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VERTICAL VS HORIZONTAL GREEN SKILLS MISMATCHES: EVIDENCE FROM NORTH MACEDONIA

Abstract: *The green transition reshapes labour markets and generate increased demand for specialized green skills, intensifying skills mismatches in transition economies. This paper provides theoretical background and empirical evidence on vertical and horizontal green skills mismatches in North Macedonia, on a representative survey of 530 firms conducted in March/April 2025. Vertical mismatch is defined as inadequacy of qualification levels, while horizontal mismatch captures misalignment between employees' field-specific green skills and job requirements. Using ordered logistic regression, the study examines how firm characteristics, including size, sector, internationalization, adoption of environmental standards, CSR practices, and training capacity, influence the likelihood of green skills mismatches. The findings indicate that underskilling and horizontal mismatches are the most prevalent challenges, particularly among SMEs, exporting companies, and firms pursuing advanced environmental standards. Conversely, firms with foreign direct investment and those actively implementing green practices face lower field-related mismatches. Sectoral and occupational analyses reveal substantial heterogeneity in green skill readiness. The study underscores the need for targeted upskilling, VET curriculum reform, and stronger industry–education collaboration to enable an inclusive and effective green transition in North Macedonia.*

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Introduction

The green transition has been globally transforming the structure of production and consumption towards less-polluting and more resource efficient economies. The adoption of new green technologies impact almost all industries, necessitating upskilling and reskilling of workers to remain competitive in the labour market. Hence, the greening of the economy will inevitably change the skills required and the tasks involved in many of the existing occupations. This transformation is particularly critical for countries like North Macedonia, where the alignment of skills with the evolving needs of a green economy remains a significant challenge.

Despite policy commitments to sustainability, many countries, including North Macedonia, face skills mismatches, where the qualifications and expertise of workers do not align with the demands of the labor market. Skills mismatches can be categorized into two primary dimensions: Vertical mismatch, which refers to discrepancies in the level of skills or qualifications (e.g., overqualification or underqualification), and Horizontal mismatch, which involves a misalignment between the field of skills or education and the requirements of the job. While the importance of addressing these mismatches is widely recognized, granular, country-specific evidence particularly in transition economies remains limited. In North Macedonia, the existing occupational structure and skill levels are often misaligned with the goals of a sustainable, green economy. This gap in evidence hinders the development of targeted policies to bridge vertical and horizontal mismatches, which are critical for a successful green transition.

This paper aims to address this research gap by providing empirical evidence on the determinants of vertical and horizontal green skills mismatches in North Macedonia. Using data from a representative survey of 530 companies conducted in March 2025, we employ ordered logistic regression models to analyze the factors influencing these mismatches. Our findings highlight the dual challenge of bridging qualification gaps (vertical) and realigning training systems to cover emerging green occupational fields (horizontal).

1. LITERATURE REVIEW

The rapid pace of the green transition has led to significant skills mismatches, which are increasingly viewed as barriers to economic and ecological transformation. Skills mismatch generally refers to the misalignment between the qualifications or skills of workers and those required by the labor market. This concept is often broken down into two main dimensions. Vertical mismatch occurs when the level of education or skills is either higher (overqualification) or lower (underqualification) relative to job requirements (McGuinness, Pouliakas, & Redmond, 2017). This type of mismatch often leads to inefficiencies in labor allocation and reduced productivity. Horizontal mismatch arises when the field of education or skills does not align with the specific needs of the job (Brunello & Wruuck, 2021). This misalignment can result in workers being employed in roles that do not fully utilize their expertise, leading to job dissatisfaction and suboptimal performance. Despite policy commitments to the green transition, systematic assessment of the green skills gaps, especially distinguishing between vertical and horizontal mismatches remains underexplored.

In the context of the green transition, green skills specialized competencies related to environmental sustainability have emerged as a critical focus. These skills are essential for occupations in renewable energy, eco-design, waste management, and energy efficiency, which are increasingly in demand as economies shift toward sustainability (Vona, Marin, Consoli, & Popp, 2015). Green skills encompass technical proficiencies, such as the application of green technologies, as well as transversal skills, including eco-conscious decision-making and values that promote sustainable development (Nikoloski, et al., 2024).

The adoption of green technologies and practices is fundamentally transforming labor markets. Studies have shown that green jobs often require higher skill levels compared to traditional roles (Consoli, Marin, Marzucchi, & Vona, 2016). For example, workers in renewable energy or eco-design sectors need not only technical expertise, but also knowledge of environmental regulations and sustainable practices. Firms engaged in innovation or international trade are particularly likely to demand specialized green expertise, which can exacerbate existing skills mismatches (da Costa, et al., 2025).

The green transition also underscores the importance of lifelong learning and continuous upskilling to ensure workers can adapt to evolving job requirements. However, many economies, particularly transition economies, struggle

to provide adequate training opportunities. This challenge is compounded by outdated educational systems that fail to incorporate green competencies into curricula (Nikoloski, et al., 2024). The Labor Market Intelligence (LMI) approach, which leverages big data and Natural Language Processing (NLP), has emerged as a promising tool for identifying green skills gaps. By analyzing on-line job vacancies and job seeker profiles, LMI can provide real-time insights into the demand and supply of green skills, helping policymakers and educators design targeted interventions (Nikoloski, et al., 2024; Sulich, Sołducho-Pelc and Grzesiak, 2023). In North Macedonia, policy commitments to the green transition have yet to translate into comprehensive skills development strategies, leaving firms and workers ill-equipped for the challenges ahead.

Transition economies face unique challenges in addressing skills mismatches such as outdated education curricula (Nedanovski & Daniloska, 2021); limited training capacities and weak institutional support; and, low technological absorption.

In North Macedonia, existing research acknowledges skill shortages but lacks a systematic distinction between vertical and horizontal mismatches (Nedanovski & Daniloska, 2021). This gap is critical, as different types of mismatches require tailored policy responses. For instance, vertical mismatches may necessitate upskilling programs to raise qualification levels, while horizontal mismatches may require reforms in vocational education and training (VET) to align skills with industry needs (Gregg, et al., 2015). The use of ESCO (European Classification of Skills, Competences, Qualifications, and Occupations) provides a structured framework for identifying and classifying green skills, enabling better alignment between education and labor market needs (Nikoloski, et al., 2024).

2. METHODOLOGY

This study employs a mixed-methods approach, combining quantitative survey data with econometric analysis to examine the determinants of vertical and horizontal green skills mismatches in North Macedonia. The primary data source is a representative survey of 530 companies conducted in March/April 2025. The survey was designed to capture firms' perceptions of employees' green skills adequacy, focusing on level of qualification (vertical mismatch) and field relevance (horizontal mismatch). The survey sample is stratified to ensure representativeness across statistical regions (NUTS-3 level), economic

sectors (classified by NACE Rev.2) and company size (micro, small, medium, and large enterprises).

The survey measures the following key variables:

- **Dependent variables:**
 - Underskilling (vertical mismatch)
 - Horizontal mismatch
 - Overskilling
- **Explanatory variables:**
 - Firm size (SME vs. large)
 - Foreign direct investment (FDI)
 - Import/export participation
 - Membership in business associations
 - Adoption of environmental standards
 - Implementation of green practices
 - Training capacity
 - Corporate Social Responsibility (CSR) activities

Skills mismatches are measured using a 5-point Likert scale, where firms self-assess the adequacy of their employees' green skills. This approach aligns with the European Centre for the Development of Vocational Training (CEDEFOP) framework, which categorizes skills mismatches as either vertical or horizontal (Cedefop, 2022).

To analyze the determinants of green skills mismatches, this study employs ordered logistic regression models. Ordered logistic regression is chosen because the dependent variables (underskilling, horizontal mismatch, and overskilling) are ordinal in nature, representing different levels of skills mismatch. Hence, three separate ordered logistic regression models are estimated with respect to underskilling, horizontal mismatch and overskilling.

The general form of the ordered logistic regression model is:

$$\log \left(\frac{P(Y \leq j)}{1 - P(Y \leq j)} \right) = \alpha_j - (\beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k)$$

where:

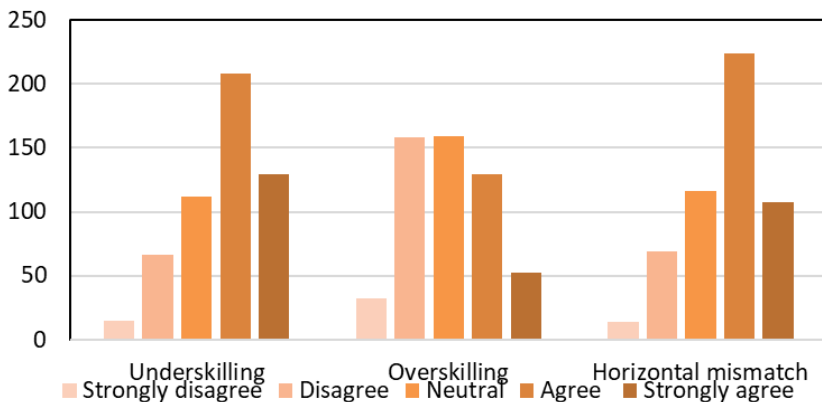
- Y is the ordinal dependent variable (e.g., Underskilling, Horizontal mismatch, or Overskilling).
- X_1, X_2, \dots, X_k are the explanatory variables.
- α_j are the threshold parameters for each level of the dependent variable.
- $\beta_1, \beta_2, \dots, \beta_k$ are the coefficients to be estimated.

3. RESULTS

The survey findings reveal a notable yet uneven adoption of green practices among companies in North Macedonia, reflecting both progress and persistent challenges in the green transition. According to the data, 59.8% of surveyed companies have implemented at least one green practice, signaling a growing commitment to sustainability and environmental responsibility. However, a significant portion of 40.2% report having no green practices in place, highlighting substantial variation across industries and firms.

The survey results presented in Figure 1 highlight the perceived severity of green skills mismatches among firms in North Macedonia, offering critical insights into the challenges posed by the green transition. The findings reveal that underskilling and horizontal mismatch are viewed as particularly pressing issues, with a significant majority of respondents strongly agreeing that these mismatches represent substantial problems. This aligns with the broader literature, which underscores the challenges firms face in finding workers with adequate green qualifications (vertical mismatch) and the right type of green skills (horizontal mismatch) (Nikoloski et al., 2024; CEDEFOP, 2022). Conversely, while overskilling is also acknowledged as a concern, it is perceived as less critical compared to underskilling and horizontal mismatch. These results underscore the dual challenge of bridging qualification gaps and realigning training systems to address emerging green occupational fields, as discussed in the literature review (OECD, 2022; Janta et al., 2023).

Figure 1: To what extent the green skills mismatch represents a problem?



Source: author's calculations

3.1 Mismatch by industry

The analysis of skills mismatches by industry reveals significant variations in the prevalence of underskilling, horizontal mismatch, and overskilling across different sectors in North Macedonia. Notably, Public Administration and Defense; Compulsory Social Security exhibits the highest level of underskilling, followed closely by Arts, Sports and Recreation and Water Supply, Sewerage, Waste Management and Remediation. This suggests that these industries face substantial challenges in securing employees with adequate green qualifications, potentially due to the specialized nature of green skills required in these fields. Conversely, Electricity, Gas, Steam, and Air-Conditioning Supply and Mining and Quarrying report no underskilling, indicating either a strong alignment of skills with job requirements or a lower demand for green skills in these sectors.

In terms of horizontal mismatch, Mining and Quarrying and Water Supply, Sewerage, Waste Management and Remediation show the highest levels, reflecting a significant misalignment between the field-specific skills employees possess and those required by their jobs. This highlights the need for targeted training and education programs to better align workers' skills with industry demands. On the other hand, Information and Telecommunication reports the lowest horizontal mismatch, suggesting a relatively better alignment of skills in this sector.

Overskilling is most pronounced in Human Health and Social Work Activities, indicating that employees in this sector often possess green skills that exceed job requirements. Conversely, Information and Telecommunication and Professional, Scientific and Technical Activities exhibit negative values for overskilling, suggesting that employees in these sectors may not possess surplus green skills.

Table 1: Average skills mismatch according to industry

	Under skilling	Horizontal mismatch	Over skilling
Water supply, sewerage, waste management and remediation	0.94	0.89	0.00
Public Administration and Defense; Compulsory Social Sec.	1.25	1.00	-0.25
Agriculture, forestry and fishing	0.93	0.90	0.03
Human Health and Social Work Activities	0.77	0.77	0.54
Construction	0.74	0.65	0.09
Financial and Insurance Activities	0.87	0.87	0.13
Wholesale and retail trade, repair of motor vehicles and mot.	0.79	0.64	0.05
Arts, Sports and Recreation	0.95	0.76	0.05
Education	0.77	0.50	0.27
Accommodation and food service activities	0.69	0.38	0.15
Other Service Activities	0.69	0.66	0.08
Professional, Scientific and Technical Activities	0.61	0.56	-0.22
Manufacturing	0.54	0.61	-0.18
Electricity, gas, steam and air-conditioning supply	0.00	0.60	0.00
Transportation and storage	0.65	0.70	0.20
Administrative and Support Service Activities	0.50	0.38	-0.17
Information and Telecommunication	0.14	0.05	-0.52
Mining and quarrying	0.00	1.00	-0.25

Source: author's calculations

3.2 Mismatch by occupation

The analysis of green skills mismatches by occupation reveals significant variations in the prevalence of underskilling, horizontal mismatch, and overskilling across different occupational groups in North Macedonia. Professionals and Plant and Machine Operators and Assemblers exhibit the highest levels of underskilling, indicating that workers in these roles often lack the necessary green skills to meet job demands effectively. Similarly, Skilled Agricultural, Forestry, and Fishery Workers and Service and Sales Workers also face considerable underskilling, suggesting a pressing need for targeted

upskilling initiatives in these sectors. In terms of horizontal mismatch, Professionals, Skilled Agricultural, Forestry, and Fishery Workers, and Craft and Related Trades Workers experience the highest misalignment between their green skills and job requirements, highlighting the importance of aligning training programs with industry-specific needs. Conversely, Managers and Elementary Occupations show relatively lower levels of underskilling, while Clerical Support Workers and Elementary Occupations exhibit the lowest horizontal mismatch, suggesting a better alignment of skills with job demands in these roles.

Overskilling is most pronounced among Skilled Agricultural, Forestry, and Fishery Workers and Service and Sales Workers, indicating that workers in these occupations often possess green skills that exceed job requirements. This may point to inefficiencies in skill utilization or a need for job redesign to better leverage workers' competencies. On the other hand, Managers and Clerical Support Workers exhibit negative values for overskilling, suggesting that their green skills are closely aligned with job demands.

Table 2: Average skills mismatch according to occupation

Occupation	Under skilling	Horizontal mismatch	Over skilling
Skilled agricultural, forestry and fishery workers	0.73	0.89	0.32
Professionals	0.91	0.90	0.10
Craft and related trades workers	0.44	0.88	0.00
Technicians and associate professionals	0.73	0.69	0.07
Plant and machine operators and assemblers	0.81	0.81	0.14
Service and sales workers	0.79	0.80	0.23
Managers	0.66	0.68	-0.08
Clerical support workers	0.70	0.60	-0.02
Elementary occupations	0.54	0.52	0.05

Source: author's calculations

3.3 Mismatch by green practices

The analysis of green skills mismatches across different green practices reveals notable variations in the extent of underskilling, horizontal mismatch, and overskilling that companies experience in North Macedonia. Eco-design

of products stands out with the highest level of underskilling, indicating that companies struggle significantly to find workers with the necessary skills to implement eco-design principles effectively. Similarly, “Other green practices” and producing eco-products also face considerable underskilling, suggesting a broad need for upskilling and reskilling initiatives to address these gaps. In terms of horizontal mismatch, “Other green practices” and Eco-design of products exhibit the highest levels, reflecting a substantial misalignment between the field-specific green skills workers possess and those required by these practices. This highlights the need for targeted training programs to better align workers’ competencies with the demands of these specialized green practices.

Conversely, overskilling is most pronounced in Eco-design of products, where workers may possess green skills that exceed the requirements of their roles. However, most green practices, such as Producing eco-products, selling waste to other companies, Energy efficiency, and Recycling by reusing materials, exhibit negative values for overskilling. This suggests that workers in these areas generally do not possess surplus green skills, and their skills are closely aligned with job demands. Renewable sources of energy and Saving materials and minimizing waste also show relatively balanced skill alignment, with moderate levels of underskilling and low overskilling.

Table 3: Average skills mismatch according to green practices

Green practice	Underskilling	Horizontal mismatch	Overskilling
Other green practice	1.00	1.50	0.33
Producing eco-products	0.54	0.80	-0.23
Eco-design of products	1.06	0.88	0.38
Renewable sources of energy	0.66	0.61	-0.08
Selling waste to other companies	0.66	0.57	-0.21
Energy efficiency	0.60	0.56	-0.22
Recycling by reusing the materials	0.59	0.69	-0.21
Saving materials and minimizing waste	0.63	0.64	-0.11

Source: author’s calculations

3.4 Econometric modelling

The results of the ordered logistic regression analysis provide valuable insights into the factors influencing underskilling, horizontal skills mismatch, and overskilling in North Macedonia. The variable year, representing the number of years since a company's establishment, shows a statistically significant positive effect on overskilling, suggesting that older companies are more likely to experience overskilling, possibly due to accumulated human capital that exceeds current job requirements. However, the effect of company age on underskilling and horizontal mismatch is not statistically significant.

Companies with public ownership are significantly less likely to experience overskilling, indicating a better alignment of skills with job demands in public sector organizations. Conversely, small and medium-sized enterprises (SMEs) face significantly higher probabilities of both underskilling and horizontal skills mismatch, highlighting the challenges these firms encounter in securing a workforce with adequate and relevant green skills.

The presence of foreign direct investment (FDI) reduces the likelihood of horizontal skills mismatch and overskilling, suggesting that companies with FDI are better equipped to manage green skills alignment, likely due to greater access to resources and training. Companies engaged in import activities are less likely to experience overskilling, while exporting companies face a higher probability of horizontal skills mismatch, indicating that integration into global value chains may expose gaps in field-specific green skills.

Membership in employers' associations (chamber) significantly decreases the probability of underskilling and overskilling, but increases the likelihood of horizontal skills mismatch. This suggests that while employers' associations help mitigate some skill imbalances, challenges in aligning field-specific skills persist. Companies that have implemented environmental standards and corporate social responsibility (CSR) practices face higher probabilities of underskilling and horizontal skills mismatch, reflecting the increased demand for specialized green skills in these organizations.

Companies with training capacity exhibit significantly higher probabilities of underskilling, horizontal skills mismatch, and overskilling. This counterintuitive result may indicate that while these companies invest in training, they still struggle to fully address green skills mismatches, potentially due to rapidly evolving skill requirements. Finally, companies that have implemented green practices are less likely to experience horizontal skills mismatch and overskilling, suggesting that active engagement in green practices helps align workers' skills with job demands.

Table 4: Ordinal logit models for green skills mismatch (estimated odd-ratios)

Variable	Underskilling	Horizontal skills mismatch	Overskilling
<i>year</i>	1.002121 (0.182)	1.002521 (0.104)	1.009435*** (0.000)
<i>public</i>	1.134976 (0.144)	1.13224 (0.150)	0.6988926*** (0.000)
<i>Sme</i>	1.306313*** (0.000)	1.562711*** (0.000)	0.9685423 (0.618)
<i>Fdi</i>	1.131734* (0.097)	0.8165877*** (0.007)	0.881286* (0.094)
<i>Imp</i>	1.018438 (0.777)	1.036462 (0.591)	0.825251*** (0.004)
<i>Exp</i>	0.9474771 (0.452)	1.201657** (0.013)	0.963869 (0.616)
<i>chamber</i>	0.7627001*** (0.000)	1.127553** (0.027)	0.9094672* (0.072)
<i>standard</i>	1.344337*** (0.000)	1.200868*** (0.004)	1.161819** (0.015)
<i>Csr</i>	1.333273*** (0.000)	1.871361*** (0.000)	0.9700439 (0.628)
<i>capacity</i>	1.47833*** (0.000)	1.357711*** (0.000)	1.796929*** (0.000)
<i>green_pract</i>	1.060366 (0.278)	0.862688*** (0.008)	0.6295258*** (0.000)

Note: p-values in the parentheses, */**/** indicate significance at 10/5/1 percent level respectively.

Source: Authors' calculations.

Conclusion and policy implications

The transition to a green economy in North Macedonia presents both opportunities and challenges, particularly in addressing vertical and horizontal skills mismatches. This study highlights that underskilling and horizontal mismatches are significant barriers to an inclusive and effective green transition. Without targeted interventions, these mismatches could hinder economic

growth, exacerbate inequalities, and limit the country's ability to meet its sustainability goals.

To ensure a just and inclusive green transition, it is essential to implement targeted skills development strategies that not only bridge qualification gaps but also equip workers with the right type of green skills and competencies. This requires a coordinated effort among policymakers, educational institutions, and industry stakeholders to align training programs with the evolving demands of the labor market. By focusing on modular upskilling, industry-academia collaboration, and VET reforms, North Macedonia can build a workforce that is both adequately qualified and adaptable to the challenges of a sustainable economy. Ultimately, addressing these mismatches is not just about meeting immediate labor market needs but also about fostering long-term resilience and competitiveness in the face of global environmental and economic changes. A proactive and inclusive approach to skills development will be key to ensuring that no worker is left behind in North Macedonia's journey toward a greener future.

The empirical findings of this study underscore a dual challenge in North Macedonia's transition to a green economy: bridging qualification gaps (vertical mismatch) and realigning training systems to address emerging green occupational fields (horizontal mismatch). The persistence of underskilling, particularly in sectors like agriculture, eco-design, and professional services, signals a pressing need for workers to acquire specialized green competencies. At the same time, the prevalence of horizontal mismatches, where workers possess skills that do not align with evolving job requirements highlights the necessity of adapting education and training systems to the demands of the green transition.

To address these challenges, a multi-faceted policy approach is required. First, modular upskilling and reskilling programs should be introduced to help workers acquire the technical and transversal green skills needed for new and evolving roles. These programs should be flexible, accessible, and tailored to the specific needs of industries most affected by skills imbalances, such as manufacturing, energy, and waste management. Second, strengthening industry-academia collaboration can ensure that educational curricula remain responsive to labor market demands. Partnerships between vocational education and training (VET) institutions, universities, and businesses can facilitate the development of competency-based training programs that align with real-world green job requirements.

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