops. By analysing the workshop results organised in Romania, this research offers insights that will support the adaptation of curricula, training materials and national qualifications related to the footwear sector.
The research was carried out within the framework of the ISOV- Innovative Skills for an Old Vocation [8], which aims to adapt Initial Vocational Education and Training (IVET), Continuous Vocational Education and Training (CVET), and Higher Education (HE) with the evolving demands of the industrial footwear production sector in response to the megatrends of globalisation, digitalisation, and sustainability, while maintaining a strong focus on sector-specific work processes and acknowledging the varying impact of each trend on different areas of activity.

The research presented in this paper is connected to previous projects, ICSAS [9] and DIA-CVET [10], where 18 spheres of activity that define skilled work in industrial shoe production in Germany, Romania, and Portugal were identified.

2 Method

The research was conducted in two stages. The first stage, preparatory, involved desk research, specifically a literature review aimed at identifying the potential dimensions of sustainability, globalisation, and digitalisation megatrends that influence the spheres of activity within the footwear sector. The second stage consisted of workshops with experts from the trends and footwear industries, to assess the impact of each dimension on these spheres of activity.

As part of the desk research phase, over 65 sources were consulted, including research papers and European regulations. In this stage, the potential dimensions of

sustainability, globalisation, and digitalisation that influence the spheres of activity within the footwear sector were identified. Based on the findings, each primary dimension was subsequently defined by 5 to 6 sub-dimensions.

In the second stage, workshops were conducted in each of the three countries: Germany, Romania and Portugal. This approach facilitates the identification of impact according to the country's footwear sector needs.

In Romania, a workshop was organised for each of the trends. Nine experts participated in each workshop, including representatives from small and medium-sized footwear companies, VET and HE providers, members of the sector association, and freelancers. To facilitate the process, an interactive presentation software tool (Mentimenter) was used that allows users to use several interactive visual elements [11].

Each workshop began with an introduction to the project and its aim Fig. 1). Participants were presented with the dimensions that define the trend.

Fig. 1. Example outlining the screen with objectives and goals of the project

Additionally, participants were asked to identify the keywords they associate with the trend discussed during the workshop. Subsequently, the significance of each dimension, along with its corresponding sub-dimensions, was explained to ensure a good workshop performance (Fig. 2).

Fig. 2. Example outlining the screen with explanation of dimensions and subdimensions

The Mentimeter tool enabled interactive engagement with the participants, allowing them to express their opinions by assigning a score from 1 to 10. A score of 1 indicated

that the dimension did not influence the sphere of activity, while a score of 10 showed a high impact (Fig. 3).

Fig. 3. Example outlining the screen with interactive evaluation of dimension impact using the Mentimeter tool

3 Results and Discussions

To see precisely how each trend impacts the 18 spheres of activity identified in previous projects, ICSAS [9] and DIA-CVET [10], a matrix has been created. The Y-axis includes the potential dimension of each trend identified during the first stage of the research. At the same time, on the X-axis, the 18 spheres of activity are listed.

Based on the discussion during the workshop, a correlation was identified between the potential dimensions of each trend and the spheres of activity. The dimensions with high impact are highlighted in yellow, and those with medium impact are highlighted in light blue. High impact was considered to have been achieved if the average score given by workshop participants exceeded 7.5 out of 10.

3.1 Impact of the sustainability dimensions on the Romanian footwear sector

The results of the sustainability workshop (Fig. 4a and 4b) highlighted how key sustainability dimensions, such as green awareness, energy efficiency, process and resource efficiency, sustainable design, circular economy, chemical safety, and social responsibility, influence different spheres of activity within Romanian footwear manufacturing. The participants' evaluations and justifications provide insights into how these departments interact with and are influenced by broader sustainability trends.

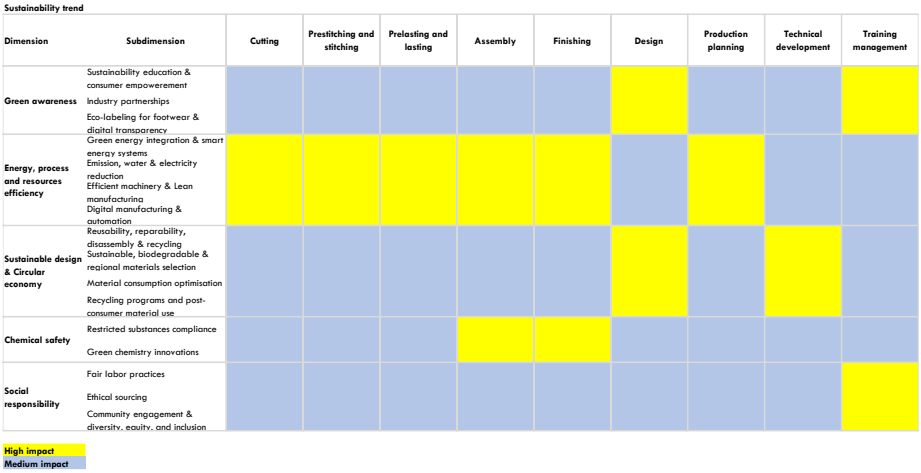

Fig. 4a. Spheres of activity in the footwear sector impacted by sustainability dimensions (part 1).

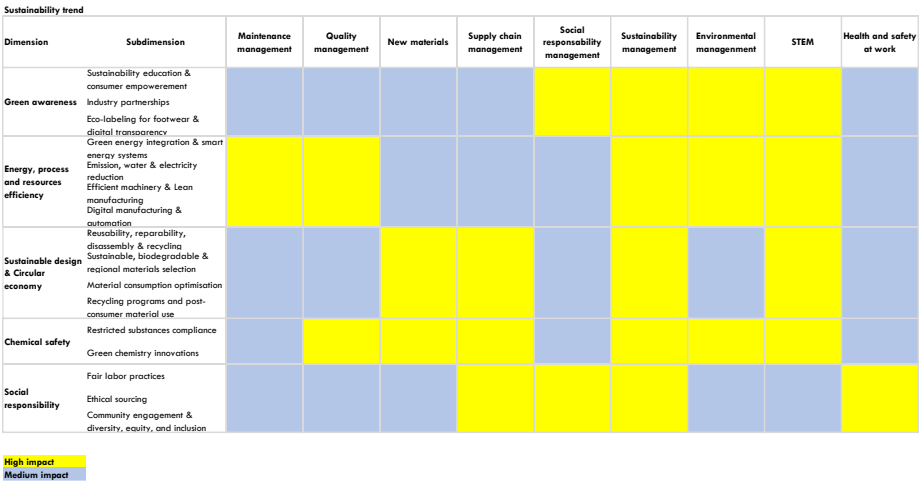

Fig. 4b. Spheres of activity in the footwear sector impacted by sustainability dimensions (part 2).

The dimension of **green awareness** demonstrates a common impact, particularly on departments such as design, sustainability management, social responsibility management, STEM (Science, Technology, Engineering and Mathematics), environmental management, and training management. High scores (ranging from 9.3 to 9.8) reflect the recognition of these spheres of activity roles in communicating sustainable values through products, packaging, labelling, and campaigns, as well as integrating sustainability into employee education and technical transparency efforts.

For the dimensions of **energy, process, and resource efficiency**, the most impacted spheres of activity include environmental management, maintenance management,

production planning, quality management, and manufacturing, all of which received scores above 9.0. These departments are considered central to improving operational efficiency, optimising flows, and reducing waste and energy consumption. STEM and sustainability management were also seen as contributing departments, supporting process automation and coordination of initiatives, respectively.

The dimension of **sustainable design and circular economy** primarily impacts the design, technical development, new materials, and supply chain management spheres of activity. These departments are responsible for proposing circular product concepts, selecting recyclable and local materials, and ensuring sustainable sourcing. Additionally, STEM and sustainability management were identified as supporting units through technical innovation and oversight of circular initiatives.

The **chemical safety** dimension impacts quality management, new materials, supply chain management, environmental management, sustainability management, STEM, and assembly and finishing. The consistently high scores (mostly above 9.0) reflect the critical importance of chemical compliance, testing, monitoring emissions, and using safer alternatives in production processes.

Finally, the **social responsibility** dimension is most strongly associated with social responsibility management, which received a perfect score (10), underlining its central role in applying ethical principles within the company. Additional impacted spheres of activity include supply chain management, training management, sustainability management, and health and safety at work, all of which contribute to ensuring fair working conditions, ethical sourcing, employee education, and social impact monitoring.

3.2 Impact of the globalisation dimensions on the Romanian footwear sector

The outcomes of the second workshop (Fig. 5a and 5b), focusing on globalisation, provide valuable insights into how different spheres of activity within Romanian industrial footwear production are affected by global demographic, economic, social, and regulatory shifts. The evaluation, based on expert scoring and qualitative arguments, highlights the increasingly complex environment in which footwear companies operate, requiring adaptive strategies across multiple operational and strategic functions.

The dimension of **demography** shows a notable impact on spheres of activity such as manufacturing (9.3), design (9.1), and technical development (9.0). These high scores reflect the indirect yet significant effects of changing population structures, including labour shortages and shifting cultural values, on production capacity and product development. Furthermore, training management (8.9) and health and safety at work (8.8) were also identified as impacted areas, due to the ageing workforce and the need to retrain employees and adapt workplace safety standards.

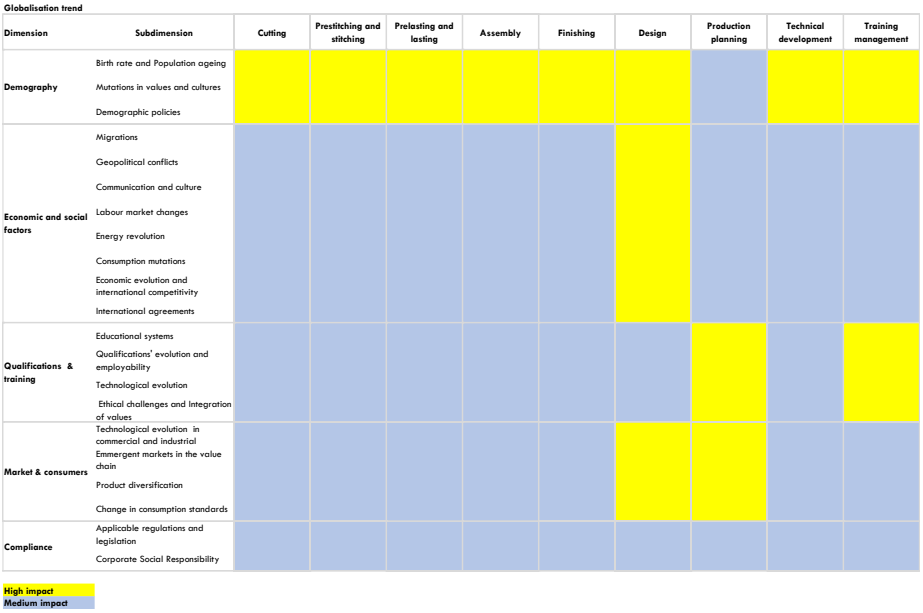

Fig. 5a. Spheres of activity in the footwear sector impacted by globalisation dimensions (part 1).

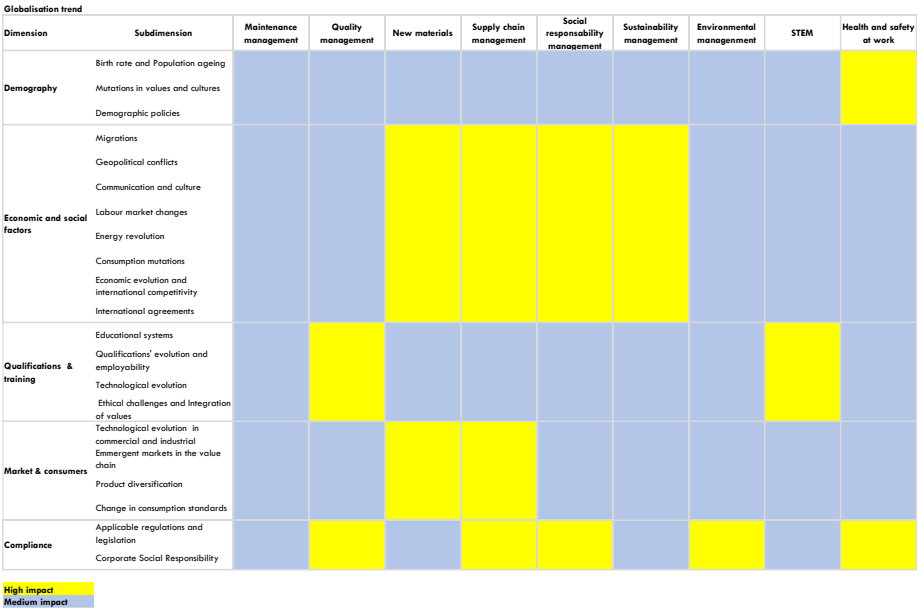

Fig. 5b. Spheres of activity in the footwear sector impacted by globalisation dimensions (part 2).

Within the dimension of **economic and social factors**, the most affected spheres of activity include production planning (9.2) and supply chain management (8.7). These high scores reflect the tangible effects of migration, conflict, and geopolitical instability on the reliability of supply chains and planning processes. Social responsibility management and sustainability management (both 8.2) are also impacted, particularly in the context of aligning strategic priorities with global trends such as renewable energy and ethical business conduct. New materials (7.4), while less affected, must respond to pressures related to energy transitions and international competition by offering innovative, cost-effective solutions.

The dimension of **qualification, training, and knowledge** reveals a strong cross-functional influence, particularly on STEM (9.8), which was identified as critical for integrating new technologies and ethical values into production systems. Training management (8.8), technical development (8.4), and quality management (8.1) were also rated highly, indicating that all these spheres must respond to the ongoing need for upskilling in response to technological advancement and market evolution.

The **market and consumer** dimension has a strong influence on spheres such as design (9.3), production planning (8.7), and new materials (8.6), reflecting the need to rapidly adapt to changing consumer preferences, emerging markets, and new business models. These spheres must continuously innovate to remain competitive and relevant, particularly in terms of sustainability, product diversification, and responsiveness. Supply chain management (7.9) also plays a role in aligning sourcing practices with market trends.

The dimension of **compliance** impacts a broad range of spheres. The highest score was attributed to health and safety at work (9.3), underscoring the critical role of regulatory compliance in maintaining workplace standards. Other significantly affected spheres include quality management and social responsibility management (both 8.6), environmental management (8.4), and supply chain management (7.9), all of which are responsible for ensuring adherence to national and international regulations on quality, environment, and ethical conduct.

3.3 Impact of the digitalisation dimensions on the Romanian footwear sector

The findings from the third workshop (Fig. 6a and 6b), which focused on digitalisation, underline the increasing digital transformation of the footwear sector. The participants' evaluations and justifications suggest that digital technologies are transforming various activities, ranging from design and production planning to maintenance and training. The analysis of the dimensions—robotics, Artificial Intelligence (AI), Big Data, 3D printing, integration of digitalisation and sciences, and Virtual and Augmented Reality (VR/AR)—demonstrates how digital tools and systems are embedded across both technical and strategic levels of footwear manufacturing.

Digitalisation trend

Dimension	Subdimension	Cutting	Prestitching and stitching	Prelasting and lasting	Assembly	Finishing	Design	Production planning	Technical development	Training management
New era of robots	2 arm robots Adaptive robots Lightweight robots									
Artificial Intelligence (AI)	Image generation tools Text generating and translating Text-to-speech and speech-to- Data mining									
Big data	Digital marketing and branding Personalisation and mass Data-driven decision-making Traceability Internet of Things (IoT)									
3D printing	Plastics Metals									
Combination digitalisation and sciences	Wearables Cyber physical systems (cps)									
Virtual and augmented reality	Virtual reality Augmented reality									

High impact
Medium impact

Fig. 6a. Spheres of activity in the footwear sector impacted by digitalisations dimensions (part 1).

Digitalisation trend

Dimension	Subdimension	Maintenance management	Quality management	New materials	Supply chain management	Social responsability management	Sustainability management	Environmental managenment	STEM	Health and safety at work
New era of robots	2 arm robots Adaptive robots Lightweight robots									
Artificial Intelligence (AI)	Image generation tools Text generating and translating Text-to-speech and speech-to- Data mining									
Big data	Digital marketing and branding Personalisation and mass Data-driven decision-making Traceability Internet of Things (IoT)									
3D printing	Plastics Metals									
Combination digitalisation and sciences	Wearables Cyber physical systems (cps)									
Virtual and augmented reality	Virtual reality Augmented reality									

High impact
Medium impact

Fig. 6b. Spheres of activity in the footwear sector impacted by digitalisation dimensions (part 2).

The **new era of robotics** has a powerful impact on maintenance management (9.0), which is increasingly responsible for implementing predictive maintenance strategies to ensure the smooth operation of industrial robots. Assembly (8.9), cutting (8.6), and pre-stitching and stitching (8.4) are also significantly impacted by robotic integration, mainly as robots are used for repetitive, high-precision tasks. Production planning (7.9) must adapt to synchronise workflows between human labour and robotic operations, indicating a need for planners who are digitally literate and can manage hybrid systems.

In the **Artificial Intelligence** dimension, the most affected spheres of activity include STEM (9.1), where AI is viewed as a foundational competence for engineers and researchers, and training management (8.6), which is expected to use AI tools to personalise educational content. AI also influences technical development (8.4) and design (8.3), as it supports the rapid generation of product concepts and the optimisation of design features, thereby bridging creativity with technical feasibility.

The **Big Data** dimension received the highest overall scores, particularly for design and supply chain management (both 9.7), highlighting the transformative role of data in

understanding consumer needs and optimising sourcing and delivery processes. Quality management (9.2) and production planning (9.1) also benefit from real-time data analytics, which enable the immediate detection of faults and the flexible adjustment of production schedules. These results suggest a strong need to integrate data analysis and interpretation into training programs across multiple spheres.

3D printing shows a concentrated impact on design, new materials, and product technical development (all above 9.3), as it allows rapid prototyping, testing of complex geometries, and demands the creation of compatible, innovative materials. These capabilities significantly shorten product development cycles and enhance customisation, underlining the importance of digital fabrication literacy in higher education curricula.

The **combination of digitalisation and sciences** affects STEM (9.6), where the convergence of cyber-physical systems, engineering, and data science requires interdisciplinary expertise. Health and safety at work (8.9) benefits from digital sensors for real-time monitoring of working conditions, and sustainability management (8.9) uses digital tools for tracking ecological footprints, reflecting the integration of digitalisation into occupational and environmental spheres.

Lastly, the **Virtual/ Augmented Reality** dimension has a significant impact on training management (9.6), enabling immersive and resource-efficient learning environments. Design (9.2) also benefits through virtual product simulations, while cutting (9.0) uses AR to guide manual processes with higher accuracy. These applications reinforce the relevance of experiential digital tools in both training and production contexts.

4 Conclusion

The three workshops organised in spring 2025 in Romania facilitated the identification of the impact of sustainability, globalisation, and digitalisation trends on the national footwear sector.
Overall, the distribution of results confirms that sustainability has a cross-departmental impact, requiring a systemic approach to training and upskilling the workers and students. These findings are essential in the development of targeted educational resources and curricula for vocational and higher education in Romania, ensuring that future professionals in the footwear industry are equipped with the necessary competencies to integrate sustainability into their respective areas of responsibility.
In terms of globalisation, it affects not only external-facing functions such as supply chain and market engagement but also internal structures like training, compliance, and production. This multifaceted impact reinforces the need for a systemic approach to training and curriculum design in vocational and higher education. The future workforce must be equipped with a mix of global awareness, adaptability, and specialised knowledge across technical, managerial, and regulatory domains. The insights gained from this workshop highlight the need to prepare trainees to navigate the globalised realities of the industrial footwear sector.

The digitalisation workshop results demonstrate a broad and deep influence across various spheres of activity. Digital tools are not isolated to technical functions but span strategic roles in training, sustainability, and planning. This multifaceted integration requires the development of training manuals and higher education curricula that incorporate digital competencies, including data literacy, AI application, virtual simulation, and robotics. Equipping future professionals with these skills is essential for ensuring the competitiveness and innovation capacity of the Romanian industrial footwear sector in the digital age.

A comparative report based on the workshops organised in all 3 countries, Germany, Romania and Portugal, will be available on https://isov-project.eu/results/.

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