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# OVEREDUCATION IN GREEN INDUSTRIES: METHODOLOGICAL ASYMMETRIES AND EVIDENCE FROM CENTRAL AND EASTERN EUROPE

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## *Abstract*

*Educational mismatch in the labour market generates measurable economic losses through underutilised human capital, wage penalties for overeducated workers, and an inefficient allocation of resources invested in education, making its analysis particularly relevant in sectors affected by the green transition. This paper examines the extent and structure of overeducation in green industries across Central and Eastern European countries (Croatia, Czechia, Hungary, Latvia, Lithuania, Poland, and the Slovak Republic), using microdata from the second cycle of the Programme for the International Assessment of Adult Competencies (PIAAC). Green industries are identified by combining the Eurostat Environmental Goods and Services Sector (EGSS) methodology with the Cedefop (2019) analytical framework, mapped onto two-digit NACE Rev. 2 industry classifications. Two complementary and conceptually distinct measures of overeducation are applied: a subjective measure, based on workers' self-assessment of the education required for their job, and an objective (modal) measure, based on the statistical distribution of educational attainment within occupations. The results reveal a pronounced methodological asymmetry: subjective overeducation rates in green industries do not differ significantly from those in other industries, whereas objective overeducation rates are significantly lower in green industries than in other industries. The findings indicate that conclusions about the prevalence of overeducation in green industries depend on the measure applied and should be interpreted with caution, particularly given the broad sector-level definition of green industries used here.*

***Keywords: educational mismatch; overeducation; green industries; PIAAC; Central and Eastern Europe***

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## 1. INTRODUCTION

Educational mismatch, and particularly the overeducation of workers, is one of the most persistent and well-documented phenomena in contemporary labour markets. Workers whose level of education exceeds the formal requirements of their workplace generally earn lower wages than adequately employed workers with the same level of education but still earn higher wages than workers with a lower level of education in the same jobs. Hartog (2000), reviewing evidence from several countries, finds that overeducated workers generally receive positive returns to their additional years of schooling, but these returns are lower than the returns to the level of education required for their jobs. The findings therefore indicate a wage disadvantage associated with overeducation relative to adequately matched workers, although its magnitude varies across studies and countries. Although this is a well-researched problem in the context of developed labour markets, its connection with processes of structural transformation of the economy, and in particular with the green transition, remains relatively under researched and fragmented (Vona et al., 2018; Consoli et al., 2016).

This paper seeks to contribute to the literature on the relationship between the rapid structural changes generated by the green transition and the slow adaptation of education systems, qualification frameworks, and institutional classifications of occupations. The green transition, understood as a systematic process of decarbonising the economy in line with the goals of the European Green Deal (European Commission, 2019), not only changes the energy mix and technological systems but also reshapes the structure of labour demand. Similar structural changes are also evident in the digital transformation of labour markets, particularly in the emergence of digital labour platforms and new forms of work, which alter the characteristics and potential composition of the workforce (Vojinić et al., 2026). Cedefop (2019) identifies three channels through which this change occurs: the emergence of entirely new green occupations; the 'greening' of existing occupations through the addition of green competences; and the gradual obsolescence of occupations linked to the 'brown' economy based on fossil fuels. Under these conditions of accelerated structural transformation, formal occupational classifications may not fully reflect changes in the competency content of jobs, as indicated by signalling theory (Spence, 1973) and search-and-matching models in the labour market (Mortensen & Pissarides, 1994), creating fertile ground for the emergence and deepening of educational mismatches.

Over-education represents a loss for the economy on several levels: for individuals, it means a lower rate of return on investment in education and wages below their potential (Hartog, 2000); for employers, it implies unused human capital; and for the economy as a whole, it reflects an inefficient allocation of public and private funds invested in higher education. In the context of the green transition, this problem becomes even more pressing if countries are simultaneously undergoing an energy transition that requires significant investment and may face a shortage of workers with adequate technical green competences (García-Quevedo et al., 2026). These transformations occur alongside other profound changes in the organisation of work, including the expansion of platform work across labour markets in Central and Eastern Europe (Vojinić & Bečić, 2024). Evidence from a Flash Eurobarometer survey of European SMEs indicates that firms have considerable difficulty finding workers with the skills required for the green transition, mainly workers with secondary and vocational education, whereas no significant difficulties were found for workers with higher-education degrees; reported shortages are more frequent in countries lagging behind in eco-innovation than in eco-innovation leaders (García-Quevedo et al., 2026). Shortages of workers with specific vocational skills may therefore coexist with overeducation among workers with higher education, indicating a misallocation of educational investment relative to the skills required for the green transition.

The aim of this research is to examine the extent of overeducation across industries in Central and Eastern European countries and to compare green industries with other industries. Emphasis is placed on comparing two conceptually distinct measures of mismatch, in line with Leuven and

Oosterbeek (2011), to assess whether conclusions about green industries depend on how overeducation is measured. The study addresses following research questions:

RQ1: Does the prevalence of overeducation differ between green and other industries?

RQ2: How does the measurement approach affect the estimated incidence of overeducation in green and other industries?

The research is based on microdata from the second cycle of the Programme for the International Assessment of Adult Competencies (PIAAC; OECD, 2024), which provides harmonised data suitable for comparative research on mismatch in the CEE context.

## 2. CONCEPTUAL FRAMEWORK

Educational mismatch appears in the literature in two forms: overeducation, where a worker has a higher level of education than required for the job, and undereducation, which refers to the opposite situation (Freeman, 1976). The theoretical explanation of overeducation is primarily based on human capital theory (Becker, 1964; Mincer, 1974), which holds that education increases workers' productivity and thus their market value. However, human capital theory assumes a balance between the supply and demand for skills, so educational mismatch within this framework remains an anomaly. A broader explanation is provided by signalling theory (Spence, 1973), which suggests that education does not necessarily increase productivity but primarily serves as a signal to employers about workers' unobservable characteristics. In this context, credential inflation, particularly relevant in fast-growing sectors where occupational profiles are still developing, may lead to structural changes, as certification institutions lag behind actual changes in the content of work.

A complementary theoretical framework is provided by the job search and matching model, developed in the tradition of Mortensen and Pissarides (1994). This approach highlights that labour market frictions, information asymmetry, job heterogeneity, and search costs, are a source of both temporary and persistent mismatches. In the context of the green transition, the model is particularly relevant, as it predicts that sectors undergoing accelerated structural transformation will experience increased market frictions, since neither workers nor employers have reliable information about which skill profiles will be relevant in the long term.

The literature distinguishes formal overeducation, where a worker's education exceeds the requirements of the job, from overskilling, where the worker's skills exceed those requirements; the two do not necessarily coincide (Allen & van der Velden, 2001; Green & Zhu, 2010). This distinction is relevant in the context of the green transition, where formal education may not fully capture technical and sector-specific competences. Studies based on US data indicate that green skills are mainly engineering and managerial skills (Vona et al., 2018) and that green occupations require higher levels of formal education, experience and training than comparable non-green occupations (Consoli et al., 2016), although most green employment consists of jobs whose tasks change little (Bowen et al., 2018). The implications for overeducation are not clear-cut. Where the supply of educated workers is large relative to the number of jobs requiring their level of education, job competition theory (Thurow, 1975) predicts that workers will be pushed into jobs below their qualifications, which would raise overeducation. Where the supply of specific green profiles lags behind demand, by contrast, the more likely outcome is shortages or a mismatch in the field of study rather than overeducation. Whether green industries exhibit higher or lower overeducation than other industries is therefore an empirical question, which the present study addresses.

The empirical literature on overeducation is extensive and methodologically diverse, but the basic finding consistently reported is that overeducation is a permanent and widespread phenomenon in developed labour markets (Duncan & Hoffman, 1981; Verdugo & Verdugo, 1989). This phenomenon cannot be explained solely as a temporary friction on the way to equilibrium

pairing, longitudinal studies record its persistence throughout work experience, with workers who enter a state of overeducation being statistically significantly less likely to exit it (Baert et al., 2013; Groeneveld & Hartog, 2004). Estimates of the proportion of overeducated workers range depending on the measure used and the country examined (McGuinness, 2006; Leuven & Oosterbeek, 2011; Bečić, 2025).

The methodological discussion on the operationalisation of mismatches directly affects the estimated level of overeducation. In the literature, three dominant approaches to measuring educational mismatch are established: the subjective method, the modal (or realized) method, and the normative method. Each of them rests on different assumptions about what constitutes an "appropriate" level of education for a particular job, thus actually measuring different aspects of the same phenomenon (Capsada-Munsech, 2017). The normative approach, which relies on external classifications of occupational requirements such as ISCO standards, usually produces more conservative estimates. The statistical approaches derive the required level from the observed distribution of education within occupations, using either the mean plus or minus one standard deviation (Verdugo and Verdugo, 1989) or the mode (Kiker et al., 1997). The resulting rates depend strongly on the exact rule applied, the level of educational and occupational detail, and the country, and a stricter threshold yields lower rates than a looser one. The subjective approach, which uses workers' self-assessment, gives the highest estimates (Sicherman, 1991; Mavromaras et al., 2013). A literature review by Leuven and Oosterbeek (2011), confirms that the choice of measure of mismatch is itself a source of variability in findings and recommends triangulation of approaches as the standard of robustness, a recommendation that serves as a methodological guide for this study as well.

The distribution of overeducation across sectors and occupations is not uniform and is theoretically significant. Sectors and occupations may differ in the incidence and nature of educational mismatch, particularly where the content of work and the skills used in jobs are changing. Green and Zhu (2010), for example, distinguish between formal overqualification and overqualification accompanied by skill underutilisation, while Autor, Levy and Murnane (2003) document substantial changes in the task content of occupations associated with technological change. This provides a possible reason to examine whether educational mismatch differs in green industries, which are an example of accelerated structural transformation.

The literature directly linking educational mismatch and the green transition is relatively new and remains fragmented, highlighting the research gap this paper aims to address. Most existing studies on work and the green transition focus on employment levels, wages, and occupational demand, rather than on the dimension of educational adequacy. Vona et al. (2018) show that the demand associated with the green transition is particularly strong for specific technical and engineering skills. This suggests that formal educational attainment alone may not fully capture the specific skill profiles demanded in some green activities.

Consoli et al. (2016) show that green occupations are characterised by higher levels of formal education, work experience, on-the-job training, and high-level cognitive and interpersonal skills than comparable non-green occupations. Although their study focuses on the skills and human capital characteristics of green occupations, its findings have broader implications for the green economy, suggesting that green jobs may require more specialised combinations of skills than are typically captured by formal educational qualifications.

Recent survey evidence points to difficulties in finding workers with the skills needed for the green transition. In a Flash Eurobarometer survey of European SMEs, firms reported considerable difficulty in finding the required skills, concentrated among workers with secondary and vocational education rather than among those with higher-education degrees (García-Quevedo et al., 2026). Such shortages could, in principle, coexist with workers whose qualifications do not correspond closely to the requirements of their jobs, but the existing evidence does not establish whether this takes the form of overeducation.

For research on overeducation in specific sectors, such as green industries, methodological sensitivity is particularly important. Green industries may be characterised by changing competency requirements, although the evidence on the extent of this change is mixed. Analyses of US occupational data suggest that most green employment consists of jobs whose tasks and skills change little (Bowen et al., 2018), while difficulties in defining and measuring green skills (Cedefop, 2019) complicate the anticipation of skill needs. The choice of measure affects the estimated incidence of overeducation (Groot & Maassen van den Brink, 2000; Leuven & Oosterbeek, 2011); therefore, comparing several measures is particularly informative in this context.

## 3. METHODOLOGY

The empirical analysis of educational mismatch in this study uses two established operationalisation approaches to overeducation applied to microdata from the Programme for the International Assessment of Adult Competencies (PIAAC), second cycle (OECD, 2024). PIAAC provides harmonised individual-level data on educational attainment, occupational classification, and self-assessed job requirements across participating countries, making it particularly suitable for comparative mismatch research in the CEE context (Pellizzari & Fichen, 2017). All estimates are weighted using the final person weights provided in the PIAAC dataset to ensure population representativeness.

The first measure applied is the subjective method, operationalised through the PIAAC item that asks respondents to indicate the level of education they consider necessary to obtain their current job. Educational mismatch is defined as the discrepancy between the respondent's actual level of educational attainment and the level they report as required for job entry. A respondent is classified as overeducated if their actual educational level exceeds the self-reported requirement. The principal advantage of this approach is its direct capture of the worker's perception of adequacy, without reliance on external occupational classifications or sample-derived norms. However, the subjective method is susceptible to well-documented cognitive biases: respondents tend to adapt their perception of required qualifications to their own educational status, a phenomenon known as rationalisation bias, and cultural and institutional contexts may independently shape responses in ways unrelated to actual job demands (Sicherman, 1991; Allen & van der Velden, 2001). Overeducation is defined as a binary variable:

$$OE_i^{sub} = \begin{cases} 1 & \text{if } E_i > E_i^{req} \\ 0 & \text{otherwise} \end{cases}$$

Where Ei is the actual level of education of the worker, and Ereq is the level of education that the worker estimates is necessary to perform the current job. The questions from PIAAC used are: "What is the highest level of education you have achieved?" and, assuming a hypothetical situation in which someone were to be hired in their place, "What level of formal education is required to get your job?". The respondents' levels of education, as stated in response to these two questions, were compared, and subjective overeducation was identified when the level indicated in the second question was lower than the level of education obtained.

The second measure is the objective method based on the modal level of education within an occupation, proposed by Kiker et al. (1997), who built on the statistical approach of Verdugo and Verdugo (1989), in which required education is derived from the observed distribution of attainment within occupations. In this approach, the required level of education for each occupation is determined empirically as the modal educational level observed among workers within the same two-digit ISCO-08 occupational category. A worker is classified as overeducated when their educational attainment exceeds the occupational modal level. The modal method therefore derives educational requirements from the observed distribution of educational attainment within occupations rather than from formally prescribed or individually perceived requirements. Its main limitation is its sensitivity to sample composition, as reliable estimation of the occupational mode requires a sufficient number of observations within each occupational category (Leuven &

Oosterbeek, 2011). In the present study, this limitation is partly addressed by pooling observations across Czechia, Hungary, Latvia, Poland, and the Slovak Republic, which increases the number of observations available for estimating occupational education modes. Occupational modes are estimated from this pooled sample and applied to workers in the same five countries. The modal measure could not be estimated for Croatia and Lithuania because the data file used contains no information on respondents' current occupation (ISCO-08) for these two countries, which is required to determine the modal level of education within occupations. These two countries are therefore excluded from all analyses based on the modal measure. The modal level of education for each ISCO-08 category is defined as follows:

$$\hat{E}_o = \text{Mo}(E_i \mid occ_i = o)$$

where Mo is the statistical mode of distribution of the educational levels of all workers employed in the occupation o. For each occupation, overeducation is then defined as:

$$OE_i^{mod} = \begin{cases} 1 & \text{if } E_i > \hat{E}_o \\ 0 & \text{otherwise} \end{cases}$$

The required level for each two-digit ISCO-08 occupation is the modal educational level among its workers, and a worker is classified as overeducated if their attainment exceeds it. The mode suits an ordinal variable: unlike the mean-based approach of Verdugo and Verdugo (1989), it does not assume equidistant categories and is unaffected by the tails of the distribution. To increase the number of observations per occupation, modes are estimated from the pooled sample of Czechia, Hungary, Latvia, Poland, and the Slovak Republic and applied to workers in the same five countries. The measure captures attainment relative to the prevailing level within an occupation, not the requirements of individual jobs, and may miss mismatch arising from differences in job content within an occupation. Results are therefore sensitive to the occupational classification, the level of aggregation, and the educational categories used (Leuven & Oosterbeek, 2011).

The parallel use of both measures reflects the methodological recommendation for triangulation established in the mismatch literature (Leuven & Oosterbeek, 2011; Capsada-Munsech, 2017). As the two methods capture conceptually distinct dimensions of the same phenomenon, perceived adequacy versus statistical deviation from occupational norms, their divergence is analytically informative. The analysis therefore examines whether the gap between subjective and modal estimates differs between green and other industries, a question of interest because competency requirements in green industries may change faster than formal occupational categories. Both measures of educational mismatch, subjective and modal, were first calculated separately for each of the CEE countries included in the analysis, in order to capture cross-country heterogeneity in the extent of mismatch prior to any sectoral disaggregation. For each country, all estimates and standard errors were computed with the Complex Samples procedures in IBM SPSS Statistics, using the final person weights to ensure nationally representative results.

The concepts of green industries and green occupations are not standardised in either the academic literature or policy documents, making an explicit operational definition necessary. At the most general level, UNEP (2011) defines the green economy as one that improves human well-being and social equity while significantly reducing environmental risks and ecological scarcities. Owing to its breadth, however, this definition cannot be applied directly to identify industries or occupations in empirical labour-market analysis. The present study therefore draws on two complementary European frameworks: the Eurostat Environmental Goods and Services Sector (EGSS) accounts (Eurostat, 2016), which identify economic activities aimed at environmental protection and resource management, and Cedefop's work on green jobs and skills (Cedefop, 2019), which addresses the labour-market implications of the green transition. Both frameworks were selected for their European scope and their comparability with the institutional context of the countries examined. Green industries are identified at the level of two-digit NACE Rev. 2 divisions and cover activities associated with low-carbon energy, energy efficiency, sustainable transport, the circular economy and waste management, water management, sustainable agriculture and land use, and pollution

control and environmental protection (Table 1). Because the classification operates at the industry level, all workers employed in a given division are treated as working in a green industry, irrespective of their individual occupation or tasks. The measure therefore captures the sectoral rather than the job-level dimension of greenness, and its boundaries involve a degree of analytical judgement.

Table 1 Classification of green industries by NACE Rev. 2

| Green industry domain | NACE Rev. 2 |
|---|---|
| Low-carbon energy | 35 – Electricity, gas, steam and air conditioning supply |
| | 27 – Manufacture of electrical equipment |
| | 28 – Manufacture of machinery and equipment |
| Energy efficiency | 41 – Construction of buildings |
| | 42 – Civil engineering |
| | 43 – Specialised construction activities |
| Sustainable transport | 29 – Manufacture of motor vehicles, trailers and semi-trailers |
| | 49 – Land transport and pipeline transport |
| | 50 – Water transport |
| | 51 – Air transport |
| | 52 – Warehousing and support activities for transportation |
| | 53 – Postal and courier activities |
| Circular economy and waste | 38 – Waste collection, treatment and disposal activities; materials recovery |
| | 39 – Remediation activities and other waste management services |
| | 25 – Manufacture of fabricated metal products, except machinery and equipment |
| Water management | 36 – Water collection, treatment and supply |
| | 37 – Sewerage |
| Sustainable agriculture and land | 01 – Crop and animal production, hunting and related service activities |
| | 02 – Forestry and logging |
| Pollution control and environmental protection | 72 – Scientific research and development |

Source: Authors' work based on Eurostat (2016), Cedefop (2019)

Table 1 presents the sector classification used in this study. It is a study-specific operationalisation of green industries at the level of two-digit NACE Rev. 2 divisions, informed by the Eurostat EGSS framework (Eurostat, 2016) and by Cedefop's work on green jobs and skills (Cedefop, 2019), and it should not be read as a reproduction of the EGSS classification. The classification combines divisions whose activities are directly associated with environmental protection and resource management with broader divisions that supply inputs or infrastructure for the green transition. Each division is assigned to a single sub-domain, so that no division is counted more than once in the aggregate green-industry category.

The inclusion of NACE divisions 25, 27, and 28 is based on a functional criterion, namely their role in green-transition supply chains, and not on the assumption that all activity within these divisions is environmentally oriented. PIAAC identifies the respondent's industry only at the two-digit level, which makes it impossible to isolate environmentally relevant activities within a division. The classification is therefore a sector-level proxy for participation in the green transition: the estimates cover all workers employed in the listed divisions, irrespective of whether their own jobs involve green tasks. Moreover, EGSS statistics are organised around environmental activities and products rather than industries (Eurostat, 2016), and no European classification delimits green industries at the NACE level in an exhaustive and unambiguous way. The boundaries drawn here therefore involve analytical judgement and constitute a limitation of the study.

Overeducation measures were estimated for each two-digit NACE classification, pooling the countries for which the respective measure is available (seven countries for the subjective measure and five for the modal measure). The divisions were then aggregated into two mutually exclusive categories: green industries (the divisions listed in Table 1) and other industries (all remaining divisions). The latter is a residual comparison group and does not imply that these industries lack environmental relevance. The analysis thus proceeds on three levels: country-level estimates, division-level estimates, and the comparison between green and other industries. Differences in overeducation rates between green and other industries were tested with a design-based test of independence applied to this aggregate classification. Because PIAAC uses a complex sampling design, the conventional Pearson chi-square test does not account for the effects of sampling weights on the variance of the estimates and may therefore overstate statistical significance. The second-order Rao–Scott adjusted F test corrects for these design effects (Rao & Scott, 1984).

## 4. RESULTS AND DISCUSSION

This section presents the empirical results of the study in two stages. The first stage reports descriptive statistics on the prevalence of educational mismatch across the CEE countries included in the analysis, comparing estimates derived from the subjective and modal measurement approaches. The second stage disaggregates mismatch rates at the sector level across all two-digit NACE industries, with analytical attention given to green industries as defined in the classificatory framework outlined in the Methodology section. Together, these two levels of analysis provide the empirical foundation for the subsequent discussion of the relationship between educational mismatch and the green transition in the CEE context.

Table 2 Overeducation by countries

| | Subjective OE (st. err.) | Objective OE (st. err.) |
|---|---|---|
| Croatia | 30.3% (1.0%) | |
| Czechia | 37.7% (1.1%) | 9.7% (0.6%) |
| Hungary | 38.9% (0.9%) | 7.6% (0.5%) |
| Latvia | 45.9% (1.0%) | 10.9% (0.6%) |
| Lithuania | 46.5% (1.1%) | |
| Poland | 33.5% (0.9%) | 9.8% (0.6%) |
| Slovak Republic | 33.0% (1.0%) | 9.7% (0.6%) |

Source: Authors' calculation based on PIAAC (OECD, 2024)

Table 2 reveals differences in overeducation rates among the analysed CEE countries, with the choice of measurement method having a decisive impact on the estimates obtained, in line with theoretical expectations (Leuven & Oosterbeek, 2011; Capsada-Munsech, 2017). Subjective overeducation rates range from 30.3% in Croatia to 46.5% in Lithuania. Latvia and Lithuania consistently recorded higher rates than the other countries in the sample, which may reflect the specificities of smaller labour markets with a more pronounced mismatch between educational supply and the structure of labour demand. These results align with the findings by McGuinness (2006), who reports substantial variation in subjectively measured incidences of overeducation

across studies. The modal measure, which could be applied to five of the seven countries due to data limitations, gives considerably lower estimates, ranging from 7.6% in Hungary to 10.9% in Latvia. This may reflect the use of broad educational categories, which places most workers in the modal category of their occupation, and the fact that overeducation cannot be identified in occupations where the mode is already the highest category. These estimates are not directly comparable with modal estimates obtained using other educational classifications or levels of occupational aggregation. The modal measure is not reported for Croatia and Lithuania because information on current occupation (ISCO-08) is not available for these two countries in the data file used.

The fundamental difference between these two measures is conceptual, not merely technical. The subjective measure records the worker's perception of the inadequacy of their own education for a specific job, making it sensitive to individual cognitive biases, especially the tendency to rationalise one's own educational status and adapt aspirations to current working conditions (Sicherman, 1991; Allen & van der Velden, 2001). The modal measure, by contrast, captures deviation from the prevailing level of education within an occupation but ignores intra-occupational variations in actual competency requirements and is subject to bias related to sample composition within each ISCO category (Verdugo & Verdugo, 1989; Leuven & Oosterbeek, 2011). It is precisely because of this conceptual incoherence between measures that Capsada-Munsech (2017), in a systematic review, concludes that different measures of overeducation show only moderate to weak correlation with each other and capture different dimensions of the same phenomenon, rather than the same construct measured with different precision.

To assess whether the differences between green and other industries are consistent across the two measures, the Rao–Scott adjusted F test of independence was applied separately to the subjective and the modal measure. To describe the size of these differences, the odds ratio and the risk difference were also calculated for each measure; the risk difference is expressed as the rate in other industries minus the rate in green industries. Table 3 reports the results for the five countries for which both measures are available, together with unweighted sample sizes and weighted population estimates.

Table 3 Overeducation in green versus other industries: subjective and modal measures, five CEE countries

| | | Subjective OE | Objective OE |
|---|---|---|---|
| Percentage Share | Green industries | 34.4% (SE: 1.1%) | 7.1% (SE: 0.6%) |
| | Other industries | 36.2% (SE: 0.6%) | 10.2% (SE: 0.4%) |
| Test of Independence (Rao-Scott Adjusted F) | | F=1.807 (p=0.180) | F=16.869 (p<0.001) |
| Odds Ratio | | 0.926 | 0.677 |
| Risk Difference | | 0.018 (1.8%) | 0.031 (3.1%) |
| Unweighted N | | 16 077 | 18 428 |
| Population Estimate | | 24 134 319 | 28 042 338 |

Source: Authors' calculation based on PIAAC (OECD, 2024)

When examining subjective overeducation, the Rao-Scott adjusted F test indicates no statistically significant association with green industry. Employees within green sectors report a subjective OE rate of 34.4%, which is statistically indistinguishable from the 36.2% observed in non-green sectors. In contrast, the objective measure demonstrates a highly significant relationship with green sector classification: green industries exhibit a significantly lower objective OE prevalence rate of 7.1% compared with 10.2% in non-green industries. The corresponding odds ratio indicates that employees in green industries have approximately 32.3% lower odds of being classified as overeducated. Furthermore, the risk difference for the presence of objective OE stands at 0.031. This

disparity highlights a crucial methodological insight: while workers in sustainable sectors perceive their qualification mismatches at rates comparable to conventional sectors, objective operational metrics demonstrate that green industries exhibit significantly lower levels of formal overeducation.

Table 4 Subjective and modal overeducation rates by green industry (five CEE countries)

| Category | Industry | Subjective OE | Objective OE |
|---|---|---|---|
| Low carbon/ Clean energy | 35 – Electricity, gas, steam... | 27.90% | 13.10% |
| | 27 – Manufacture of electrical equipment | 30.50% | 6.00% |
| | 28 – Manufacture of machinery and equipment | 36.60% | 9.50% |
| Energy efficiency | 41 – Construction of buildings | 23.60% | 3.90% |
| | 42 – Civil engineering | 38.30% | 8.10% |
| | 43 – Specialized construction activities | 28.30% | 5.40% |
| Sustainable transport | 29 – Manufacture of motor vehicles, trailers... | 42.90% | 10.60% |
| | 49 – Land transport and transport via pipelines | 39.60% | 7.80% |
| | 50 – Water transport | 32.20% | 3.10% |
| | 51 – Air transport | 76.20% | 41.00% |
| | 52 – Warehousing and support activities | 42.50% | 7.80% |
| | 53 – Postal and courier activities | 47.10% | 13.10% |
| Circular economy & Waste | 38 – Waste collection, treatment and disposal | 31.50% | 2.70% |
| | 39 – Remediation activities and other waste management | 32.30% | 13.90% |
| | 25 – Manufacture of fabricated metal products | 27.10% | 5.50% |
| Water management | 36 – Water collection, treatment and supply | 21.30% | 3.90% |
| | 37 – Sewerage | 31.70% | — |
| Sustainable land use | 01 – Crop and animal production, hunting... | 43.70% | 6.60% |
| | 02 – Forestry and logging | 29.60% | 8.00% |
| Pollution control | 72 – Scientific research and development | 35.40% | 6.30% |
| | Total (Green industries) | 34.4% | 7.1% |

Source: Authors' calculation based on PIAAC (OECD, 2024)

Table 4 shows heterogeneity in overeducation rates across industries, including only five countries for which modal measurement could be applied, with the sectoral structure of labour demand and the speed of structural transformation crucially shaping the levels of mismatch. Objective overeducation rates in green sectors are relatively low: building construction (3.9%), specialised construction activities (5.4%), waste collection and treatment (2.7%), water supply (3.9%), and forestry (8.0%). This finding appears to contradict the theoretical expectation of increased overeducation in sectors undergoing accelerated structural transformation However, this finding should be interpreted considering how the modal measure is constructed. The required level of education is defined as the most common level of attainment within an occupation, and a worker is classified as overeducated only if their attainment exceeds that level. Because PIAAC records education in a small number of broad categories, most workers fall into the modal category of their occupation, and in occupations where the mode is already the highest available category overeducation cannot be identified. The modal measure also cannot detect differences in job content within an occupation. Low modal rates therefore indicate that few workers have more education than is typical for their occupation, and not necessarily that educational mismatch is absent. The present data do not allow us to establish whether the green transformation has altered the content of jobs within these occupations. This is where the key difference between objective and subjective measures in green industries becomes evident. Subjective overeducation rates are significantly higher: the circular economy shows large differences compared to the objective measure. This is broadly consistent with Consoli et al. (2016), who show that green occupations tend

to combine higher levels of formal education with greater work experience, on-the-job training, and high-level cognitive and interpersonal skills. These findings suggest that formal educational attainment alone may not fully describe the human-capital and skill requirements of green occupations.

The answer to the first research question varies depending on the measure of overeducation employed. Using the subjective measure, no statistically significant difference in the incidence of overeducation is observed between green and other industries. In contrast, the modal measure indicates a statistically significant lower incidence of overeducation in green industries. These findings also address the second research question, showing that the choice of measurement approach affects not only the estimated magnitude of overeducation but also the substantive conclusions regarding its prevalence in green industries. Across all countries and industry groups, subjective measures yield considerably higher estimates of overeducation than modal measures. Accordingly, the results based on the modal approach should be interpreted with consideration of the way this measure is constructed, which identifies only workers whose education exceeds the most common level in their occupation, using broad educational categories. Overall, the findings suggest that conclusions regarding the prevalence of overeducation in green industries are sensitive to the measurement approach adopted and should therefore be interpreted explicitly in relation to the respective operationalisation of overeducation.

## 5. CONCLUDING REMARKS

The research provides insight into the extent and structure of educational mismatch in green industries across Central and Eastern European countries by applying two complementary methodological approaches to PIAAC survey microdata. The results indicate that the choice of measurement methodology has an important influence on the estimated incidence of overeducation. Subjectively measured rates of overeducation range from 30.3% in Croatia to 46.5% in Lithuania, while estimates obtained using the modal, or objective, method are substantially lower, ranging from 7.6% to 10.9%. The difference between the two approaches suggests that subjective and objective measures should not necessarily be interpreted as interchangeable measures of the same phenomenon, as they may reflect different aspects of the relationship between workers' education and their employment.

Objectively measured overeducation rates in activities such as construction, waste management and water supply are relatively low, which, when considered on its own, may suggest a limited incidence of educational mismatch according to the modal criterion. Subjective assessments, however, are considerably higher, with differences between the two measures ranging from about 15 to 30 percentage points in these activities. This asymmetry may indicate that formal occupational and educational classifications do not fully capture all aspects of the relationship between workers' education and the requirements of their jobs. Standardised occupational classifications such as ISCO necessarily organise employment into relatively broad and stable occupational categories, whereas the content of certain jobs may vary within these categories and may change in response to technological, regulatory and organisational developments associated with the green transformation. Workers' subjective assessments, in turn, may reflect their own perceptions of how well their acquired education corresponds to the requirements of their current workplace.

Accordingly, the difference between subjective and objective measures should not be regarded solely as a technical issue of measurement. It may also provide an indication that different approaches to educational mismatch capture different dimensions of the relationship between formal qualifications and work requirements. In this respect, the findings suggest that formal educational adequacy, as defined through standardised qualification and occupational categories, does not necessarily correspond fully to workers' perceptions of the adequacy of their education for the tasks performed in their jobs. This distinction may be relevant for understanding the challenges associated with adapting education and training systems to changing labour market requirements,

although the present study does not allow conclusions to be drawn about the direction or causality of these relationships.

When interpreting the results, several important limitations of the study need to be considered. The modal measure could not be applied to Croatia and Lithuania because the data file contains no information on respondents' current occupation for these countries. The operationalisation of green industries at sector level is based on a combination of methodological approaches from Eurostat's Environmental Goods and Services Sector Accounts System (EGSS) and Cedefop's conceptual framework. However, the available European classification documents do not define completely unambiguous boundaries for green industries at the level of individual NACE activities. Consequently, the inclusion of certain manufacturing activities, such as the manufacture of metal products, electrical equipment, and machinery and appliances, inevitably involves a certain degree of functional and analytical judgement. More broadly, because the classification operates at the level of two-digit divisions, all workers in a listed division are treated as working in a green industry, irrespective of their occupation or tasks. Some divisions, notably all transport, construction and agriculture divisions, are included in their entirety, so the classification is a broad sector-level proxy that may include workers whose jobs have little or no connection with the green transition, and the estimates should not be read as describing green jobs. This methodological circumstance highlights the need for further development of standardised classification frameworks that would allow more precise and comparable identification of green economic activities.

The subjective measure of educational mismatch is subject to limitations characteristic of self-assessment data. Workers' perceptions can be influenced by various cognitive and interpretive biases, including the rationalisation of their own educational and professional position. Therefore, part of the recorded subjective mismatch may reflect individuals' perceptions of the relationship between education and employment rather than an objectively measurable mismatch between competencies and job requirements. It is also not possible to monitor individual changes in the educational and professional positions of workers over time, nor to analyse the dynamics of how competences adapt to changing labour market demands. Longitudinal research therefore represents an important direction for future analyses, as it could provide a stronger basis for examining changes over time and for assessing the possible mechanisms through which the green transformation may be associated with changes in educational and skills mismatch.

The limitations of this study suggest several directions for future research. First, the sector-level definition of green industries classifies all workers in a division as green, irrespective of their tasks. Future studies could identify green activity at the level of occupations or tasks, for example by combining industry classifications with task-based indicators of greenness. This would allow a comparison of overeducation among workers who do and do not perform green tasks within the same industry. Moreover, since in this study the modal measure could be applied to only five of the seven countries, studies using data with more detailed occupational information could apply both measures to the same set of countries and workers and test the sensitivity of the results to alternative thresholds (for example, the mode alone or other multiples of the standard deviation) and to the level of occupational aggregation. Future research could also incorporate measures that rely on skills rather than formal education, such as indicators of skill mismatch based on assessed proficiency, to distinguish overeducation from skill underutilisation in green industries. The cross-sectional design does not show how educational requirements and mismatch change over time. Longitudinal and repeated cross-sectional data, including future PIAAC cycles, would allow researchers to examine whether the gap between measures widens or narrows as the green transition progresses. Finally, the analysis is descriptive and does not investigate the consequences of overeducation, such as its association with wages or job satisfaction in green industries. Studies that control for individual and job characteristics could assess whether the patterns observed here persist and whether the wage penalty of overeducation differs between green and other industries.

Despite these limitations, the findings may have implications for several stakeholder groups. For education and labour market policymakers, the results point to the potential value of more

closely aligning qualification frameworks, educational programmes and curricula with changing competence requirements in occupations associated with the green transition. For institutions responsible for strategic planning of the energy and green transition, the findings may provide a useful starting point for identifying sectors in which differences between formal educational measures and workers' perceptions of job requirements are particularly pronounced. For researchers in the field of educational economics and labour markets, the study highlights the value of considering different measures of educational mismatch in parallel, particularly when examining sectors characterised by technological and structural change.

Finally, lifelong learning institutions may use these findings as one indication of the potential importance of programmes aimed at supporting workers whose existing qualifications may not fully correspond to the changing requirements of green jobs. Strengthening opportunities for lifelong learning and continuous training may contribute to workforce adaptability and to the capacity of education and training systems to respond to changing economic conditions. However, further research would be needed to establish which forms of education and training are most effective in addressing the types of mismatches identified in this study.

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## REFERENCES

Allen, J., & van der Velden, R. (2001). Educational mismatches versus skill mismatches: Effects on wages, job satisfaction, and on-the-job search. *Oxford Economic Papers, 53*(3), 434–452. https://doi.org/10.1093/oep/53.3.434

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *Quarterly Journal of Economics, 118*(4), 1279–1333. https://doi.org/10.1162/003355303322552801

Baert, S., Cockx, B., & Verhaest, D. (2013). Overeducation at the start of the career: Stepping stone or trap? *Labour Economics, 25*, 123–140. https://doi.org/10.1016/j.labeco.2013.04.013

Bečić, M. (2025). Overeducation and Earnings in Croatia: Evidence from PIAAC. *Društvena istraživanja-Časopis za opća društvena pitanja*, *34*(4), 473-493. https://doi.org/10.5559/di.34.4.03

Becker, G. S. (1964). *Human capital: A theoretical and empirical analysis, with special reference to education*. National Bureau of Economic Research.

Bowen, A., Kuralbayeva, K., & Tipoe, E. L. (2018). Characterising green employment: The impacts of 'greening' on workforce composition. *Energy Economics, 72*, 263–275. https://doi.org/10.1016/j.eneco.2018.03.015

Capsada-Munsech, Q. (2017). Overeducation: Concept, theories, and empirical evidence. *Sociology Compass*, *11*(10), e12518. https://doi.org/10.1111/soc4.12518

Cedefop. (2019). *Skills for green jobs: 2018 update: European synthesis report* (Cedefop Reference Series No. 109). Publications Office of the European Union. https://www.cedefop.europa.eu/en/publications/3078

Consoli, D., Marin, G., Marzucchi, A., & Vona, F. (2016). Do green jobs differ from non-green jobs in terms of skills and human capital? *Research Policy, 45*(5), 1046–1060. https://doi.org/10.1016/j.respol.2016.02.007

Duncan, G. J., & Hoffman, S. D. (1981). The incidence and wage effects of overeducation. *Economics of Education Review, 1*(1), 75–86. https://doi.org/10.1016/0272-7757(81)90028-5

European Commission. (2019). *The European Green Deal* (COM(2019) 640 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2019:640:FIN

Eurostat. (2016). *Environmental goods and services sector accounts: Practical guide* (2016 edition). Publications Office of the European Union. https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/ks-gq-16-011

Freeman, R. B. (1976). *The overeducated American*. Academic Press.

García-Quevedo, J., Jové-Llopis, E., & Martínez-Ros, E. (2026). Addressing skills shortages to advance the green transition in European SMEs. *Eurasian Business Review, 16*(3), 919–952. https://doi.org/10.1007/s40821-026-00368-4

Green, F., & Zhu, Y. (2010). Overqualification, job dissatisfaction, and increasing dispersion in the returns to graduate education. *Oxford Economic Papers, 62*(4), 740–763. https://doi.org/10.1093/oep/gpq002

Groeneveld, S., & Hartog, J. (2004). Overeducation, wages and promotions within the firm. *Labour Economics*, *11*(6), 701–714. https://doi.org/10.1016/j.labeco.2003.11.005

Groot, W., & Maassen van den Brink, H. (2000). Overeducation in the labor market: A meta-analysis. *Economics of Education Review, 19*(2), 149–158. https://doi.org/10.1016/S0272-7757(99)00057-6

Hartog, J. (2000). Over-education and earnings: Where are we, where should we go? *Economics of Education Review, 19*(2), 131–147. https://doi.org/10.1016/S0272-7757(99)00050-3

Kiker, B. F., Santos, M. C., & de Oliveira, M. M. (1997). Overeducation and undereducation: Evidence for Portugal. *Economics of Education Review, 16*(2), 111–125. https://doi.org/10.1016/S0272-7757(96)00040-4

Leuven, E., & Oosterbeek, H. (2011). Overeducation and mismatch in the labor market. In E. A. Hanushek, S. Machin, & L. Woessmann (Eds.), *Handbook of the economics of education* (Vol. 4, pp. 283–326). Elsevier. https://doi.org/10.1016/B978-0-444-53444-6.00003-1

Mavromaras, K., McGuinness, S., O'Leary, N., Sloane, P., & Wei, Z. (2013). Job mismatches and labour market outcomes: Panel evidence on university graduates. *Economic Record*, *89*(286), 382–395. https://doi.org/10.1111/1475-4932.12054

McGuinness, S. (2006). Overeducation in the labour market. *Journal of Economic Surveys, 20*(3), 387–418. https://doi.org/10.1111/j.0950-0804.2006.00284.x

Mincer, J. (1974). *Schooling, experience, and earnings*. National Bureau of Economic Research.

Mortensen, D. T., & Pissarides, C. A. (1994). Job creation and job destruction in the theory of unemployment. *Review of Economic Studies, 61*(3), 397–415. https://doi.org/10.2307/2297896

OECD. (2024). *PIAAC 2nd cycle database* [Data set]. OECD. https://www.oecd.org/en/data/datasets/PIAAC-2nd-Cycle-Database.html

Pellizzari, M., & Fichen, A. (2017). A new measure of skill mismatch: theory and evidence from PIAAC. *IZA Journal of Labor Economics*, *6*(1), 1. https://doi.org/10.1186/s40172-016-0051-y

Rao, J. N. K., & Scott, A. J. (1984). On chi-squared tests for multiway contingency tables with cell proportions estimated from survey data. *The Annals of Statistics, 12*(1), 46–60. https://doi.org/10.1214/aos/1176346391

Sicherman, N. (1991). "Overeducation" in the labor market. *Journal of Labor Economics, 9*(2), 101–122. https://doi.org/10.1086/298261

Spence, M. (1973). Job market signaling. *Quarterly Journal of Economics, 87*(3), 355–374. https://doi.org/10.2307/1882010

Thurow, L. C. (1975). *Generating inequality: Mechanisms of distribution in the U.S. economy*. Basic Books. https://doi.org/10.1007/978-1-349-15723-5

UNEP. (2011). *Towards a green economy: Pathways to sustainable development and poverty eradication*. United Nations Environment Programme. https://wedocs.unep.org/20.500.11822/32245

Verdugo, R. R., & Verdugo, N. T. (1989). The impact of surplus schooling on earnings: Some additional findings. *Journal of Human Resources, 24*(4), 629–643. https://doi.org/10.2307/145998

Vojinić, P., & Bečić, M. (2024). Platform work in selected countries of Eastern and Central Europe. DIEM: Dubrovnik International Economic Meeting. https://doi.org/10.17818/DIEM/2024/1.14

Vojinić, P., Prug, A., & Matić Šošić, M. (2026). Characteristics of the potential participants in the digital labour platforms. DIEM: Dubrovnik International Economic Meeting. https://doi.org/10.17818/diem/2026/1.2

Vona, F., Marin, G., Consoli, D., & Popp, D. (2018). Environmental regulation and green skills: An empirical exploration. *Journal of the Association of Environmental and Resource Economists, 5*(4), 713–753. https://doi.org/10.1086/698859