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Electrifying Skills: a Cluster Analysis of Green Competencies in the Electric Mobility Sector

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ABSTRACT

Electrifying Skills: a Cluster Analysis of Green Competencies in the Electric Mobility Sector

The paper aims to analyze the skills that will be necessary for individuals working in the electric mobility sector. To this end, it examines the key competencies required in online job postings related to the e-mobility sector, which consists of 82 Activity Areas (ADA) from the Atlante del Lavoro.
Thanks to the Atlante del Lavoro's classification structure, the CP and ATECO codes of the ADA could be linked to the vacancies containing the same information. This dataset allowed for measuring the frequency of skills required in online job postings in the electric mobility sector.
To synthesize these data, we perform a cluster analysis (K-means, Ward), identifying seven homogeneous groups of skills required by companies in this sector: production and design processes; project management; quality systems and information systems; machinery; mechanics and vehicles; vehicle maintenance; automation and electrical machinery; and support services.

KEYWORDS: skills, labour market, electric mobility, green transition
JEL CODES: J63, J24, J68

Il paper ha l'obiettivo di comprendere quali saranno le skills necessarie per gli individui che opereranno nella filiera della mobilità elettrica.
A tal fine si esaminano le competenze chiave richieste nelle offerte di lavoro online inerenti alla filiera della e-mobility, costituita da 82 Aree di Attività (ADA) dell'Atlante del Lavoro. Grazie alla struttura classificatoria dell'Atlante del Lavoro, è stato possibile collegare i codici CP e ATECO delle ADA alle vacancies contenenti le stesse informazioni. Questo set di dati ha permesso di misurare la frequenza delle competenze richieste nelle offerte di lavoro online nel settore della mobilità elettrica.
Per sintetizzare queste informazioni, è stata effettuata una cluster analysis (K-means, Ward), che ha identificato sette gruppi omogenei di competenze richieste dalle aziende del settore: processi di produzione e progettazione; gestione dei progetti; sistemi di qualità e sistemi informativi; macchinari; meccanica e veicoli; manutenzione dei veicoli; automazione e macchinari elettrici; servizi di supporto.

PAROLE CHIAVE: *competenze, mercato del lavoro, mobilità elettrica, transizione ecologica*

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1. Introduction

Over the past decade, there has been a consistent flow of innovative and beneficial advancements in the field of electric vehicles (EVs), offering potential societal improvements ranging from enhanced quality of life to economic and environmental benefits. Consulting The Electric Vehicle World Sales Data Base[1] it emerges that the market for plug-in electric vehicles for passengers has witnessed significant growth. In 2021, a total of 6.75 million electric vehicles were sold, surpassing the sales volume of the entire year of 2012 within a single week. During the first half of 2022, 4.3 million new EVs were delivered, marking a remarkable increase of +62% compared to the first half of 2021. This trend is expected to continue in the coming years.

The context of intelligent electric transportation encompasses more than just electric vehicles. Emerging electric mobility technologies will undoubtedly reshape the labour market demands in urban areas. A broader and more adaptable range of skills is required for highly skilled professionals (Siebertz *et al.* 2018).

According to Küpper *et al.* (2020), over the next decade, the total number of employees in the European automotive industry and its ancillary sectors will remain relatively stable. The same authors also argue that significant changes in employment levels will occur in specific sectors and professional profiles within the automotive industry. Furthermore, an important policy indication provided in the same study is that ensuring a smooth transition to electric mobility will require the development of skills and competencies among workers. Küpper *et al.* (2020) also reflect that careful planning and implementation of this transition will be necessary to ensure that the automotive industry continues to drive employment. In this context, governments, companies, and individuals will play crucial roles. Like any major epochal change, the transition to e-mobility will also impact certain professional roles and employment. However, this research suggests it is prudent to assess the overall balance between new job creation and job losses resulting from this transition.

Cotterman *et al.* (2024) suggest that the electrification of vehicles might increase automotive manufacturing employment, particularly in the short- to medium term. However, the feasibility of this transition for existing automotive workers largely hinges on the geographic proximity of new battery production facilities to current internal combustion engine vehicle (ICEV) manufacturing sites, as well as the alignment between the skill sets of automotive workers and the requirements of emerging electric vehicle (EV) roles. Hence, it is evident that the primary challenge presented during this transition revolves around skills. The more workers' skills align with market demands, the better equipped they will be to integrate into the electric mobility sector.

Therefore, the research question is: what are the skills most requested by the labour market in the field of electric mobility?

In recent years, the nature and characteristics by which job demand is advertised have undergone radical changes. The primary reasons for this transformation lie in technological advancements, globalization, the introduction of new professions, and the emergence of associated new skills (Cedefop 2021). To analyse the phenomenon of market and labour market flexibility and dynamism, traditional tools are

[1] For further details, see: https://www.evvolumes.com/country/total-world-plug-in-vehicle-volumes/.

no longer sufficient; therefore, it is necessary to develop new knowledge that allows the study and understanding of ongoing changes (Colombo *et al.* 2018). Internet and social recruiting have become indispensable channels for job seekers and can also provide invaluable data for labour policies, training, and employers.

Big Data offers a significant opportunity in terms of informational sources. Online job advertisements (OJAs) are characterized by the following strengths: detail and depth; sharing and freshness (Fernandez *et al.* 2024).

Therefore, they enable a more comprehensive understanding of the needs of companies and employers compared to using data and analysis from surveys and questionnaires. Specifically, an added value of our research is the ability to leverage the primary source through which human resources are recruited in the labour market.

The final aspect is the real-time updating and connection between the tasks demanded by the labour market and the new skills associated with them, which can be interpreted before they solidify into standardized occupations. This renders skills-level data a relevant analytical tool for institutions aiming to identify emerging roles in the labour market.

The European Commission, in its 2020 Communication titled "European Skills Agenda for sustainable competitiveness, social fairness and resilience[2]" at point 2.1 "Improving skills intelligence: the foundation for up- and reskilling" asserts that to ensure individuals can acquire the necessary skills for current or future employment, it is important to have up-to-date information on skill needs, leveraging the potential offered by big data analysis.

For these reasons, to analyse the skills required for the electrical mobility, we utilized the online job advertisement database provided by Lightcast[3].

The contribution consists of a literature review section that examines previous works related to the analysis of the changing labour market, particularly focusing on its transition towards greener practices based on online vacancies. Subsequently, a methodological section is presented, explaining the procedures employed to analyse the skills required for electric mobility. Then we present the results and the discussion. This is followed by theoretical and practical implications and limitations. Finally, the future research is discussed.

2. Literature review: green jobs and online advertisements

The literature on green jobs and the low-carbon transition has primarily focused on two key areas: (a) defining and identifying green jobs and (b) assessing the labour market impacts of climate policies. Existing studies have highlighted the diversity of green jobs across various sectors and occupations, emphasising the importance of skill development and retraining programs to facilitate labour market transitions.

[2] Communication from the Commission to the European parliament, the council, the European economic and social committee and the committee of the regions European Skills Agenda for sustainable competitiveness, social fairness and resilience, Brussels, 1.7.2020 https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=CELEX%3A52020DC0274.

[3] For further details, see: https://lightcast.io/.

Saussay *et al.* (2022) employed a novel three-step methodology aimed at accurately identifying and isolating low-carbon activities within online job vacancy data. The approach integrates natural language processing techniques with expert surveys to differentiate between job postings classified as low-carbon and those classified as non-low-carbon. The authors use job advertisement data from Lightcast. They offer a nuanced comprehension of the skill sets and wage differentials associated with low-carbon employment opportunities, along with their implications for labour market dynamics. Their findings demonstrate that low-carbon employment differs significantly from high-carbon or generic jobs in several key aspects. Low-carbon jobs exhibit elevated skill requirements across a diverse spectrum of competencies, particularly emphasizing technical skills. The research indicates that the transition to a low-carbon economy carries the potential for substantial labour reallocation costs, including the need for re-skilling and income losses.

The OECD\OCSE paper authored by Borgonovi *et al.* (2023) highlights the significance of upskilling and reskilling initiatives aimed at facilitating the transition of workers across sectors and occupations impacted by the shift toward a low-carbon economy. Key findings show the necessity for tailored interventions that account for demographic attributes and equity considerations to ensure an equitable transition process. The methodology employed in the study integrates modelling analysis of the effects of the Fit for 55[4] policy targets on labour markets with empirical examination of skill demand. This empirical investigation relies on aligning labour market shifts within sectors and occupations with skill-related data extracted from online job postings within the same sectors. The research delves into the distribution of workers across various European Union nations, sectors, and occupations, with a particular focus on demographic factors such as gender, educational attainment, age, and receptiveness to adult education and training, to evaluate the equitable implications of the policy. The analysis suggests that under a scenario where equally stringent policy measures are implemented globally and workforce reallocation occurs seamlessly, overall employment is anticipated to grow by 1.3% between 2019 and 2030. However, had the Fit for 55 policy packages not been enacted, this growth would have reached 3%. Nevertheless, even under these assumptions, certain sectors and worker demographics are expected to experience significant reductions in employment opportunities. Specifically, employment prospects for blue-collar workers are forecasted to decline by 3% between 2019 and 2030 in the Fit for 55 scenarios. Conversely, employment in other occupations is projected to increase by 4-5%.

Ehlinger Gonzalez and Stephany (2023) delve into the transition towards skill-oriented recruitment within the UK labour market, specifically focusing on AI and green job sectors. Employing a bottom-up approach based on skills taxonomy, the study identifies AI and green jobs and examines trends in job postings, educational requirements, and salary premiums associated with these roles. Results indicate a significant increase in demand for AI-related skills, with a decline in the emphasis on university degrees for AI roles but not for green roles. The study notes a more prominent adoption of skill-based hiring practices in the domain of AI roles, underscoring the significance of alternative skill acquisition pathways to alleviate talent shortages and effectively manage the concurrent transition. To investigate this phenomenon, the methodology integrates quantitative scrutiny of online job vacancy data with a meticulous bottom-up approach grounded in skills taxonomy.

[4] For further details, see: https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55/.

The International Labour Organization's report *Greening with Jobs* (ILO 2018) provides a comprehensive analysis of the implications of transitioning to a green economy for employment. The report emphasises the potential for job creation and the importance of ensuring that the transition is inclusive and equitable. It delves into various sectors, encompassing renewable energy, energy efficiency, sustainable agriculture, and waste management, elucidating the prospects for green job creation within each domain. The report also examines the skills needed for green jobs and the role of education and training in facilitating the transition. The study serves as a valuable resource for policymakers, employers, workers, and other stakeholders interested in understanding the intersection of environmental sustainability and employment.

3. Data and methodology

The first step of this research consists of an examination of job content as described in the Atlante del Lavoro, aiming to identify all activities conducted by companies throughout the entire supply chain of the electric mobility transition.

Our research adopts the task-based method to explore the transition of workers towards electric mobility, analyzing a subset of green jobs. To this end, however, we propose a source of data and job descriptors drawn from the Atlante del Lavoro (Mazzarella *et al.* 2018), which shares some elements with the O*NET classification but also many differences. The most significant difference lies in the construction methodology of the job descriptors within the Atlante del Lavoro, formulated in accordance with the standard logic of organized labour division and rooted in the value chain model. This model has been extensively applied to all Economic Professional Sectors (EPS) identified in the Atlante, and analytically for each Area of Activity (ADA). Within each ADA, value generators have been identified as the complex result of the interaction between specific production requirements dictated by the activities to be carried out and the resources necessary for the performance of such activities. This characteristic makes the Atlante suitable for building a shared system of technical elements around which to identify the relevance of specific demands from innovative markets, such as electric mobility, compared to the existing ones.

The map of the 24 Economic Professional Sectors (SEP) in the Atlante del Lavoro consists of two independent ISTAT classifications: the classification of economic activities (ATECO 2007) and the classification of professions (CP 2011). All codes constituting these statistical classifications, at their maximum extension, were regrouped in the EPS of the Atlante to meet an empirical need to identify a "perimeter" where to place, ordering the informational field, sets of work processes and activities with relative internal homogeneity (intra-sectoral) and sufficient external distinction (inter-sectoral) (Mazzarella *et al.* 2018).

Thanks to this structure, in the initial phase of the research, a thorough analysis of the job descriptors in the Atlante was carried out, selecting the ADA referred to by the ATECO codes of the companies involved in the Italian electric mobility supply chain. Then, the contents of the Atlante were reanalysed, not only observing the ADA referred to by the ATECO codes previously selected, but also examining the entire heritage of descriptors, with particular attention to the expected results. The classificatory perimeter of the 24 ESP in the Atlante also allowed the association of data from the sample survey of the Istat Labor Force to individual ADA. Within this study, pairs of CP-ATECO codes, according to the research group, were extracted, mostly involved in the supply chain, thus allowing for an initial estimation of the number of employees (Ferri *et al.* 2021).

This work isolated 82 Areas of Activity, which were then linked to occupation codes and industry sector codes. These linkages allow for an analysis starting from the segments of work performed by individuals to ascertain the number of workers engaged in a specific profession within a given sector. Focusing on the area of activities involved in the mobility transition, qualifications, and detailed competencies, both knowledge and skills, were extracted using online job postings data. Approximately 680 qualifications associated with these identified ADAs encompass over 2,100 articulated skills. The linking of 5-digit CP professional codes with industry sector codes enabled the identification of combinations that are integral to the supply chain likely to be impacted by the shift towards electric mobility.

Lightcast aggregates postings from over 100,000 online job sites globally to construct a comprehensive, up-to-date representation of labour market demand. The platform extracts key details from each job listing, including title, employer, and industry, and then parses the job description to identify specific job titles, skills, and qualifications sought by employers. Duplicate postings are removed, and each job is catalogued in a database for in-depth analysis. This detailed dataset provides a distinctive capability to detect and monitor significant labour market trends in real-time, often preceding their visibility in other data sources. After extraction, job postings underwent processing and quality assurance. The process of information processing and quality control can be summarized in five main steps.

The first step is the data collection: this includes the activities related to the data collection, such as crawling, fetching, scraping, and storing data (figure 1). It is the process of obtaining and importing data from web portals and storing it in a database. The second step (data quality) includes data cleaning to remove noise or inappropriate outliers (if any), deciding how to handle missing data, and identifying a way to detect and remove deficient entries (e.g. duplicated vacancies and vacancies with missing values).

Lightcast employs methods to identify and eliminate duplicates across multiple sources. This prevent that the same job posting from being counted multiple times. At this stage, repeated advertisements are detected using text similarity techniques and consolidated into a single instance. However, it's important to note that if similar advertisements are found with significant time gaps between their publication dates (exceeding three weeks), they are treated as distinct instances. The subsequent step is the classification: this is the process of extracting structured data from unstructured text through text classification algorithms (based on ontology, machine learning etc.) to build a classification function for mapping data items into standard statistical classifications[5]. The last step is data visualisation, the

5 NUTS for the territorial level: the NUTS (Nomenclature des Unités territoriales Statistiques) classification is standardised across all EU countries to enable cross-country comparison. NACE for the economic sector: the NACE (Statistical classification of economic activities in the European Community) taxonomy is the classification of economic activities or industries in the European Union. ISCED for educational levels: the ISCED (International Standard Classification of Education) taxonomy provides a comprehensive framework for organising education programmes and qualifications by applying uniform and internationally agreed on definitions to facilitate comparisons of education systems across countries. ISCO08/ESCO for occupations and skills: ISCO08/ESCO taxonomy identifies and categorises skills/competencies, qualifications, and occupations relevant for the EU labour market and education and training, in 25 European languages. It was built

representation of knowledge extracted from data using data visualisation paradigms according to web usability techniques. This method ensures a very granular and representative dataset of the labour market (Lovaglio 2022, Lovaglio *et al.* 2020).

The research steps are many and refer to other works published on the topic (Ferri *et al.* 2021, Ferri and Porcelli 2023). Through initial research on electric mobility, we traced the perimeter of the electric mobility supply chain, identifying the work segments that are part of this supply chain. In this sense, it was then possible to identify the areas of activity that refer to these segments of work.

Each area of activity refers to a set of occupations (expressed in the Classification of Occupations, CP 2011[6]) and thanks to this key it is possible to connect the job advertisements and all their content in terms of skills (ESCO[7]) required of the professional figures sought. For each skill we will then be able to calculate how many times it is mentioned in the total area of activity-related online vacancies.

In the numerator we therefore have the number of times a skill is mentioned, in the denominator, however, the number of total online job advertisements that refer to a specific area of activity, as per formula (1).

$$\textit{Share of mentions of skills} = \frac{\textit{Number of mentioned skills}}{\textit{Total number of job advertisements referring to the area of activity}} \quad (1)$$

We have constructed a matrix where the areas of activity are represented as columns and the individual skills as rows, with the matrix elements reflecting the proportionate frequency of skill mentions within each area. The methodology begins by collating the frequency of skill mentions by area of activity. From this, we construct a sparse matrix, M, where skills are our observations (rows) and areas of activity are our features (columns). Each element M_{ij} of the matrix signifies the share of mentions of skill i within area of activity j. With 695 instances and 82 features, our matrix takes the form $M \in R^{695\times 82}$.

Before deploying the matrix M as input for further analysis, we undertook data pre-processing steps. Skills mentioned in fewer than 5 / 82 of activity areas were pruned to refine the dataset. Additionally, any observation where the share of mentions was below the interquartile range (IQR) minimum value (which amounted to 0.009) was excluded. Post-cleaning, we normalized the matrix such that it adhered to a normal distribution, with a mean (μ) of 0 and a standard deviation (σ) of 1, enhancing the homogeneity of the data for subsequent analytical processes.

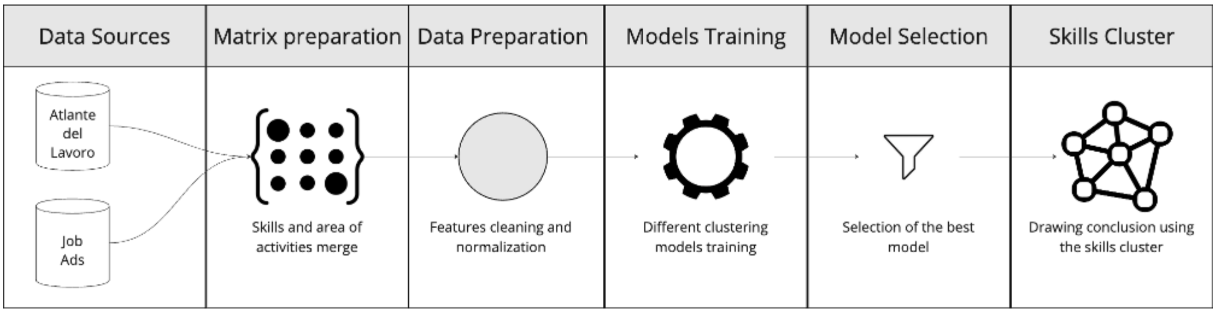
The objective of the analysis is to cluster the units (skills) into homogeneous classes based on all considered characteristics (variables, the ADA). Subsequently, the intention is to create a certain number of distinct groups containing similar units, based on all considered variables.

to provide a common language to help job seekers find jobs that match their skills, connect employment and education providers, and connect labour markets across the European Union. The ISCO08 Occupation taxonomy covers 436 unique occupations.

[6] For further details, see: https://www.istat.it/it/archivio/18132.

[7] For further details, see: https://esco.ec.europa.eu/en/classification/skill_main.

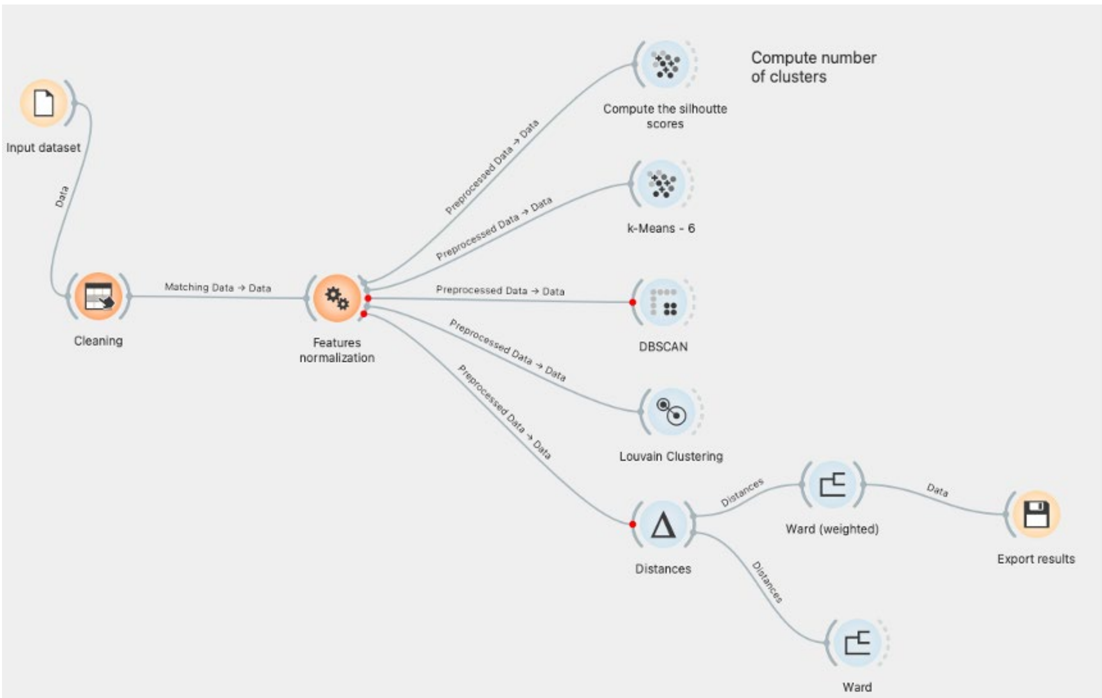
Figure 1. Method used to identify skill clusters



Source: Authors' elaboration

The aim of the analysis is for the grouping to allow the creation of sets of units that are as homogeneous as possible on one hand and as separated as possible on the other hand. This aims to simplify a complex reality. No a priori classification is employed. Each unit is characterized by observations (figure 2) on as many variables, and in the search for groups, consideration is given to all considered characteristics simultaneously. In our multifaceted clustering analysis, we employed a suite of methodologies including K-means, DBSCAN, Louvain, and Ward to effectively discern patterns within our dataset. Specifically, K-means was utilized to determine the optimal number of clusters by leveraging the silhouette score—a measure of how similar an object is to its cluster compared to other clusters. Subsequently, we applied the Ward method, which is recognized for its hierarchical clustering approach that joins data points into clusters based on minimizing the variance within each cluster.

Figure 2. Process used to compute number of clusters



Source: Authors' elaboration

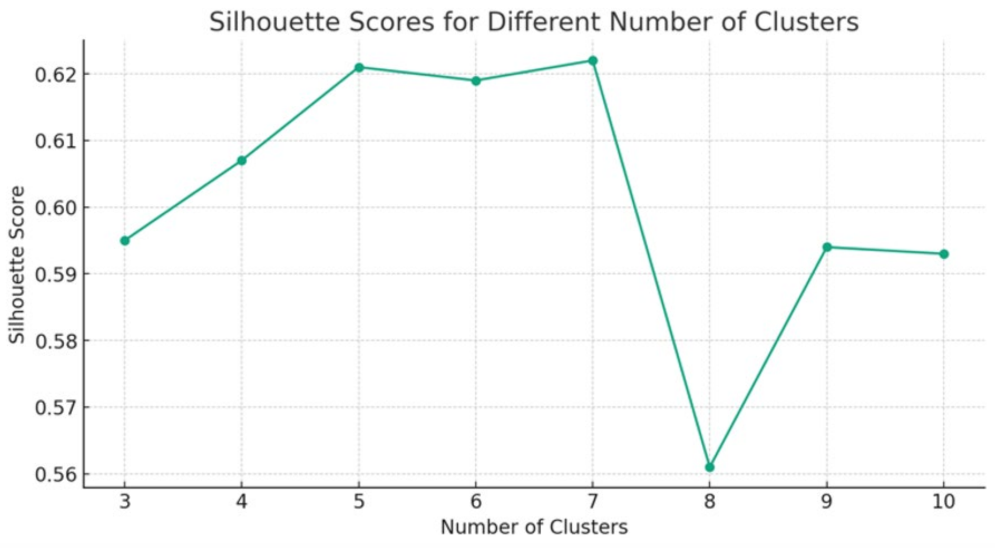
The Ward method, also recognized as Ward's minimum variance method, is largely used among hierarchical clustering algorithms. Its objective is to minimize variance during the merging of clusters at each hierarchical step, rendering it (table 1) especially advantageous for datasets featuring numerical attributes. We focus our analysis on seven clusters, as the results of the silhouette scores denote the max value around it (figure 3).

Table 1. Silhouette score of clusters

Number of clusters	Silhouette score
3	0.595
4	0.607
5	0.621
6	0.619
7	0.622
8	0.561
9	0.594
10	0.593

Source: Authors' elaboration on Lightcast data, 2022

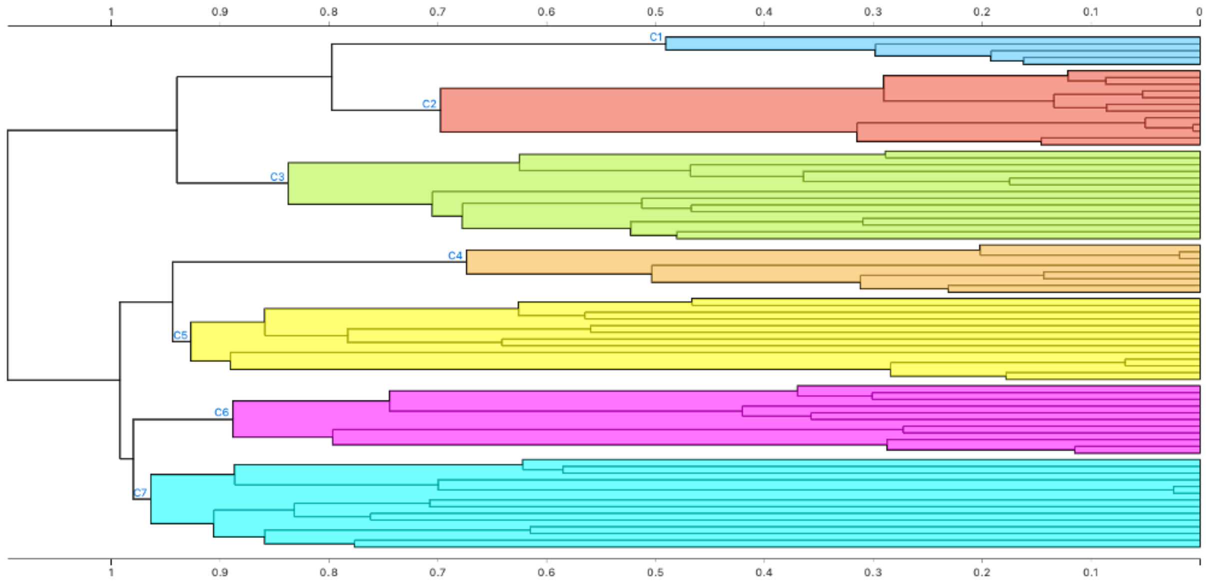
Figure 3. Silhouette score of clusters



Source: Authors' elaboration on Lightcast data, 2022

In hierarchical clustering using the Ward method, the algorithm initiates by treating each data point as a separate cluster. Then, during each iteration, it combines two clusters that minimize the rise in total within-cluster variance (figure 4). This iterative process persists until either all data points are merged into a singular cluster or until a predetermined number of clusters is attained.

Figure 4. Hierarchical clustering with the Ward method



Source: Authors' elaboration on Lightcast data, 2022

4. Results

The resultant hierarchical clustering dendrogram facilitates visualizing the formation of clusters and the degree of similarity between them. It offers insights into the interrelationships among data points and the data's structure. In conclusion, hierarchical clustering utilizing the Ward method serves as a potent tool for uncovering inherent groupings within datasets and finds extensive applications across diverse fields, including biology, finance, and marketing.

The results of our analysis culminate in the identification of skills clusters. A skills cluster is a grouping of skills that tend to be mentioned together within the same or similar areas of activity. In other words, it is a collection of competencies, abilities, and knowledge sets that are commonly required across specific job roles or industry sectors. Skills within the same cluster share a contextual relationship and are likely to be co-dependent or complementary. These clusters help us understand the interconnectedness of skills and how they combine to fulfil the multifaceted requirements of occupational roles inside the context of analysis.

The identified clusters are outlined in the accompanying table 2, which provides a clear representation of how individual skills aggregate into meaningful groupings. These clusters can be instrumental for policymakers, educators, and workforce development professionals, as they provide a framework for designing targeted training programs, aligning educational curricula with labour market demands, and guiding individuals in their professional development and career planning efforts.

Table 2. The identified clusters of individual skills required in the job postings

Cluster	Name of the skills cluster	Top demand skills
C1	Production processes and design	Creating designs in AutoCAD; Production processes; Designing computer graphics; Architectural design; Using software for technical drawing
C2	Project Management, Quality Systems, and Information Systems	Project Management, ICT Systems, Data Analysis, and Quality Standards
C3	Machinery	Machinery maintenance, Machinery installation, and Operation of CNC machinery
C4	Mechanics and vehicles	Mechanics (principles), Vehicles (components), and Engines
C5	Vehicle maintenance	Painting techniques, Cleaning, and Welding techniques
C6	Automation and electrical machinery	Automation, Electrical Machinery, and Electromechanics
C7	Support services	Marketing, Logistics, Customer Assistance and Customer care

Source: Authors' elaboration on Lightcast data, 2022

Cluster C1, labelled "Production processes and design" encompasses skills central to design and manufacturing, such as proficiency in AutoCAD, understanding of production processes, competence in computer graphics, architectural design, and the use of specialized technical drawing software.
As for the architectural design, Autocad and other technical drawing software are concerned, engineers and architect could design components of EV, battery packs and charging infrastructure in the context of electrical mobility. This can result in more streamlined designs and assist engineers in visualizing and addressing potential issues before the production phase.

These competencies form an integral part of the broader process encompassing the design, production, and promotion of electric vehicles and their associated infrastructure, all of which are fundamental elements of electric mobility.

This cluster is indicative of the high value (figure 5) placed on detailed design and production planning in the manufacturing sector. Cluster C2 focuses on "Project Management, Quality Systems, and Information Systems," highlighting the demand for skills in project management, ICT systems, data analysis, and adherence to quality standards. This cluster embodies the pivotal role that efficient project supervision, quality assurance, and information governance play in propelling business prosperity. As far project management is concerned it involves planning, organizing and managing, that are critical skills also for other sectors. Quality systems play a pivotal role in upholding the dependability and safety of electric vehicles and charging stations. These aspects are essential for building trust among users and are key to the overall success of electric mobility. The role of information systems is to handle the data produced by electric vehicles and their charging infrastructure. They assist in observing and controlling the power grid load, fine-tuning charging periods based on the supply and demand of electricity and offering real-time updates to users about the status of charging stations, among other things.

In Cluster C3, "Machinery" the emphasis is on operational skills including machinery maintenance, machinery installation, and the operation of CNC (Computer Numeric Control) machinery. This cluster signifies the importance of technical proficiency in handling, maintaining, and operating complex machinery.

Cluster C4 is characterized by "Mechanics and vehicles" concentrating on the principles of mechanics, knowledge of vehicle components, and engine technology. Such skills are vital within industries that rely on the maintenance and innovation of vehicle systems. “Vehicle maintenance” forms Cluster C5, where the top demanded skills are painting techniques, cleaning, and welding techniques—skills that are essential for the upkeep and repair of vehicles.

Cluster C6, “Automation and electrical machinery” underlines skills in automation, electrical machinery, and electromechanics, pointing to the increasing significance of automated and electrical systems in modern industry. The automated production of this type of vehicle does involve efficiency and precision, scalability, flexibility, quality control, innovation, and cost reduction. The skills required to achieve these objectives are indeed grouped in this cluster. This approach ensures the production process is optimized for the unique requirements of electric mobility.

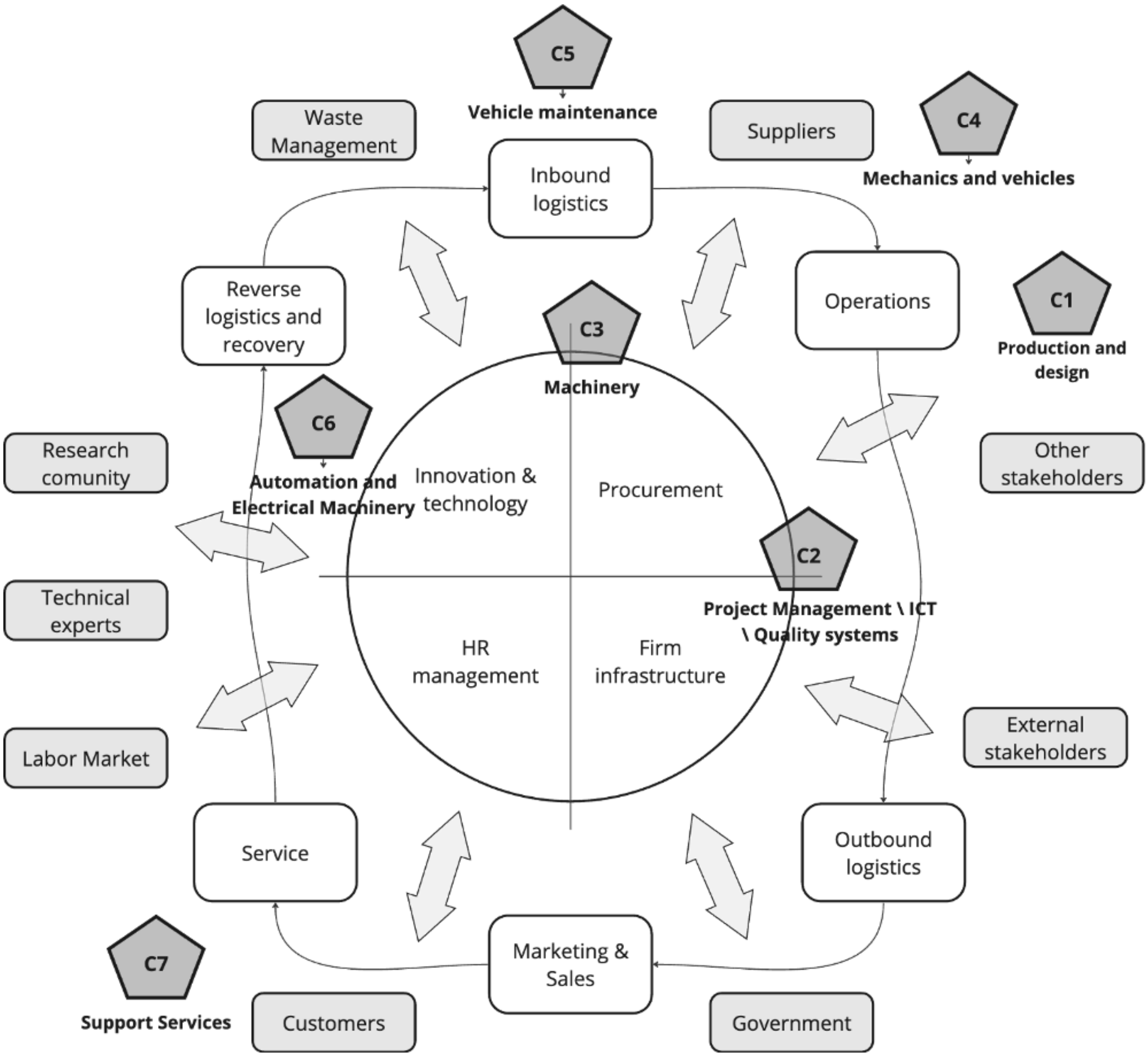
Lastly, Cluster C7, “Support services”, includes skills in marketing, logistics, customer assistance, and customer care. This cluster highlights the need for professionals who can manage customer relations, logistical operations, and market products effectively. This skill set is important for this emerging supply chain as well as for many other more traditional sectors. It involves product support and logistics and marketing, skills that can be required and used in various sectors

These clusters offer a strategic roadmap for skill development, emphasizing areas for investment in training and education to meet the dynamic needs of the workforce. They serve as a guide for individuals aiming to enhance their employability and for organizations striving to cultivate a skilled and capable workforce.

The identified skills clusters are mapped onto Michael Porter’s value chain analysis, which serves as a framework to dissect a company’s activities and identify where competitive strategies can be applied to gain advantage. By aligning these clusters with the value chain, we can trace how each cluster contributes to the various primary and support activities within a business, from inbound logistics to after-sales service. Cluster C1, “Production processes and design” aligns with the “Operations” component of the value chain, as it encompasses the actual creation and assembly of products and the design processes that precede manufacturing. Cluster C2, “Project Management, Quality Systems, and Information Systems” spans across several aspects of the value chain but particularly fits within “Firm Infrastructure” for quality systems and “Technology Development” for information systems. This highlights the need for managerial and analytical skills to oversee complex projects and maintain high standards. Cluster C3, “Machinery” directly contributes to “Operations” within the value chain, dealing with the equipment and machinery essential for production processes. Cluster C4, “Mechanics and Vehicles” and Cluster C5, “Vehicle Maintenance” are pivotal to both “Operations” in maintaining the efficiency of production systems and “After Sales Services”, ensuring the longevity and reliability of the final product.

Cluster C6, “Automation and Electrical Machinery” can be linked to ‘Technology Development’ due to its role in advancing production techniques and operational efficiencies. Finally, Cluster C7, “Support Services” finds its place in multiple support activities like “Firm Infrastructure” (for Marketing and Logistics) and “Service” (Customer Assistance and Care), highlighting the roles that support the firm’s infrastructure and enhance customer experience.

Figure 5. Graphic representation of the clusters



Source: Authors' elaboration on Lightcast data, 2022

5. Discussion

The paper conducts an evaluation of workforce competencies within the electric mobility sector, examining these skills through Michael Porter's value chain framework. Our investigation began with a thorough analysis of job content as documented in the Atlante del Lavoro, leading to the identification and classification of 82 Areas of Activity (ADA).

Our research has yielded seven distinct skill clusters, reflecting the key competencies required in the electric mobility sector. These clusters underscore the convergence of digital, cross-functional, and technical skills essential for the various interconnected roles within the sector. From primary production

operations to after-sales services, each cluster represents a critical aspect of the sector vital for its systemic development and sustainability.
When viewed through the lens of job postings, innovations such as electric mobility indicate a need for skills across all areas of the organizational process. This suggests that, rather than merely replacing jobs (Ferri and Porcelli 2022), there is an extended need for competencies in every role. Innovations of this nature require the enhancement of skills at higher levels, such as design found in clusters one and two, as well as at more operational levels, such as vehicle mechanics and maintenance. Furthermore, by examining the competency categories aggregated within each area, we observe not entirely new keywords but rather keywords that express the innovation of traditional competencies, highlighting the need for knowledge and skills related to the twin transition.
The analysis reveals a critical necessity for competencies in infrastructure and energy network administration, automotive manufacturing and maintenance processes, and research and development initiatives. This pronounced emphasis on technological and infrastructural proficiencies underscores the industry's paradigm shift towards innovative and sustainable mobility solutions. The findings suggest a significant transformation within the sector, necessitating a workforce adept in cutting-edge technologies and systems management to facilitate the evolution of transportation modalities. This focus on advanced skill sets reflects the industry's trajectory towards more sophisticated, environmentally conscious vehicular systems and the concomitant need for expertise in their development and implementation.

6. Theoretical and practical implications

Understanding these clusters within the context of the value chain offers multiple benefits for decision-makers and policymakers. The system would need to tailor educational and vocational training programs to develop the specific skill sets identified in each cluster. This customization ensures that individuals receive training directly aligned with the most current needs of the sector, thereby cultivating a more competent and effective workforce that aligns seamlessly with the requirements of the electric mobility sector.
Additionally, it is critical to assist companies in identifying areas within the value chain that could benefit from strategic investments in skill development. By pinpointing these strategic areas, companies can effectively allocate resources to enhance the efficiency and effectiveness of upskilling and reskilling pathways for personnel, thus strengthening their competitive advantage in the market. Our study offers methodological insights aimed at further optimizing workforce benefits, guiding companies in precisely identifying the skills required for various segments of the electric mobility value chain.
This recruitment approach aims to promote the creation of personalized pathways, contributing to the innovation, technological development, and sustainability of the entire sector.
Our work facilitates better matching between business needs and education providers to ensure that curriculum development is closely aligned with the evolving needs of the electric mobility sector. An objective to improve matching should be to promote methods of connection between stakeholders, aiming to foster the development of educational programs tailored to the needs of the job market, thereby bridging the skills gap and promoting workforce readiness.

This value chain-based approach allows for the identification of multidisciplinary pathways that promote the intersection of digital, managerial, and technical skills, adapting to the rapidly evolving needs of the electric mobility sector.

The growth of the sector can be encouraged through partnerships between industry, academia, training institutions, and qualified professionals capable of addressing the complex skill demands expressed by the system.

Continued investigation into this subject matter is deemed valuable for tracking the evolving skill requirements within the industry. Expanding the research paradigm to encompass a global perspective would be beneficial, as it would yield a more comprehensive understanding of the collective expertise present in the electric mobility sector. This broader approach would facilitate a more nuanced analysis of international trends and variations in skill demands, potentially revealing insights that could inform strategic workforce development and educational initiatives across diverse geographical contexts.

7. Limitations

Understanding the extent and nature of reskilling within companies for the green transition poses significant challenges. Training bodies do not disclose detailed data on the skills being updated, which limits our ability to track continuous skill development. Consequently, while we can identify company requests for new hires, we lack insight into the ongoing skill updates that enable workers to remain in their roles long-term.

The online job postings utilized in our analysis might not be exhaustive. Informal job demands may not be captured in traditional channels. When a company identifies a skills gap needing to be filled through a vacancy, it may already have assessed that its current staff cannot meet this need, or the cost of training is prohibitive. In such cases, the availability and capacity to utilize public policies supporting upskilling and reskilling become critical to prevent staff turnover. Online job postings, while a valuable and detailed data source, may overfit or underfit certain economic sectors, leading to biases in labour market analysis. According to the OECD\OCSE study, online job postings often represent hight-skilled and tech jobs more accurately, while low-skilled, public sector, and low-tech jobs may be underrepresented. This discrepancy arises because not all employers use online platforms equally, and some sectors rely more on informal hiring channels or private web channel (e.g. Telegram groups). Therefore, the data might skew the real labour demand, affecting the accuracy of economic sector representation.

A recent study by the JRC underlines that while online job advertisements offer valuable insights into labour market dynamics, they come with several limitations. One of the most important limitations is representation bias. OJAs tend to over-represent white-collar and tech jobs while under-representing blue-collar, public sector, and low-tech jobs, leading to a skewed picture of the labour market. Another limitation concerns incomplete data: many jobs, particularly in smaller firms, are not advertised online and thus are missing from OJA data. Regarding skill details, OJAs often emphasize advanced digital skills but understate basic digital skills, which may be considered self-evident by employers[8]. Employers may not always accurately describe the skills they need, leading to potential mismatches between job requirements and postings.

The second main area of limitations is the application of cluster analysis. Cluster analysis, when applied to web data, faces a confluence of methodological and data-specific challenges that undermine its efficacy and reliability. Standard limitations of cluster analysis, including the sensitivity to the choice of distance metrics and the determination of the optimal number of clusters, are exacerbated by the inherent characteristics of web data. Web data is often plagued by inconsistencies, noise, and incomplete entries, which complicate the clustering process. Duplicate entries and varying job titles for similar roles further confound the accuracy of cluster identification, as noted by Lovaglio and Colombo (2020). Moreover, the dynamic and ephemeral nature of online job postings, which are continuously updated, is a significant challenge to the stability and temporal reliability of clusters, potentially leading to volatile and unreliable labour market insights. The representation bias in online job postings is another critical limitation. The tendency for white-collar and tech jobs to be over-represented, while blue-collar, public sector, and low-tech jobs are under-represented, skews the clustering results. This bias results in an unbalanced view of labour market demands, potentially misleading policymakers and stakeholders. Additionally, the contextual variations in job descriptions and required skills across postings complicate the clustering process, as similar skills may be described differently, making it difficult to group them accurately. These issues necessitate robust methodological frameworks and careful data preprocessing to mitigate the effects of noise, inconsistencies, and bias. However, even with such measures, the intrinsic limitations of cluster analysis, such as the reliance on predefined distance metrics and the subjective determination of cluster numbers, remain significant hurdles. These limitations underscore the need for cautious interpretation and application of cluster analysis results derived from web data, ensuring that conclusions are drawn with an understanding of the underlying data complexities and methodological constraints.

8. Future research

The future trajectory of research should aim at the broad applicability and continuous evolution of our methodological framework across various sectors. One of the primary areas of focus should be the replication of the current methodology to other industries (e.g. aerodynamics and aerospace sector, additive manufacturing and new materials). This involves a detailed longitudinal study of electric mobility, capturing the dynamic nature of this sector by regularly updating the data to reflect ongoing changes. Such an approach would provide a nuanced understanding of sector-specific skill demands over time.

A significant advantage of our methodology is its foundation on the Atlante del Lavoro dataset, which offers detailed classifications of activities. This allows for an in-depth analysis of specific skills and the associated tasks required within each activity. By leveraging these detailed descriptors, researchers can

[8] For further details, see: https://joint-research-centre.ec.europa.eu/scientific-activities-z/employment/skills-intelligence-online-job-advertisements_en#jobs-skills-and-tasks .

identify precise skill sets and their relevance to various roles within the electric mobility sector. This granular approach facilitates the development of targeted training programs and informs workforce development strategies tailored to the needs of this evolving industry.

To enhance the robustness of our analysis, it is critical to integrate data from innovative company surveys. Eurostat's Community Innovation Survey (CIS)[9] provides a rich source of information on innovation activities within enterprises across Europe. By linking this survey data with the skills and tasks identified through the Atlante del Lavoro, researchers can gain insights into the human resource needs of innovative firms. This integration would enable the identification of emerging skill requirements driven by technological advancements and innovation practices, thus aligning workforce development with industry trends.

Moreover, the development of a comprehensive needs analysis model for innovative sectors is imperative. Such a model would start with the competencies required in job postings, linking them to the value chain to deduce the human resource needs for specific, highly skilled roles. This approach ensures a precise matching of job market supply and demand, facilitating more effective recruitment strategies. For instance, understanding the competencies required in the context of the electric mobility value chain would allow for the identification of critical skill gaps and the design of training programs that address these gaps, thereby improving the employability of the workforce.

The methodology developed for this study also holds potential for analysing the upskilling and reskilling needs within companies. By applying the same principles, researchers can assess the current skill sets of employees and identify areas where additional training is required to meet future demands. This is particularly relevant in the context of the green transition, where rapid technological advancements necessitate continuous skill updates. Public policies supporting upskilling and reskilling can play a crucial role in facilitating this transition, preventing workforce obsolescence, and promoting sustainable employment.

Furthermore, future research should consider the implications of political and technological changes on skill demands. The integration of big data analytics with traditional labour market information can provide real-time insights into emerging roles and competencies. This dynamic approach allows for the proactive adjustment of educational curricula and training programs, ensuring that they remain aligned with industry needs.

The overarching aim of this research is to cultivate an enabling environment for sustainable industry growth by harmonizing educational policies with industrial initiatives, thereby optimizing value chain efficiency through targeted skill development and anticipating future workforce requirements in rapidly evolving sectors like electric mobility.

In conclusion, the replicability of our methodological framework, the integration of detailed activity-based skill analysis, and the linkage with innovative company data provide a comprehensive approach to understanding and addressing the evolving skill demands of various sectors. These efforts will contribute significantly to the development of a skilled and adaptable workforce, capable of driving and sustaining industry innovation and growth.

[9] For further details, see: https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey .

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