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Competency Requirements for EU Taxonomy Implementation in Production and Logistics

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Abstract

The implementation of the EU Taxonomy represents a key challenge for organisations operating in production and logistics systems, as it requires not only regulatory compliance but also the development of specific skills and knowledge. While existing research has addressed legal and financial aspects of the taxonomy, limited attention has been given to the competencies required for its practical application. This study aims to determine whether the legislative framework can be used as a structured database for identifying the skills and knowledge necessary to implement the EU Taxonomy and to assess the potential of Do No Significant Harm (DNSH) analysis as a learning and educational tool. The research adopts a qualitative case study approach, using Slovenia as an illustrative example. An analysis of European and national legislative acts was conducted and treated as a structured source of competency requirements. In total, 182 legal acts were reviewed and categorised according to EU Taxonomy environmental objectives. Based on this analysis, a set of 26 competencies was identified, including 11 general and 15 specific skills and knowledge areas relevant to production and logistics activities within organisational contexts. In addition, three DNSH analyses were developed to demonstrate the interdependencies between economic activities and environmental objectives. The results confirm that the legislative framework can serve as a comprehensive basis for identifying taxonomy-related competencies. Furthermore, DNSH analysis was used to demonstrate its potential as an educational and analytical tool for translating regulatory complexity into actionable and educational insights. The findings contribute to the understanding of capacity-building for EU Taxonomy implementation and provide a transferable foundation for developing education and training programmes across different European contexts.

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1. Introduction

The European Union's pathway toward climate neutrality has positioned sustainability as a strategic priority across all sectors of the economy. In order to support this transition, the European Union has introduced a comprehensive framework for classifying environmentally sustainable economic activities, known as the EU Taxonomy (Schütze and Stede, 2021; European Union, 2020). The taxonomy is designed to guide investment and operational decisions toward activities that contribute to environmental objectives, while ensuring transparency and consistency in sustainability-related reporting. Although its regulatory objectives are well defined, the effective implementation of the EU Taxonomy requires more than formal compliance; it demands adequate institutional capacity, professional skills, and sector-specific knowledge (Bohnert, 2025; Busch, 2025). The EU Taxonomy is closely linked to the objectives of the European Green Deal, which aims to transform the European Union into a climate-neutral economy by 2050. The taxonomy framework defines six environmental objectives: climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, and protection and restoration of biodiversity and ecosystems. An economic activity can be classified as environmentally sustainable only if it makes a substantial contribution to at least one of these objectives, does no significant harm (DNSH) to the others, complies with minimum social safeguards, and meets detailed technical screening criteria. By 2023, the taxonomy was expected to become fully operational for selected sectors and entities, increasing the need for systematic approaches to its application (European Commission, 2021).

In parallel with regulatory developments in the European Union, various countries worldwide have introduced or are developing classification systems to support sustainable finance. Such taxonomies differ in scope, governance, and maturity, and are being implemented in countries including South Africa, the United Kingdom, Chile, Mexico, Canada, Japan, China, and others. While many of these frameworks are government-led, some initiatives, such as those in Canada, are driven by private sector actors aiming to support a transition-oriented approach to sustainability classification (Bohnert, 2025; Busch, 2025). Despite these differences, a common challenge across jurisdictions remains the availability of adequately trained professionals capable of interpreting and applying taxonomy requirements in practice.

The implementation of the EU Taxonomy relies heavily on the integration of Environmental, Social, and Governance (ESG) criteria (Aguilera et al., 2021, La Torre et al., 2021). This challenge is consistent with prior findings showing substantial divergence and limited comparability among ESG ratings, which complicates their use as a reliable basis for regulatory and decision-making purposes (Berg et al., 2022). The environmental dimension focuses on issues such as greenhouse gas emissions, energy efficiency, and resource use. The social dimension addresses labour standards, human rights, and community impacts, while governance concerns transparency, management structures, and compliance with legal requirements. Together, these dimensions form the basis for assessing the sustainability of economic activities and introduce a high level of complexity for companies, particularly in production and logistics sectors, where activities are strongly interconnected across value chains.

Differences in the pace and depth of taxonomy implementation can be observed among EU member states. Countries such as France and Germany are considered leaders in aligning regulatory frameworks, educational systems, and professional training with sustainable finance requirements. Both countries have invested in developing advanced educational programs and institutional support mechanisms aimed at enhancing competencies related to ESG reporting and taxonomy application (Fatica and Panzica, 2021). In contrast, other member states, including Slovenia and Poland, are at earlier stages of practical implementation. While national strategies in both countries are aligned with the European Green Deal and long-term climate objectives, awareness and operational readiness among companies, particularly small and medium-sized enterprises, remain limited. This situation highlights a growing demand for targeted education and capacity-building initiatives tailored to national economic structures and sector-specific needs.

Existing research has addressed various aspects of environmental law, sustainable finance, and ESG frameworks; however, the identification of concrete skills and knowledge required for implementing the EU Taxonomy remains underexplored. Reviews of environmental and climate change law provide valuable insights into regulatory developments but offer limited guidance on competency requirements. The question of professional skills needed for taxonomy implementation is identified as a potential direction for future research. Empirical studies have further shown that key stakeholders, including financial institutions and advisory services, often demonstrate limited knowledge of the EU Taxonomy despite a strong interest in its application. Moreover, challenges related to internal knowledge sharing within organizations have been identified as a significant barrier to effective implementation (Alexander et al., 2014; Centobelli et al., 2022; Kretschmer et al., 2025). Empirical sector-level studies indicate that the EU Taxonomy introduces heterogeneous reporting and compliance demands across industries, which has been observed, for example, in analyses of food subsectors (Gombkötő et al., 2025).

Recent studies have increasingly addressed the practical challenges and consequences associated with the implementation and reporting requirements of the EU Taxonomy. Existing research has examined organizational responses to mandatory taxonomy disclosures, operational barriers to compliance, and the availability and reliability of taxonomy-related data (Hummel and Bauernhofer, 2024; O'Reilly et al., 2024; Alessi et al., 2024). Empirical evidence indicates that the application of taxonomy criteria, including DNSH requirements, involves substantial regulatory complexity and requires specialized technical and analytical capabilities, particularly in industrial and operational contexts (Ostojić et al., 2024).

Despite these contributions, the literature has primarily focused on reporting outcomes, governance implications, and financial effects of the EU Taxonomy, while comparatively limited attention has been paid to the systematic identification of competency requirements implied by the legislative framework itself, especially from the perspective of production and logistics engineering.

The aim of this study is to determine whether the legislative framework can be used as a structured database for identifying the skills and knowledge required to implement the EU Taxonomy in the production and logistics sector. Additionally, the study aims to examine whether Do No Significant Harm (DNSH) analysis can serve as an effective learning and educational tool for academic courses and professional training. The research is conducted using Slovenia as a case study, addressing an identified research gap and providing one of the first DNSH-based analyses tailored to the national context. Recent studies emphasise that DNSH operationalises a systemic approach to sustainability by explicitly addressing trade-offs between environmental objectives (Alessi et al., 2024; Esposto and Nupieri, 2025).

2. Experimental

2.1. Research design and analytical approach

The study was guided by two research questions focusing on the identification of skills and knowledge required for the implementation of the EU Taxonomy in the production and logistics sector, as well as on the potential of Do No Significant Harm (DNSH) analysis as an educational and learning tool. In order to address these questions, a qualitative research approach based on document analysis and case study methodology was adopted. According to Regulation (EU) 2020/852, the Do No Significant Harm (DNSH) principle requires that an economic activity making a substantial contribution to one environmental objective does not cause significant harm to any of the remaining objectives (European Union, 2020). The application of DNSH requires advanced regulatory, technical, and analytical competencies, extending beyond traditional ESG reporting practices (Achterfeldt et al., 2025; Dobija et al., 2025). The DNSH principle operationalises a systemic sustainability logic by explicitly addressing trade-offs between environmental objectives, which aligns with earlier life-cycle and circular economy approaches (Geissdoerfer et al., 2017; Sala et al., 2013; Schütze and Stede, 2021).

The DNSH assessment applied in this study is grounded in the EU Taxonomy framework as defined in Regulation (EU) 2020/852 and its delegated acts. The analysis refers to the technical screening criteria specifying conditions under which an economic activity does not cause significant harm to the remaining environmental objectives. In addition, the application of DNSH is subject to the fulfilment of minimum social safeguards, which constitute a horizontal requirement of the EU Taxonomy framework. In the present study, these safeguards were treated as a boundary condition ensuring regulatory compliance, while the analytical focus was placed on the environmental dimensions of DNSH relevant to production and logistics activities.

2.2. Selection protocol of legislative acts

The selection of legislative acts was conducted following a structured and transparent protocol to ensure replicability of the analysis. The review included European Union and national legislative acts relevant to the six environmental objectives defined in Regulation (EU) 2020/852. Data collection and legislative screening were conducted between December 2024 and January 2025. The temporal scope covered legal acts in force as of January 2025, including both primary legislation and delegated acts applicable to production and logistics activities. Acts were included if they contained provisions related to environmental performance, sustainability requirements, or regulatory conditions affecting economic activities covered by the EU Taxonomy. Procedural regulations without substantive environmental or operational relevance were excluded. In cases where legal acts had been amended, the consolidated versions valid at the time of analysis were used. Repealed acts were not included unless their provisions remained applicable through transitional arrangements. This protocol resulted in a final dataset of 182 legislative acts subjected to further qualitative analysis.

Legislative acts were retrieved primarily from the Ecolex legal database using structured keyword searches (e.g., “environmental protection,” “emissions,” “waste,” “energy efficiency,” “transport”) and filtered by document type (binding legal acts) and language (Slovenian and English). Acts were screened manually for substantive relevance to production and logistics activities and assigned to environmental objectives based on the primary objective explicitly addressed in the regulation. Where multiple objectives were referenced, the dominant regulatory focus was used for classification.

2.3. Procedure for competency identification and coding

The identification of competency requirements was based on a qualitative content analysis of the selected legislative acts. Relevant passages referring to obligations, technical requirements, reporting duties, and compliance conditions affecting production and logistics activities were systematically screened. Competencies were extracted iteratively and grouped into preliminary thematic categories reflecting regulatory, technical, organizational, and analytical skill domains. To enhance analytical reliability, the extraction and categorization of competencies were conducted collaboratively by the research team and discussed iteratively during the analysis process. Overlapping or closely related competencies were merged to avoid duplication and inflation of the final list. Ambiguous cases were resolved through expert discussion, taking into account the context of the legal provisions and their relevance to the implementation of the EU Taxonomy. The resulting competency set represents a synthesized and consolidated outcome of the legislative review. This process resulted in the identification of 26 core competencies, which form the basis for the subsequent analysis and discussion.

In the first stage of the research, long-term strategies and policy documents related to the transition toward a low-carbon economy by 2040 or 2050 were reviewed. In parallel, a targeted literature search was conducted using Google Scholar, applying keywords such as “EU taxonomy,” “skills,” and “knowledge.” Although a substantial number of publications were identified, only a limited number were directly relevant to the research objectives. These findings were subsequently combined with insights from previous studies addressing priority topics in logistics and production companies in Slovenia.

The core of the study was based on an analysis of the legislative framework at both the European Union and national (Slovenian) levels. The legislative framework was treated as a structured database used to identify the skills and knowledge necessary for adopting the EU Taxonomy. Due to the extensive scope of relevant legal acts, a selection process was required. For this purpose, the Ecolex portal was used as the primary source for identifying applicable legislation (“Zakonodaja” [Portal Ecolex Life], n. d.). The identified legal acts were then categorized according to their relevance to individual EU Taxonomy environmental objectives. The unit of analysis was a regulatory obligation or requirement expressed at the level of articles or paragraphs (e.g., "shall," "must," "is required to"). Normative statements were mapped to competencies by translating regulatory requirements into corresponding skills or knowledge areas (e.g., an obligation related to emissions monitoring was mapped to competency in emissions measurement and reporting). For example, requirements related to energy efficiency reporting under EU legislation were translated into competencies in energy performance assessment and regulatory compliance. To ensure consistency, a subset of legislative acts was independently reviewed by a second researcher, and discrepancies in competency interpretation were resolved through iterative discussion until consensus was reached.

2.4. DNSH regulatory basis and screening criteria

To further illustrate the complexity of the EU Taxonomy and the interdependencies between business activities and environmental objectives, Do No Significant Harm (DNSH) analyses were conducted. The DNSH analyses were designed to demonstrate how specific economic activities may contribute to one environmental objective while potentially affecting others. Three DNSH analyses were developed and adjusted to the Slovenian context, taking into account national economic structures and regulatory conditions.

The finalized list of legal acts served not only as the basis for the DNSH analyses but also as an input for identifying the general and specific skills and knowledge required for the implementation of the EU Taxonomy in Slovenia. A visual representation of the overall research methodology is presented in Figure 1.

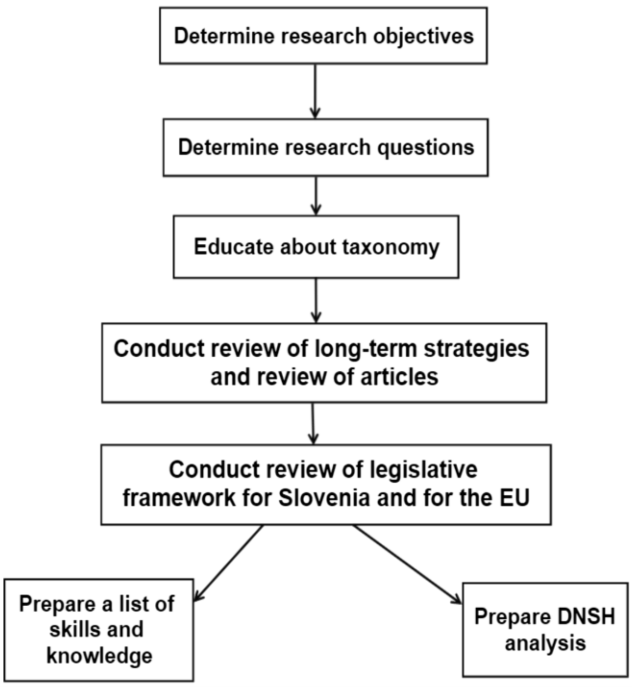

Fig. 1. Visual representation of methodology

The selection of business activities for the DNSH analyses was based on the list of activities defined within the EU Taxonomy regulations ("Application of the EU Taxonomy for Companies" [EU Taxonomy Info], n. d.; "EU taxonomy" [Deloitte], n. d.). To ensure relevance at the national level, data from the Slovenia Business Point (SPOT) and the Statistical Office of the Republic of Slovenia (SISTAT) were used. Business activities employing more than 250 persons were identified using the category "Enterprises by activities," based on NACE Rev. 2 classification ("Enterprises by activities (NACE Rev. 2) and size class by number of persons employed, Slovenia, annually," n. d.). The DNSH references were based on the climate, circular economy, and pollution-related technical screening criteria defined in the Commission Delegated Regulations supplementing Regulation (EU) 2020/852, while minimum social safeguards were treated as a prerequisite for compliance and were not assessed separately in the illustrative DNSH examples.

3. Results and discussion

3.1. Competency requirements derived from the legislative framework

Based on the analysis of the legislative framework, a structured list of skills and knowledge required for the implementation of the EU Taxonomy in Slovenia was developed. The results indicate that successful adoption of the taxonomy requires a combination of general, cross-sectoral competencies and highly specific, technically oriented knowledge. In total, 26 distinct competencies were identified, comprising 11 general skills and knowledge areas and 15 specific ones, as presented in Table 1.

The general skills and knowledge primarily relate to an understanding of the EU Taxonomy framework, its environmental objectives, and the systemic logic underpinning the Do No Significant Harm (DNSH) principle. These competencies include familiarity with the legislative environment, the ability to navigate regulatory requirements, and awareness of the interdependencies between environmental goals. Such skills are not limited to a single sector and are essential for professionals involved in decision-making, reporting, and strategic planning across production and logistics systems.

The specific skills and knowledge reflect the technical and operational complexity of implementing the taxonomy in practice. They are closely linked to production and logistics activities and include knowledge of renewable energy systems, zero- and low-emission transport technologies, smart infrastructure, digital tools, and supply chain management solutions. The results indicate that taxonomy implementation extends beyond compliance-oriented activities and requires a strong technical foundation, particularly in sectors where environmental impacts are distributed across multiple stages of the value chain (Lazar et al., 2022; Pacana et al., 2025; Staniszewska et al., 2020).

Table 1: Skills and knowledge, needed to adopt EU taxonomy in Slovenia

General skills and knowledge	Specific skills and knowledge
Knowledge of the EU taxonomy tool	Understanding the importance of sustainable development in logistic processes
Knowledge of the importance of a systemic approach (with DNSH criteria in mind)	Renewable energy sources (with infrastructure)
Knowledge of the technical characteristics of means of transport and infrastructure to accommodate regulations	Zero-emission (electric vehicles, hydrogen vehicles) and low-emission means of transport
Knowledge of the technical criteria for each taxonomy pillar (with DNSH criteria in mind)	Energy corridors and its infrastructure (renewable energy)
Knowledge of the legislative framework for a certain business area	Smart grid (artificial intelligence in urban transport, 5G network, TEN-T network)
Ability to identify sources of pollution in supply chain	Emission standards for different means of transport
Ability to manage city logistics within regulations and given technical criteria	Mechanism of financial grants and subsidies
Ability to manage supply chain in digital and/or multicultural environment	Zero-emission urban transport (sustainable means of transport)
Knowledge of digital infrastructure	Development of computer-based models for analysis
Ability to predict the need for logistic assets (means of transport and which services to use)	Cloud services
Knowledge of the sustainable transport corridors (and its properties)	Energy market operators
	Multimodal transport
	Managing the flow of recycled raw materials and waste management
	Management of supply chain (reducing time and spatial distances, reducing negative external effects)

The review of Slovenia's legislative framework covered a total of 182 legal acts. Of these, 45 laws (24.7%) apply universally to all business activities, while the remaining acts are sector-specific. Notably, 61% of the analyzed legislation applies to less than 10% of business activities, highlighting the fragmented and specialized nature of the regulatory environment (Figure 2). This finding demonstrates that taxonomy implementation cannot rely on a uniform approach and reinforces the need for tailored competencies aligned with specific business activities.

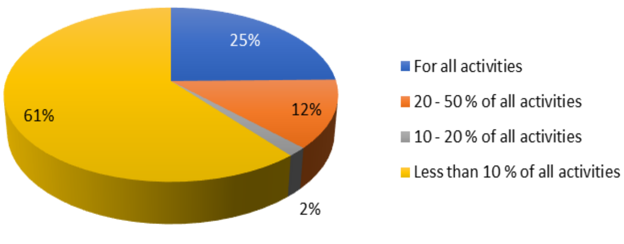

Fig. 2. Visual representation of the methodology, showing the distribution of Slovenia's legislative framework by the applicability of laws to business activities

Although the EU Taxonomy defines six environmental objectives, the present analysis focuses on three of them: climate change mitigation, transition to a circular economy, and pollution prevention and control. This selection reflects the objectives most directly relevant to production and logistics activities, which are characterized by high energy intensity, material flows, and emissions. From a regulatory perspective, these objectives are associated with the highest density of legislative acts and the most detailed technical screening criteria affecting industrial and logistics operations. Consequently, they generate the most significant and immediate competency requirements for organizations operating in these sectors. The remaining environmental objectives were not excluded due to lack of importance but were considered beyond the analytical scope of this study, which aims to identify core competencies under conditions of the strongest regulatory and operational pressure.

3.2. DNSH-based analysis of environmental objectives

In line with the declared analytical scope of this study, the DNSH analysis focuses exclusively on climate change mitigation, transition to a circular economy, and pollution prevention and control. The DNSH analysis provided additional insight into the distribution of environmental impacts across economic activities in Slovenia. The results show that most analyzed activities significantly contribute to climate change mitigation while simultaneously being required to avoid causing significant harm to other environmental objectives as defined by the DNSH principle. This asymmetry between contribution and harm highlights the practical challenges of applying the DNSH principle, particularly in production-oriented sectors where trade-offs between environmental objectives are common. An extract of the DNSH analysis is presented in Table 2.

From an educational and practical perspective, the DNSH analysis proved to be a valuable analytical and learning tool. By mapping business activities against multiple environmental objectives, the DNSH framework enables a clearer understanding of systemic interactions and unintended consequences. The results suggest that DNSH analysis can effectively support training programs by illustrating the complexity of the EU Taxonomy and encouraging holistic thinking among students and practitioners.

The findings also underline the relevance of the public sector and service industries in supporting regulatory compliance related to climate change mitigation and pollution prevention and control. In these sectors, competencies associated with monitoring, reporting, and managing environmental impacts play a particularly important role, as regulatory requirements often translate into organisational procedures rather than direct technological interventions. This highlights the need for cross-sectoral skills that enable organisations to operationalise mitigation-oriented objectives within administrative and service-based contexts.

Overall, the results confirm that the legislative framework can serve as a comprehensive and structured source for identifying the skills and knowledge required to implement the EU Taxonomy. Moreover, the DNSH analysis offers a practical mechanism for translating regulatory complexity into actionable insights, supporting both organizational decision-making and educational program development.

Table 2: Extract of DNSH analysis, adjusted for Slovenia's example

Business activity	Climate change mitigation	Climate change adaptation	Sustainable use and proteciton of water and marine resources
02 Forestry	substantial contribution	substantial contribution	no significant harm
05 Mining of hard coal	no significant harm	no significant harm	no significant harm
10 Manufacture of food	no significant harm	no significant harm	substantial contribution
11 Manufacture of drinks	no significant harm	no significant harm	substantial contribution
13 Manufacture of textiles	no significant harm	no significant harm	no significant harm
15 Manufacture of leather and leather goods	no significant harm	no significant harm	substantial contribution
16 Wood skidding, manufacture of products form wood or articles of cork, straw and plaiting materials	no significant harm	no significant harm	no significant harm
17 Manufacture of paper and paper products	no significant harm	no significant harm	substantial contribution
20 Manufacture of chemicals and chemical products	substantial contribution	substantial contribution	substantial contribution
21 Manufacture of basic pharmaceutical products and pharmaceutical preparations	substantial contribution	substantial contribution	no significant harm
22 Manufacture of rubber and plastic products	no significant harm	no significant harm	substantial contribution
23 Manufacture of non-metallic mineral products	substantial contribution	substantial contribution	substantial contribution
24 Casting of metals	substantial contribution	substantial contribution	substantial contribution
25 Production of other metal products	no significant harm	no significant harm	substantial contribution
26 Manufacture of computers, electronic equipment and optical products	substantial contribution	substantial contribution	substantial contribution
27 Manufacture of electric equipment	substantial contribution	substantial contribution	substantial contribution
28 Production of other machines	substantial contribution	substantial contribution	substantial contribution
29 Manufacture of motor vehicles, trailers and semi-trailers	substantial contribution	substantial contribution	substantial contribution

Courses on the EU Taxonomy can be effectively integrated into existing educational programmes offered by academic institutions. Current curricula already include content aligned with many of the skills and knowledge areas identified in the analysis; however, this content is often dispersed across different courses and not explicitly linked to the EU Taxonomy framework. Study programmes such as Smart and Safe Mobility or Managing the Supply Chain of the Future provide a solid foundation for developing or adapting courses focused specifically on EU Taxonomy requirements (Achterfeldt et al., 2025; Alexander et al., 2014; Centobelli et al., 2022).

A general understanding of the legislative framework emerged as a fundamental competence. This does not require detailed knowledge of every individual regulation, but rather the ability to navigate the legal landscape, identify relevant sources of information, and interpret legal requirements in relation to specific business activities. Regulations related to financial subsidies, grants, or waste management typically apply across a wide range of sectors, whereas more specialized legal acts concern specific materials, technologies, or operational processes and are relevant only to selected industries.

At the technical level, familiarity with emerging technologies, including new transport solutions and artificial intelligence-based systems such as smart grids, is essential. Professionals in the logistics and production sectors must be capable of identifying, selecting, and implementing appropriate technologies within their operational processes. Managing supply chains with an environmental focus was also identified as a key requirement, which necessitates a systemic approach. Without such an approach, broader environmental impacts of interconnected business activities may remain unrecognized.

Understanding the EU Taxonomy framework, particularly the Do No Significant Harm (DNSH) principle, constitutes a core competency. Individuals are required to identify economic activities subject to taxonomy reporting, assess potential negative impacts on other environmental objectives, and quantify contributions to sustainability goals. The results indicate that companies benefit from developing their own DNSH analyses, as these support a clearer understanding of how operational activities align with taxonomy pillars and facilitate informed adjustments aimed at improving environmental performance and regulatory compliance.

DNSH analysis provides a clear and structured representation of the complexity of the EU Taxonomy. For example, manufacturing activities were found to significantly contribute to five of the six environmental objectives, highlighting the need for specialized knowledge in this sector. Given that manufacturing represents a substantial share of Slovenia's economy, the potential target group for taxonomy-related education and training is considerable. In contrast, relatively few activities are directly linked to objectives beyond climate change mitigation, circular economy, and pollution prevention and control, which reinforces the need to prioritise these three objectives in competency development, which underscores the importance of focused competencies related to DNSH criteria in this area. Furthermore, the manufacturing sector plays a central role in the transition toward a circular economy, particularly through sustainable product design.

The results also emphasize the important role of the public sector and service industries in supporting regulatory compliance related to climate change mitigation and pollution prevention and control, reinforcing the need for cross-sectoral knowledge and skills related to the EU Taxonomy. Continuous updates to the legislative framework require ongoing data collection and analysis to maintain alignment with evolving taxonomy requirements. Future research should further explore the complexity of the taxonomy in terms of the volume and scope of applicable regulations, while comparative studies across countries or industries could provide additional insight into the specific skills and knowledge required for effective implementation.

Recommendations for countries developing their own approach to the EU Taxonomy, derived from the results of this study, include the following steps:

Step 1: Establish a legislative database as a starting point by identifying and organizing existing legal acts according to their relevance to taxonomy pillars, such as climate change mitigation, circular economy, or biodiversity protection.

Step 2: Conduct a Do No Significant Harm (DNSH) analysis at the national or sectoral level to identify activities that substantially contribute to environmental objectives and those that must avoid causing harm to other goals.

Step 3: Identify key skills and knowledge required for taxonomy implementation by developing a comprehensive list of general and sector-specific competencies for businesses, public authorities, and educational institutions.

Step 4: Use existing educational programmes as a foundation for new or adapted courses by integrating taxonomy-related content, including smart mobility, sustainable supply chain management, and green technologies.

Step 5: Develop tailored educational materials, such as DNSH analyses, regulatory mappings by business activity, and simplified models for assessing environmental impacts, to ensure practical applicability.

Step 6: Address the specific needs of local economic sectors by focusing educational and training efforts on industries most affected by taxonomy requirements, such as manufacturing, public services, or agriculture.

Step 7: Apply a systemic approach in both education and implementation to emphasize the interconnected nature of environmental objectives and the multi-sectoral impacts of economic activities.

Step 8: Monitor legislative changes and regularly update educational content and DNSH analyses to ensure continued compliance with evolving EU Taxonomy regulations.

Building on this European perspective, the results also allow for indicating potential directions for developing courses in production engineering with explicit reference to the EU Taxonomy, using countries such as Poland as illustrative examples. In such national contexts, production engineering programmes traditionally emphasize process optimisation, manufacturing technologies, quality management, and logistics efficiency. The findings of this study suggest that these core areas can be systematically expanded by embedding taxonomy-related content, without the need to establish entirely new study programmes.

In particular, courses related to production systems, manufacturing technologies, and operations management may be enriched by incorporating EU Taxonomy criteria as an additional analytical layer. For example, assessments of production processes can be extended beyond cost, quality, and efficiency indicators to include substantial contribution to environmental objectives and compliance with DNSH requirements. This approach enables students to analyse production decisions simultaneously from technical, economic, and regulatory perspectives.

The results further indicate that subjects such as sustainable manufacturing, industrial ecology, and circular economy provide a natural entry point for introducing taxonomy-related competencies. In countries with a strong manufacturing base, case-based teaching focused on energy-intensive industries, material efficiency, waste management, and product design for circularity may be particularly relevant. DNSH analysis can be applied as a practical tool within project-based courses, allowing students to evaluate trade-offs between environmental objectives in realistic production scenarios.

Moreover, the integration of EU Taxonomy content into production engineering education in such contexts may support closer cooperation between universities and industry. Courses developed in collaboration with manufacturing companies can address real regulatory challenges faced by enterprises, particularly in relation to reporting obligations, investment planning, and technology selection under taxonomy requirements. Such cooperation enhances the practical relevance of engineering education while supporting companies in building internal competencies necessary for taxonomy implementation.

Implementing the EU Taxonomy guidelines in the manufacturing sector requires not only knowledge of regulations but also a deep understanding of technological and material processes. For example, optimizing the microstructure of components in advanced foundry processes (Szczotok et al., 2017) demonstrates how precise control of production parameters impacts product durability, which aligns with the goals of the circular economy. At the same time, the pursuit of sustainable production in the energy sector requires optimizing the operating cycles of generating units, where shortening start-up and shutdown times directly translates into reduced environmental impacts (Dwornicka, 2014). Energy efficiency of infrastructure, which forms the foundation of taxonomy reporting, also remains a key challenge. Research shows that intelligent building management systems offer significantly improved thermal comfort while simultaneously reducing resource consumption compared to traditional solutions (Orman et al., 2022). The selection of appropriate structural components, such as door and window joinery, must be closely correlated with the climatic conditions of a given location to effectively support climate change mitigation goals (Djokovic et al., 2022).

Implementing new regulations requires engineering staff to be able to manage data uncertainty and analyze complex biological and chemical relationships. In situations with limited sample sizes, traditional statistical methods may be insufficient, justifying the use of a fuzzy regression approach in the optimization of biotechnological and industrial processes (Pietraszek and Skrzypczak-Pietraszek, 2014). This variability is also evident in analyses of natural biochemical cycles, where the timing of raw material extraction is critical for their quality and composition (Skrzypczak-Pietraszek and Pietraszek, 2014). In the context of logistics and maintenance, monitoring deposits and contaminants in biomass-coal co-firing systems is essential to maintaining operational efficiency in compliance with environmental standards (Opydo et al., 2019). Similar requirements apply to the design of materials for bioimplant production (Dudek, 2011). Ultimately, the reliability of reporting within the Taxonomy depends on the objectivity of assessment methods, where modern image analysis tools and statistical techniques such as bootstrap allow for increased measurement repeatability (Gadek-Moszczak et al., 2015).

Overall, the results suggest that expanding production engineering curricula with EU Taxonomy-related content does not require a radical restructuring of existing programmes. Instead, it can be achieved through targeted, modular integration of legislative knowledge, DNSH-based analysis, and systemic thinking into established engineering courses, thereby strengthening the preparedness of future engineers for regulatory and sustainability challenges across the European manufacturing sector.

4. Summary and conclusion

The study adopts an exploratory and methodological perspective; therefore, the identified competency set represents a synthesized outcome of legislative analysis, while further empirical validation of these competencies and the educational effectiveness of DNSH-based approaches constitutes an important direction for future research.

This study addressed the challenge of building competencies required for the implementation of the EU Taxonomy in production and logistics systems. By treating the legislative framework as a structured database, it was possible to identify a comprehensive set of general and specific skills and knowledge necessary for applying taxonomy requirements in practice. The results demonstrate that taxonomy implementation extends beyond formal compliance and requires a combination of regulatory awareness, technical expertise, and systemic thinking.

The analysis illustrated the potential of DNSH analysis as an analytical and educational support tool. DNSH analysis enables a clearer understanding of the interdependencies between environmental objectives and economic activities, supporting informed decision-making and learning processes. In the Slovenian case, the DNSH analyses conducted represent a novel contribution and provide a foundation for further research.

Overall, the findings confirm that the legislative framework can be effectively used to identify competency requirements for EU Taxonomy implementation, while DNSH analysis offers a practical mechanism for operationalising these requirements. The study contributes to the growing body of research on sustainable production and logistics and supports the development of education and training initiatives aligned with the objectives of the European Green Deal.

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