

Article

Key Competences for Technology Commercialisation

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Abstract

The achievement of the sustainable development goal of fostering innovation is directly related to the successful commercialisation of technologies that deliver economic, environmental, and social value. The article presents the theoretical prerequisites for substantiating the relationship between competences and innovation and identifies key commercialisation competences on the basis of an extensive literature review and empirical investigation. The literature emphasises that the success of commercialisation depends on technological and organisational resources as well as the competences of those involved in commercialisation activities. However, to date, research has mainly focused on selected competences, with relatively few studies simultaneously analysing the perceived importance of competences and the extent to which employees of research organisations possess them. This article aims to identify the key commercialisation competences necessary for executing technology commercialisation in research network organisations and to evaluate the extent to which employees involved in commercialisation activities possess and recognise the importance of these competences. Many of these can be treated as core sustainability-oriented competences, understood as capabilities that enable sustainability-oriented commercialisation by integrating environmental and social considerations into innovation processes. An empirical investigation was conducted at the Łukasiewicz Research Network, one of the largest research networks in Europe. The CAWI (Computer-Assisted Web Interviewing) method was employed. Eighty-nine respondents, employees involved in commercialisation processes, represented both research and commercialisation support departments. Statistical analyses included confirmatory and exploratory factor analyses, scale reliability, measurement invariance analysis, and comparison tests. As a result, ten key commercialisation competences were identified, including both interpersonal competences and job-related commercialisation competences for research network organisations. The ten identified key competences constitute an integrated competence framework that enables research network organisations to effectively support sustainability-oriented innovation and commercialisation activities. Out of the 25 competences identified as a result of the literature review, these were regarded as the most essential and compulsory.



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1. Introduction

In recent years, the commercialisation of research results has become a key mechanism for linking scientific activity with socio-economic development. This enables research results to be transformed into market innovations and practical technological applications, thereby fostering innovation [1,2]. In this context, research organisations, particularly those operating within research networks, play a strategically important role because they are involved in both creating innovative technologies and transferring them to economic entities. The paper focuses on research network organisations. These are defined as networks of research entities established within a formal network of affiliated organisations [3]. The subject of the empirical research was chosen for two reasons: (1) the successful commercialisation activities carried out by research network organisations in various countries [4], and (2) the fact that the core mission of the analysed research network is strongly oriented towards the commercialisation of research outcomes and cooperation with the socio-economic environment [5].

The performance of commercialisation processes largely depends on the competences of the people involved [6]. Despite the growing number of studies on research commercialisation and technology transfer, there is still a lack of understanding regarding the specific competences required for successful commercialisation [7]. This applies particularly to research network organisations. In response to this research gap, this article addresses the following questions:

- Which commercialisation competences are essential for executing commercialisation processes in research network organisations?
- How do employees involved in commercialisation processes evaluate the importance of commercialisation competences, and what is their level of proficiency in these competences?

Accordingly, the aim of the article is to identify and evaluate the key commercialisation competences required for the implementation of innovative technologies within a research network organisation.

The paper is structured as follows. First, it presents a literature review on the theoretical prerequisites for substantiating the relationship between competences and innovation and on identifying the competences required for the commercialisation of research results. This is followed by a presentation of the method. Empirical data are collected using the CAWI method. The data are analysed using statistical analysis. The research results comprise the key competences needed for commercialisation and the extent to which employees of a research network organisation involved in commercialisation activities possess them. The research results are then discussed. The paper concludes with a summary of final remarks, practical implications, limitations of the study, and directions for future research.

2. State of the Art

2.1. Conceptualisation of Commercialisation Competences

Technology commercialisation is defined as the design, development, manufacture and marketing of products based on new technologies [8]. The way in which commercialisation is conducted and its success depend on the competences of the people involved in the process.

The literature on innovation commercialisation consistently highlights the pivotal role of competences possessed by actors operating at the interface between academia and industry [9–11]. Despite their recognised importance, conceptualisations of commercialisation competences remain fragmented, with most studies focusing on specific organisational roles and institutional settings rather than proposing an integrated theoretical framework.

Within the technology transfer literature, commercialisation effectiveness is commonly associated with a combination of technical and behavioural competences. Technology transfer professionals are expected to possess specialised knowledge related to intellectual property management, licensing, and technology assessment, while simultaneously demonstrating strong communication abilities, strategic thinking, entrepreneurial orientation, adaptability, and continuous learning capabilities. The interplay between these technical and interpersonal competences is considered fundamental to the successful translation of scientific knowledge into marketable innovations [11].

Research on open innovation extends this perspective by emphasising competences that facilitate knowledge exchange and inter-organisational collaboration [12]. Creativity, entrepreneurship, communication skills, networking capabilities, openness to collaboration, risk-taking propensity, and digital literacy are frequently identified as critical for managing knowledge flows within increasingly complex innovation ecosystems [13,14]. More comprehensive approaches are comparatively rare. One notable example is the “Wheel of Competencies” framework, which integrates fourteen interrelated competences—including agility, complexity management, critical thinking, teamwork, creativity, and learning motivation—to support mission-oriented and innovation-driven knowledge transfer activities [15].

Important contributions to the conceptualisation of commercialisation competences also emerge from studies on open innovation and innovation brokerage. Systematic reviews and large-scale empirical investigations have enabled the identification and clustering of competence domains associated with contemporary innovation challenges [16]. Similarly, research on innovation brokers has led to the development of holistic competence frameworks encompassing both technical and relational dimensions of innovation intermediation [17]. Collectively, these studies suggest that differences among existing competence models largely reflect variations in organisational roles and analytical perspectives rather than fundamental disagreements regarding the nature of commercialisation competences themselves.

2.2. Relationship Between Competences and Innovation Commercialisation

A substantial body of literature demonstrates that competences constitute one of the principal determinants of successful innovation commercialisation [18–20]. Their influence can be observed across multiple levels of analysis, including technology transfer organisations, entrepreneurial ventures, and broader university–industry collaboration processes.

Evidence from university technology transfer offices indicates that commercialisation speed—typically defined as the time required to bring a technology to market—is positively associated with organisational resources and competences related to identifying and engaging potential licensees. Faster commercialisation processes, in turn, contribute to higher licensing revenues and increased spin-off creation [21].

The importance of competences is further supported by qualitative and case-based research [18,22,23]. Studies reveal that successful technology transfer offices develop competences related to translational engagement, including trust-building, reputation management, and boundary-spanning activities between academic and industrial stakeholders. Simultaneously, these organisations cultivate value co-creation competences associated with service quality management and risk reduction. Such competences become embedded within the key stages of the commercialisation process, including technology identification, evaluation, protection, promotion, and monetisation [24]. Similarly, Weckowska [25] identified two distinct approaches to commercialisation—transactional and relational—each underpinned by different competence configurations and assumptions regarding the innovation process.

Entrepreneurial competences are particularly important in the context of university spin-offs. Longitudinal research conducted by Rasmussen et al. [26] identified three critical entrepreneurial competences that shape spin-off development. These include opportunity refinement, referring to the ability to transform research outcomes into viable business opportunities; leveraging, which involves acquiring and integrating internal and external resources; and championing, understood as the capacity to build commitment and mobilise stakeholder support. Complementing these findings, Thomas et al. [27] demonstrated that competences related to technology–market alignment, intellectual property protection, founder team development and mentoring, and appropriate market timing provide critical resources that enhance the likelihood of commercial success.

Several studies have also conceptualised commercialisation success as a function of competence-related behavioural factors. Communication, innovativeness, knowledge, motivation, and product quality have been identified as the five most influential determinants of successful technology transfer from public institutions to small and medium-sized enterprises [28]. These findings are consistent with broader systematic reviews, which emphasise the central role of organisational resources, dynamic capabilities, and university–industry relationships in shaping commercialisation outcomes [29,30].

2.3. Factors Influencing the Development of Commercialisation Competences

The development of commercialisation competences is a multidimensional process shaped by individual, organisational, and ecosystem-level factors. Contemporary research suggests that such competences do not emerge solely from individual attributes but rather evolve through continuous interactions between actors, organisations, and institutional environments.

At the individual level, entrepreneurial attitudes, creativity, willingness to take risks, collaborative capabilities, and the ability to mobilise others are frequently identified as foundational drivers of competence development. These attributes are considered particularly important in open innovation environments and are increasingly recognised as essential for preparing future professionals to manage knowledge flows in digitally enabled economies [13,14].

At the organisational level, competence development is supported through structured training initiatives, talent management practices, and strategic human resource development. For example, competence-based training models developed for technology transfer professionals using the Fuzzy Delphi method encompass technical, interpersonal, entrepreneurial, and knowledge-related competences aimed at enhancing technology transfer and commercialisation performance [7]. Concurrently, research continues to identify substantial competence gaps, particularly in entrepreneurship, marketing, promotion, and business knowledge, highlighting the need for targeted development programmes and revised recruitment strategies within commercialisation-oriented organisations [11].

Organisational learning processes also play a significant role in shaping competence development. Drawing on a practice-based perspective, Weckowska [25] demonstrated that commercialisation practices adopted within technology transfer offices generate specific “competence regimes” that simultaneously facilitate learning and reinforce established patterns of behaviour. Consequently, the transition towards more relational forms of commercialisation requires deliberate leadership interventions and the removal of organisational barriers that constrain learning and adaptation.

Finally, competence development is strongly influenced by broader institutional and sectoral contexts. Research conducted in emerging and transitional economies highlights the growing importance of relationship-building capabilities, trust creation, and organisational absorptive capacity. These competences enhance the effectiveness of technology

transfer activities and facilitate the commercialisation of publicly generated technologies under conditions of increasing market competition and environmental uncertainty [13,31].

2.4. Identification of Commercialisation Competences

Based on the literature review conducted, commercialisation competences can be understood as a multidimensional construct encompassing technical, strategic, relational, entrepreneurial, and future-oriented capabilities required to transform research outcomes into innovations that generate both market and societal value [11,15,18,19]. The literature indicates that these competences are conceptualised differently depending on the actors under investigation, including technology transfer professionals, innovation brokers, open innovation teams, academic entrepreneurs, and founders of university spin-offs [11,14,17,26,27]. Moreover, different competences are listed by researchers, depending on whether they carry out a complex analysis or focus on selected competences. Comprehensive analyses are rare, with most of them referring to universities and/or technology transfer offices [11,20]. There is a lack of publications devoted directly to the competences needed in research network organisations. Researchers more commonly focus on specific competences, e.g., intellectual property protection [32], entrepreneurial competences [23], organisational competences [33], technology co-development competences [22], marketing competences [34], or networking capabilities [35].

Despite this fragmentation, there is broad consensus that successful commercialisation requires not only specialised knowledge of technology, intellectual property, and markets, but also relational, strategic, adaptive, and entrepreneurial capabilities [11,16,19,25,26]. Accordingly, the present study builds upon the existing body of knowledge by integrating prior findings into a coherent competence framework [29,36,37].

Two groups should be considered when distinguishing commercialisation competences: those directly related to the commercialisation process, and the so-called “21st-century competences”. The first group is obvious and comprises competences that are traditionally related to the commercialisation process, such as knowing how to commercialise R&D results or analyse customer needs. The need to include the second group is related to the fact that commercialisation takes place in a dynamic, complex and uncertain VUCA environment, which requires specific competences known as the 21st century competences, future skills or future-oriented competences [38–41] such as collaboration, communication, network management, creativity, flexibility [42,43].

In the state-of-the-art analysis, the research papers indexed in the Scopus and Web of Science databases were used as sources of information. Scopus and Web of Science were searched in two streams. Firstly, the criterion “competences” was used, after which the authors searched the results using the criterion “commercialisation”. At the first stage, the abstracts were read, and the full papers were briefly reviewed. Initially, 134 papers from the Scopus database and 48 papers from the Web of Science were skimmed, of which 44 and 33, respectively, were selected for further reading. Seventy-three publications constituted the final publication base referring to competences in the area of commercialisation. In the second stage of the search, the criteria “future of work” and “future competences” were applied to the Scopus and Web of Science databases. Due to the dynamic nature of changes in future-oriented competences in a VUCA world, recent publications from 2016 to 2026 were analysed. Initially, 108 papers from Scopus and 98 papers from Web of Science were viewed; of these, 42 and 43 papers, respectively, were selected for detailed reading. Seventy-seven publications constituted the final publication base referring to future-oriented competences. These include papers devoted to the topic of future-oriented competences that are not too detailed, do not refer to individual professions, and are not exclusively related to commercialisation activities. As a result of the state-of-the-art

analysis, it has been observed that the commercialisation competences mentioned by scholars and practitioners in publications directly related to commercialisation also include future-oriented competences.

Based on the literature review of publications indexed in Scopus and Web of Science and following a synthesis stage, 25 commercialisation competences were identified (Table 1). Numerous commercialisation competences identified by the paper's authors can be treated as core sustainability-oriented competences understood as competences that directly enable sustainability-oriented commercialisation by integrating environmental and social considerations into innovation processes. These include: commercially oriented R&D competences [44], market analyses [45], creation of commercialisation strategy [44,46], ability to analyse customer needs [47,48], network competence [48], cooperation skills [49,50], knowledge mobilisation [49,51], evaluating the impact of commercialisation [44,45], change management [50], and creativity [47,52].

Table 1. Commercialisation competences.

Competences	Definition	Authors
Specialist competences	Specialist competences required in the industry where commercialisation is conducted.	Sharif, Nizam, Rashid, Masrom & Bakri, 2018 [32], Pistrucci & Kleine, 2019 [53]; Debowska et al., 2022 [54]; Turdalina & Kozhakhmet, 2025 [11]
Commercially oriented R&D competences	R&D competences focused on developing and applying scientific knowledge for commercialisation and aligning research with market needs.	Bayley et al., 2018 [55]; Son et al., 2021 [56]; Turdalina & Kozhakhmet, 2025 [11]
Market analyses	The ability to analyse market trends and needs to identify opportunities for product, service or business model development.	Morris et al., 2013 [57]; Aarikka-Stenroos & Lehtimäki, 2013 [18]; Sotarauta & Heinonen, 2016 [58]; Munoz-Penas, Højbjerg Clarke & Rostgaard Evald, 2024 [19]; Turdalina & Kozhakhmet, 2025 [11]
Entrepreneurial competences	Knowledge, skills and attitudes enabling the creation and development of business activities.	Sotarauta & Heinonen, 2016 [58]; Gbadegeshin, 2019 [59]; Treanor, Noke, Marlow & Mosey, 2021 [60]; Magruk & Rollnik-Sadowska, 2021 [61]; White paper, 2022 [62]; Hayter, Fischer & Rasmussen, 2022 [63]; Szulczewska-Remi & Nowak-Mizgalska, 2023 [23]; Puurtinen & Pohjola, 2024 [64]; Cvetkovic, Jahnke, Lindley & Owen, 2024 [65]; Fisher, Blankesteyn, Harms & van Muijlwijk-Koezen, 2024 [66]; Turdalina & Kozhakhmet, 2025 [11]
Analyses of the financing sources	The ability to identify and secure external funding for commercialisation activities.	Morris et al., 2013 [57]; Gbadegeshin, 2019 [59]; Yedgenov, Alibekova, Mynbayeva & Kozhakhmetova, 2025 [67]; Al-Maadeed & Yesuf, 2025 [68]
Economic analyses	The ability to assess costs, revenues and profitability of commercialisation projects.	Aarikka-Stenroos and Lehtimäki, 2013 [18] Ballot et al., 2024 [69]
Creation of commercialisation strategy	The ability to design and implement strategies for bringing innovations to market.	Chang, Shen & Wu, 2006 [70]; Munoz-Penas et al., 2024 [19]
Creation of marketing strategy	The ability to design marketing strategies communicating the value of innovations to target groups.	Aarikka-Stenroos & Lehtimäki, 2013 [18]; Whalen, Holloway & Parkman, 2015 [34]
Creation of IP protection strategy	The ability to design strategies for protecting intellectual property.	Cervantes & Meissner, 2014 [12]; Handbook on IP, 2019 [71]; Ballot et al., 2024 [69]
Ability to analyse customer needs	The ability to identify and interpret customer needs to adjust solutions accordingly.	Morris et al., 2013 [57]; Cervantes & Meissner, 2014 [12]; Hewing, 2014 [72]; Munoz-Penas et al., 2024 [19]; Turdalina & Kozhakhmet, 2025 [11]
Managing legal issues and IP	The ability to manage legal and IP aspects to maximise commercialisation value.	Balbinot, Dias & Borim-de-Souza, 2012 [33]; Bayley et al., 2018 [55]; Stasiak-Betlejewska, 2021 [73]; Munoz-Penas et al., 2024 [19]
Using tools and practices supporting commercialisation	The ability to apply tools and methods supporting commercialisation processes.	Luoma, Paasi & Nordlund, 2008 [74]; Bayley et al., 2018 [55]
Innovation popularisation	The ability to promote and scale innovations in the market.	Munoz-Penas et al., 2024 [19]

Table 1. Cont.

Competences	Definition	Authors
Network competence	The ability to build and maintain relationships with stakeholders.	Story, O'Malley & Hart, 2011 [75]; Aarikka-Stenroos & Sandberg, 2012 [76]; Chou & Zolkiewski, 2012 [77]; Morris et al., 2013 [57]; Canning & Szmigin, 2016 [78]; Bayley et al., 2018 [55]; Gbadegeshin, 2019 [59]; Ganjeh, Khani & Tabriz, 2020 [35]; Munoz-Penas et al., 2024 [19]; Sabatini & O'Toole, 2024 [22]; Taheriruh, Jääskeläinen, Loijas & Harrison, 2025 [79]
Cooperation skills	The ability to collaborate effectively to achieve common goals.	Nagesh & Thomas, 2015 [80]; Hendarman & Cantner, 2018 [20]; Czarnik et al., 2019 [81]; Felder et al., 2019 [82]; Gbadegeshin, 2019 [59]; Lekoviv, Vojinovic & Milutinovic, 2020 [83]; PARP, 2020 [84]; Dębkowska et al., 2022 [54]; Pokojaska 2022 [85]; Delisle & Lajoie, 2022 [86]; Thornhill-Miller et al., 2023 [87]; Munoz-Penas et al., 2024 [19]; Grama & Todericiu 2025 [88]
Communication	The ability to communicate clearly with diverse stakeholders.	Phipps & Morton, 2013 [89]; Bayley et al., 2018 [55]; Hendarman & Cantner, 2018 [20]; Gbadegeshin, 2019 [59]; Magruk & Rollnik-Sadowska, 2021 [61]; Pokojaska, 2022 [85]; Delisle & Lajoie, 2022 [86]; Thornhill-Miller et al., 2023 [87]; Yeboah, 2023 [90]; Turdalina & Kozhakhmet, 2025 [11]; Taheriruh et al., 2025 [79]
Self-confidence	Confidence supporting decision-making and engagement in commercialisation activities.	Wu, 2009 [91]; Stetler, Damschroder, Helfrich & Hagedorn, 2011 [92]; Szulczewska-Remi & Nowak-Mizgalska, 2023 [23]
Prioritisation	The ability to prioritise projects based on their market potential.	Ballot et al., 2024 [69]
Knowledge mobilisation	The ability to transfer and apply knowledge across contexts.	Alves, Bomtempo, Coutinho & Munier, 2012 [93]; Gaudet, 2013 [94]; Bayley et al., 2018 [55]; Heino & Hautala, 2021 [95]
Evaluating the impact of commercialisation	The ability to assess and monitor commercialisation outcomes.	Bayley et al., 2018 [55]; Fithri, Hasan, Games & Syafrizal, 2024 [96]
Advice	The ability to advise and guide clients in implementation processes.	Balbinot et al., 2012 [33]; Bayley et al., 2018 [55]; Magruk & Rollnik-Sadowska, 2021 [61]; Dębkowska et al., 2022 [54]
Training and capacity building	The ability to develop competences through training and knowledge sharing.	Bayley et al., 2018 [55]; Magruk & Rollnik-Sadowska, 2021 [61]
Change management	The ability to manage and implement organisational and human resources changes.	Bayley et al., 2018 [55]; Munoz-Penas et al., 2024 [19]; Taheriruh et al., 2025 [79]
Creativity	The ability to generate innovative ideas and solutions.	Mumford, 2000 [97]; Morris et al., 2013 [57]; Phipps & Morton, 2013 [89]; Nagesh & Thomas, 2015 [80]; OECD, 2018 [98]; Czarnik et al., 2019 [81]; Felder et al., 2019 [82]; Sala et al., 2020 [43]; PARP, 2020 [84]; Kunicina, Zabasta, Patlins, Bilic & Peksa, 2020 [99]; Klowden & Lim, 2021 [100]; Magruk & Rollnik-Sadowska, 2021 [61]; Dębkowska et al., 2022 [54]; Delisle & Lajoie, 2022 [86]; Szulczewska-Remi & Nowak-Mizgalska, 2023 [23]; Thornhill-Miller et al., 2023 [87]; Javed, 2024 [101]; Fox & Smith, 2024 [102]; Grama & Todericiu 2025 [88]
Flexibility	The ability to adapt to changing conditions and requirements.	Stetler et al., 2011 [92]; Phipps & Morton, 2013 [89]; Felder et al., 2019 [82]; Sala et al., 2020 [43]; World Economic Forum, 2025 [103]; Turdalina & Kozhakhmet, 2025 [11]

Source: Authors' own work.

The approach used by the paper's authors to identify commercialisation competences based on database searches is consistent with the methods employed by numerous researchers to identify this type of competence. These researchers used publication databases, unpublished competence frameworks, and previously published studies and reports [11,18,20,39,54,55,59]. Some researchers also engaged experts in the field of commercialisation to create the list of commercialisation competences [55].

The 25 identified commercialisation competences served as the foundation for empirical investigations conducted within a research network organisation.

3. Method

As previously mentioned, 25 commercialisation competences were identified based on the literature review of publications indexed in Scopus and Web of Science. During the preparation of this manuscript, the authors used Research Rabbit (researchrabbit.ai (accessed on 20 May 2026)) as a supplementary tool for discovering literature, exploring citation networks and tracking relationships among key studies related to commercialisation competences and technology transfer. The tool helped to identify influential authors, seminal works and emerging research streams that were not identified in the initial database search conducted in Scopus and Web of Science.

The empirical part of the investigation is a case study examining the key commercialisation competences and the extent to which employees involved in commercialisation activities within a research network organisation possess these competences.

The case study approach is popular in investigations into commercialisation competences, including single-case studies [22] and multiple-case studies [18,23]. Questionnaires are used in many investigations employing the following techniques: CAWI [20,23], CATI [54], and Delphi [39]. Data are also often collected through interviews [11,22,33,39,59] and occasionally via direct observation [33].

The study focuses on a research network involved in commercialising research results for economic purposes. This network, the Łukasiewicz Research Network (Ł-RNO), consists of 22 institutes and is the third-largest research network in Europe. The Ł-RNO employs around 7000 people, including 4500 researchers. The CAWI (Computer-Assisted Web Interviewing) technique was used to carry out the investigations. The respondents represented two groups of employees. (1) R&D employees engaged in commercialisation (research division), and (2) Commercialisation employees (support division).

The collected data were analysed using statistical methods. Statistical analyses of empirical data were conducted in the IBM SPSS Statistics 29.0 and JASP 0.95.1.0 programmes. In order to test the theoretical competence structure, a confirmatory factor analysis (CFA) was undertaken. The maximum likelihood estimation was the chosen method. The adjustment of the model to the data was assessed according to indicators recommended in methodological literature, including the χ^2 test, the CFI comparative indicator, the RMSEA error of approximation, and the Standardised Root Mean Square Residual (SRMR). The values $CFI \geq 0.90$ (preferred ≥ 0.95), $RMSEA \leq 0.08$ (preferred ≤ 0.06), and $SRMR \leq 0.08$ were deemed acceptable according to the commonly used assessment criteria of structural model fit [104]. As the model failed to fit the data, a secondary exploratory factor analysis (EFA) was conducted according to the Principal Axis Factoring method with Promax rotation. The number of factors was determined through parallel analysis, scree plot inspection, and the criterion of characteristic root. The reliability of the scales was assessed by means of Cronbach's alpha and McDonald's alpha coefficients. The item discriminability was determined on the basis of the variable–scale correlation. Then, the model's measurement invariance for two groups was tested by analysing its subsequent levels. The tool's measurement invariance was assessed through a Multi-Group Confirmatory Factor Analysis (MGCFA) by testing subsequent, hierarchically embedded levels of measurement invariance between groups. At the first stage, the configural invariance was verified. It assumes an identical factor structure in both groups, without limiting parameter values. Then, the metric invariance was tested by putting equivalence limitations on factor loadings. Meeting the conditions of this level of invariance was interpreted as a factor allowing for a power comparison of relationships between latent constructs and other variables in different groups. In the next step, scalar invariance was verified. This consisted of an additional equivalence limitation of intercepts, a necessary condition for comparing median latent factors. Measurement invariance was assessed on the basis of matching ratios between

subsequent, more restrictive models. According to literature recommendations, variation values of the CFI indicator not exceeding 0.010 ($\Delta\text{CFI} \leq 0.01$), RMSEA variations below 0.015 ($\Delta\text{RMSEA} \leq 0.015$), and SRMR variations not exceeding 0.030 for metric invariance and 0.010 for scalar invariance were deemed acceptable [105,106].

The comparative analyses of indicators between groups were conducted by means of a *t*-test for independent samples. The importance and level of own competences were compared with a *t*-test for dependent samples. Spearman's rank correlation coefficients (ρ) were employed for the assessment of the relationship between the analysed variables and age and work experience. In all the analyses, a statistical significance of $\alpha = 0.05$ was assumed.

4. Results

4.1. Sample Characteristics

A total of 89 employees took part in the study. Most of them (61.8%) were male. The respondents were mostly middle-aged; younger and older individuals were rarer in the sample.

A vast majority of the respondents held university degrees, while some held post-graduate degrees, including MBAs. The structure of professional specialisations was varied, dominated by administration, information technology, robotics, mechanics and machine construction. However, there were also some representatives of other technical fields and communities in the sample; in some cases, there were no data on specialisations.

Approximately 33.7% of the respondents had PhDs. The respondents had considerable professional experience, usually between a dozen or so and a few dozen years of work. On the other hand, work experience in the area of commercialising the results of research-and-development studies was visibly shorter and more varied, with a majority of persons having relatively limited experience in this scope.

When it comes to professional engagement, the respondents came from both research and support departments, though they were more often connected with research activity. Detailed data are presented in Table 2.

Table 2. The analysed sample's characteristics ($n = 89$).

Variable	<i>n</i>	%
Sex		
Female	34	38.2
Male	55	61.8
Age		
31–40 years	13	14.6
41–50 years	70	78.7
Over 60 years	6	6.7
Education		
MBA	6	6.7
Postgraduate other than MBA	15	16.9
Higher	68	76.4
Specialisation		
Administration	13	14.6
Automatics	5	5.6
Information technology	10	11.2
Mechanics and machine construction	8	9.0
Environmental protection	6	6.7
Robotics	12	13.5
CAD/CAE systems	6	6.7
No data	29	32.6
Academic degree		
PhD	30	33.7
Not applicable	59	66.3

Table 2. *Cont.*

Variable	<i>n</i>	%
Joint professional experience		
11–15 years	18	20.2
16–20 years	23	25.8
21–25 years	27	30.3
26–30 years	16	18.0
Over 30 years	5	5.6
Professional experience in the commercialisation of R&D results		
0–5 years	40	44.9
6–10 years	21	23.6
11–15 years	7	7.9
16–20 years	16	18.0
21–25 years	5	5.6
Commercialisation area		
Research department	55	61.8
Support department	34	38.2

4.2. Confirmatory Factor Analysis

Employees of a research network organisation evaluated all 25 distinguished competences on a scale of 0–7, taking into account the importance of the competences and the employees' level of proficiency in them. In the case of the scale referring to the importance of a competence in the commercialisation process, the scale ranges from 0, meaning “unimportant”, to 7, meaning “very important”. If the scale refers to the level of proficiency in a competence, 0 means “no competence” and 7 means “expert”.

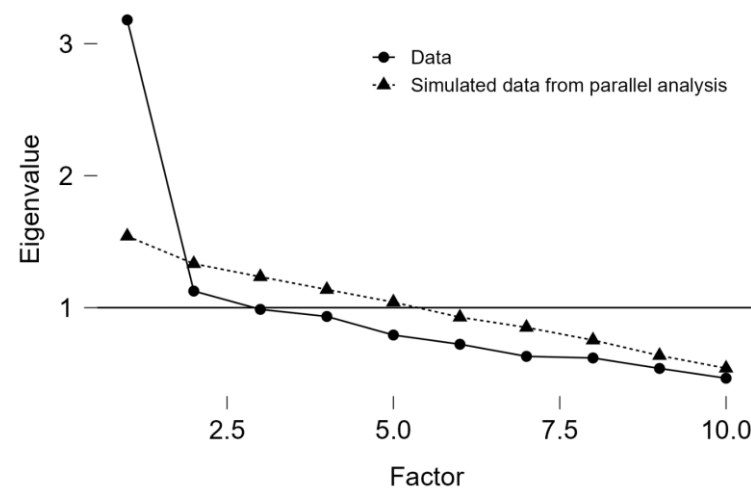
In order to determine whether the assumed structure was confirmed by the data, a confirmatory factor analysis and maximum likelihood estimation were conducted. The analysis proved that the model provided inconsistent results in assessing the level of one's competences ($\chi^2(272) = 302.60$; $p = 0.098$; CFI = 0.858; RMSEA = 0.036; 90% CI 0.000; 0.056; GFI = 0.802; SRMR = 0.084), with acceptable values of RMSEA and χ^2 , but with low values of CFI and GFI, which suggests the model insufficiently fit the data. Additionally, there was a problem with an incorrect covariance matrix of latent variables in the assessment model for competence importance. It hindered the correct interpretation of the results (This problem stems from model estimation and is present mostly in situations where the CFA structure is incorrectly assumed and loading values of specific factors are relatively low or the factors are strongly correlated with one another). The factors in the distinguished structure were strongly correlated with one another (0.92–0.99), which indicated data redundancy, and loading values of 14 positions were below 0.4. Such high correlations suggest a lack of empirical differentiation between the factors and the reasonableness of taking into account a model with fewer dimensions.

In this connection, a decision to conduct an exploratory factor analysis by means of the Principal Axis Factoring method with Promax rotation was made. Based on the characteristic root above 1, nine factors were distinguished. In turn, both for the scree plot and the parallel analysis, the result indicated a single-factor solution, assumed for further analysis. The KMO value was 0.654 (after excluding variables with a low factor loading: KMO = 0.804), and Bartlett's test proved to be statistically significant, $\chi^2(300) = 456.82$; $p < 0.001$ (after variable reduction: $\chi^2(45) = 140.84$; $p < 0.001$). This confirms the reasonableness of conducting factor analysis.

In the next step, the test variables of low factor loading (below 0.4) were excluded from the analyses—15 were excepted from the original pool of 25 variables. The decisions to exclude a variable were made while taking into account both statistical criteria and content coherence. Finally, 10 variables remained in the model (Table 3), for which a one-factor solution was assumed (Chart 1).

Table 3. The values of variable factor loadings and the results of reliability and item discriminability analysis.

	Factor Loading	Reliability Post Variable Exclusion		
		McDonald's ω	Cronbach's α	Variable–Scale Correlation
p23	0.577	0.730	0.728	0.500
p7	0.559	0.732	0.729	0.477
p2	0.552	0.732	0.728	0.474
p3	0.549	0.733	0.729	0.479
p8	0.492	0.740	0.736	0.420
p24	0.479	0.740	0.736	0.421
p18	0.456	0.744	0.740	0.391
p4	0.421	0.748	0.744	0.370
p22	0.408	0.750	0.746	0.351
p16	0.404	0.751	0.748	0.335

**Chart 1.** The scree plot with parallel analysis.

The reliability of a one-factor solution including 10 variables was satisfactory. The Cronbach's alpha coefficient was 0.756 (95%CI: 0.670; 0.824) and the McDonald's ω coefficient was 0.760 (95%CI: 0.685; 0.834), proving a good internal consistency of the scale. The exclusion of any of the variables did not significantly increase the indicator. The item discriminability, understood as a corrected variable–scale correlation, reached values above the acceptable threshold of 0.2, which indicates acceptable variability within a group.

Although the literature review enabled the identification of 25 commercialisation competences, only 10 were retained in the final empirical model. This reduction should not be interpreted as evidence that the excluded competences are of lesser importance for technology commercialisation. On the contrary, many of the competences removed during the model refinement process, including network competence, communication, cooperation skills, knowledge mobilisation, intellectual property management, and legal issues management, are consistently recognised in the literature as critical determinants of successful commercialisation outcomes [19,55,59,76,85–87].

The reduction reflects the distinction between the broader theoretical domain of commercialisation competences and the empirically validated competence structure observed within the analysed sample. The excluded competences did not demonstrate sufficient psychometric distinctiveness and therefore did not contribute to the final one-factor solution. However, this finding should not be interpreted as questioning their theoretical relevance. Rather, it suggests that these competences may function as contextual, complementary, or threshold competences that are widely distributed among employees engaged in commercialisation activities and therefore possess limited discriminatory power within the investigated organisational setting.

This interpretation is consistent with previous research indicating that commercialisation competence frameworks are inherently heterogeneous and context-dependent. Competence configurations vary across organisational roles, institutional arrangements, technology transfer mechanisms, and innovation ecosystems [25]. Consequently, competences that constitute critical success factors in technology transfer offices, university spin-offs, open innovation environments, or innovation intermediary organisations may not necessarily emerge as empirically distinct dimensions within research network organisations.

Accordingly, the proposed ten-competence framework should be viewed as an empirically validated core competence structure characterising commercialisation capability within the Łukasiewicz Research Network rather than as a universal hierarchy of commercialisation competences. The broader set of 25 competences remains theoretically relevant and reflects the multidimensional nature of technology commercialisation processes. Future studies should therefore examine the stability and transferability of the identified competence structure across different organisational and institutional contexts.

4.3. Measurement Invariance for the Research and Support Departments

In order to check if the one-factor structure of the tools is comparable between the two groups, for the research and support departments, the measurement invariance was assessed through a Multi-Group Confirmatory Factor Analysis (MG-CFA). Maintaining measurement invariance is a necessary condition for comparing groups on the level of latent results—it allows for ascertaining whether a given competence construct will be measured comparably in both groups. The analyses were conducted in stages by subsequently testing the configural, metric and scalar models, assuming the one-factor structure of the tool as the base model.

In the first step, the configural model was estimated. In this model, a uniform one-factor structure was assumed in both groups, without limiting the parameter values. The model fitted the data well: $\chi^2(40) = 36.98$; $p = 0.607$, CFI = 1.000, RMSEA = 0.000 (90% CI: 0.000; 0.092), SRMR = 0.063. The indicators suggest the analysed construct has similar factor structures in both groups, which confirms that the assumptions of configural invariance were realised.

In the next step, the metric model was tested, with a limited equivalence of factor loadings between groups. The model fit remained acceptable ($\chi^2(47) = 38.80$; $p = 0.797$, CFI = 1.000, RMSEA = 0.000 (90% CI: 0.000; 0.066), SRMR = 0.071). The metric model was not a significantly worse fit than the configural model: $\Delta\text{CFI} = 0$, $\Delta\text{RMSEA} = 0$, $\Delta\text{SRMR} = 0.008$. According to the assumed criteria ($\Delta\text{CFI} \leq 0.010$; $\Delta\text{RMSEA} \leq 0.015$; $\Delta\text{SRMR} \leq 0.030$; [105,106]), these results indicate that the assumptions of metric invariance are met. This means that the variables have similar psychometric significance in both groups, and relationships between the latent factor and indicators are comparable.

Finally, the scalar model was tested, in which the invariance of the variables' intercepts was additionally limited. This model fits the data acceptably ($\chi^2(54) = 50.19$; $p = 0.622$, CFI = 1.000, RMSEA = 0.000 (90% CI: 0.000; 0.083), SRMR = 0.086). The scalar model compared to the metric model was not a significantly worse fit ($\Delta\text{CFI} = 0$, $\Delta\text{RMSEA} = 0$, $\Delta\text{SRMR} = 0.015$). These results confirm that the scalar invariance assumptions were met, which allows for a comparison of median latent results between the groups.

In summary, the analysis of measurement invariance confirmed that the one-factor competence model meets both the configural, metric, and scalar invariance requirements. This means the construct is measured comparably in both groups, which allows for conducting direct inter-group comparisons on the level of median latent results. Thus, the tool can be considered to fully exhibit measurement invariance in the analysed groups.

4.4. Competence Description

On the basis of calculations, it was possible to create a general indicator—Core Commercialisation Capability—through averaging responses on a scale. Thus, the indicator can be further interpreted as follows: the higher the result, the stronger the competence. This indicator was developed for own proficiency in competences and for an assessment of competence importance.

Table 4 summarises the analysis of basic descriptive statistics for proficiency and importance levels. An analysis of result distribution demonstrated that the assessment of competence importance was distributed normally, while the assessment of competence level (proficiency) pointed to a positive skew, with a tendency to indicate a low competence level.

Table 4. The descriptive statistics for the competence indicators with the Shapiro–Wilk test results.

Dependent Variable	M	Mdn	SD	Sk.	Kurt.	Min.	Maks.	W	p
Assessment of proficiency in a competence	1.83	1.60	0.90	1.32	1.39	0.30	4.80	0.87	<0.001
Assessment of competence importance	3.48	3.40	0.66	0.35	−0.27	2.10	5.20	0.98	0.134

Note. M—mean; Mdn—median; SD—skewness; Kurt.—kurtosis; Min.—minimal result; Maks.—maximal result; W—the Shapiro–Wilk test statistics; p—probability value.

In Table 5, the average values for the assessment of own competence levels (proficiency) and of their importance level in the professional context are presented. Based on the averages, a ranking was also made, where first place indicated a competence rated the highest by the respondents.

Table 5. The average levels of competence assessment with a ranking.

Competence	Assessment of Proficiency in a Competence		Assessment of Competence Importance	
	M	Ranking	M	Ranking
Creativity	1.56	10	3.19	9
Economic analyses	1.75	7	3.60	4
Commercially oriented R&D competences	1.96	3	3.49	5
Market analyses	1.73	8	3.18	10
Creation of commercialisation strategy	1.82	6	3.49	5
Self-confidence	1.69	9	3.44	8
Innovation popularisation	1.94	4	3.63	2
Ability to analyse customer needs	1.98	2	3.69	1
Change management	1.84	5	3.45	7
Training and capacity building	2.01	1	3.63	2

Note. M—average; Ranking—position in the ranking—the higher the value, the lower the place in the ranking.

The data show that the highest levels of competence were indicated in training and capacity building, ability to analyse customer needs, and commercially oriented R&D competences in this sample. The first two competences were also deemed the most important in the sample. When it comes to importance assessment, innovation popularisation proved to be key.

Creativity, market analysis and self-confidence were counted among the lowest-ranked competences, both when it comes to their personal level of proficiency and importance assessment.

By means of a *t*-test for dependent samples, the assessment of proficiency in competences was compared with assessment of these competences' importance. The indicator: Core Commercialisation Capability was also compared. Table 6 shows that the assessed proficiency in a competence was significantly lower than the assessed importance of these competences. This means that the respondents indicated that these competences' importance was higher than their possession.

Table 6. A comparison of the assessment of proficiency in a competence and competence importance.

Dependent Variable	Assessment of Proficiency in a Competence		Assessment of Competence Importance		t	df	p	95% CI		Cohen's d
	M	SD	M	SD				LL	UL	
Core Commercialisation Capability	1.83	0.90	3.48	0.66	−23.77	88	<0.001	−1.79	−1.51	2.52
Creativity	1.56	1.43	3.19	1.70	−10.22	87	<0.001	−1.95	−1.32	1.09
Economic analyses	1.75	1.59	3.60	1.75	−9.27	88	<0.001	−2.24	−1.45	0.98
Commercially oriented R&D competences	1.96	1.69	3.49	1.82	−8.32	88	<0.001	−1.91	−1.17	0.88
Market analyses	1.73	1.51	3.18	1.56	−9.46	88	<0.001	−1.75	−1.14	1.00
Creation of commercialisation strategy	1.82	1.60	3.49	1.77	−10.24	88	<0.001	−2.00	−1.35	1.08
Self-confidence	1.69	1.67	3.44	1.78	−9.33	88	<0.001	−2.13	−1.38	0.99
Innovation popularisation	1.94	1.60	3.63	1.69	−9.77	88	<0.001	−2.03	−1.34	1.04
Ability to analyse customer needs	1.98	1.62	3.69	1.73	−9.44	88	<0.001	−2.07	−1.35	1.00
Change management	1.84	1.65	3.45	1.69	−9.12	88	<0.001	−1.96	−1.26	0.97
Training and capacity building	2.01	1.63	3.63	1.60	−11.01	88	<0.001	−1.91	−1.33	1.17

Note. M—average; SD—standard deviation; t—test statistic value; p—statistical significance; CI—confidence interval for the difference between averages; LL and UL—the lower and upper limits of the confidence interval; Cohen's d—effect size.

4.5. A Competence Comparison with Respect to the Type of Work Performed in the Commercialisation Area

By means of a *t*-test for independent samples, the assessments of proficiency in a competence and the level of competence importance for the whole structure and its components were compared. The analysis demonstrated some significant differences between groups of employees only for the assessment of self-confidence as part of the assessment of proficiency in competences (moderate effect). The support department employees showed a stronger sense of self-confidence than the research department staff. Similar results were obtained for the assessments of competence importance—the support department employees assessed their self-confidence as more important than the research department employees did (weak effect). The results are presented in Table 7.

Table 7. A competence comparison with respect to the type of work performed in the commercialisation area.

Dependent Variable	Research Department (n = 55)		Support Department (n = 34)		t	df	p	95% CI		Cohen's d
	M	SD	M	SD				LL	UL	
Assessment of proficiency in a competence	1.78	0.86	1.91	0.97	−0.60	63.60	0.548	−0.53	0.28	0.14
Creativity	1.41	1.30	1.79	1.61	−1.18	59.28	0.243	−1.04	0.27	0.27
Economic analyses	1.67	1.64	1.88	1.51	−0.61	74.53	0.541	−0.89	0.47	0.13
Commercially oriented R&D competences	1.98	1.73	1.91	1.66	0.19	72.23	0.849	−0.66	0.80	0.04
Market analyses	1.78	1.57	1.65	1.41	0.42	75.76	0.677	−0.51	0.78	0.09
Creation of commercialisation strategy	1.91	1.67	1.68	1.49	0.68	76.03	0.497	−0.45	0.91	0.14
Self-confidence	1.35	1.47	2.24	1.84	−2.39	58.47	0.020	−1.64	−0.14	0.55
Innovation popularisation	1.78	1.65	2.21	1.49	−1.25	75.45	0.215	−1.10	0.25	0.27
Ability to analyse customer needs	1.78	1.54	2.29	1.73	−1.41	63.67	0.162	−1.24	0.21	0.32
Change management	2.02	1.80	1.56	1.35	1.37	83.59	0.175	−0.21	1.13	0.28
Training and capacity building	2.11	1.58	1.85	1.73	0.70	65.45	0.485	−0.47	0.98	0.16
Assessment of competence importance	3.50	0.66	3.45	0.68	0.30	68.21	0.762	−0.25	0.34	0.07
Creativity	3.15	1.59	3.26	1.88	−0.30	61.79	0.765	−0.89	0.66	0.07
Economic analyses	3.49	1.69	3.76	1.86	−0.70	64.87	0.487	−1.06	0.51	0.16
Commercially oriented R&D competences	3.60	1.86	3.32	1.77	0.70	72.76	0.485	−0.51	1.06	0.15
Market analyses	3.27	1.66	3.03	1.40	0.74	78.79	0.461	−0.41	0.90	0.16
Creation of commercialisation strategy	3.56	1.76	3.38	1.81	0.46	68.60	0.644	−0.60	0.96	0.10
Self-confidence	3.15	1.75	3.91	1.76	−2.00	69.52	0.050	−1.53	0.00	0.44
Innovation popularisation	3.60	1.76	3.68	1.59	−0.21	75.45	0.833	−0.80	0.64	0.05
Ability to analyse customer needs	3.76	1.71	3.56	1.78	0.54	67.94	0.594	−0.56	0.97	0.12
Change management	3.64	1.75	3.15	1.56	1.37	76.07	0.174	−0.22	1.20	0.29
Training and capacity building	3.73	1.42	3.47	1.86	0.69	56.52	0.493	−0.49	1.00	0.16

Note. M—average; SD—standard deviation; t—test statistic value; p—statistical significance; CI—confidence interval for the difference between averages; LL and UL—the lower and upper limits of the confidence interval; Cohen's d—effect size.

To complement the statistical significance tests, Cohen's d was calculated for all comparisons (Tables 6 and 7). For the within-subject comparisons between perceived importance and self-assessed proficiency (Table 6), the effect sizes were large for the general

Core Commercialisation Capability indicator ($d = 2.52$) and for all individual competences ($d \approx 0.88$ – 1.17), indicating substantial gaps between how important respondents perceive these competences to be and how well they believe they possess them. In contrast, the between-group comparisons by department (Table 7) generally yielded small effect sizes ($d \approx 0.04$ – 0.32), with only self-confidence showing a moderate effect size ($d = 0.55$), suggesting that differences between research and support staff are relatively limited and most pronounced in the area of self-confidence.

4.6. Demographic Variables v. Competences (Sex, Age, Education, Specialisation, Academic Degree/Title, Field, Work Experience in General, Work Experience in R&D)

In the final part, comparative and relational analyses of the obtained competence indicator with respect to demographic variables were conducted. To analyse age and work experience, Spearman's correlation was applied. In turn, comparative analyses (t -test for independent samples/one-way ANOVA) were employed for sex, academic degree, and education level.

The analyses did not confirm any significant differences in the assessments of proficiency in competences and competence importance with respect to sex, academic degree, and education level (Tables 8–11) and did not demonstrate any relationship with work experience. Only the competence importance assessment was positively and moderately correlated with respondent age, which means that the older the respondents were, the higher they generally assessed the importance of competences included in the indicator.

Table 8. Spearman's correlations for the relationship between the assessment of proficiency in a competence and of competence importance and age and work experience.

Variable	Assessment of Proficiency in a Competence		Assessment of Competence Importance	
	r_s	p	r_s	p
Age	0.21	0.051	0.38	<0.001
Work experience in general	0.08	0.484	0.06	0.567
Work experience in commercialisation of R&D results	0.06	0.598	0.10	0.339

Note. r_s —Spearman's correlation coefficient; p —probability value.

Table 9. The differences in the assessment of proficiency in a competence and competence importance with respect to the respondents' sex.

Dependent Variable	Female ($n = 34$)		Male ($n = 55$)		95% CI					
	M	SD	M	SD	t	df	p	LL	UL	Cohen's d
Assessment of proficiency in a competence	1.87	1.03	1.81	0.82	0.31	58.55	0.754	−0.35	0.48	0.07
Assessment of competence importance	3.39	0.64	3.54	0.68	−1.01	72.96	0.315	−0.43	0.14	0.22

Note. M—average; SD—standard deviation; t —test statistic value; p —statistical significance; CI—confidence interval for the difference between averages; LL and UL—the upper and lower limits of the confidence interval; Cohen's d —effect size.

Table 10. The differences in the assessment of proficiency in a competence and competence importance with respect to the respondents' academic degrees.

Dependent Variable	PhD ($n = 30$)		Not Applicable ($n = 59$)		95% CI					
	M	SD	M	SD	t	df	p	LL	UL	Cohen's d
Assessment of proficiency in a competence	1.85	0.94	1.82	0.89	0.17	55.65	0.866	−0.38	0.45	0.04
Assessment of competence importance	3.53	0.57	3.45	0.71	0.57	71.04	0.568	−0.20	0.36	0.12

Note. M—average; SD—standard deviation; t —test statistic value; p —statistical significance; CI—confidence interval for the difference between averages; LL and UL—the upper and lower limits of the confidence interval; Cohen's d —effect size.

Table 11. The differences in the assessment of proficiency in a competence and competence importance with respect to the respondents' education.

Dependent Variable	MBA (<i>n</i> = 6)		Postgraduate Other than MBA (<i>n</i> = 15)		Higher (<i>n</i> = 68)		F	df	p	η^2
	M	SD	M	SD	M	SD				
Assessment of proficiency in a competence	2.03	0.97	1.77	1.11	1.82	0.86	0.18	2; 86	0.835	0.00
Assessment of competence importance	3.73	0.49	3.29	0.81	3.50	0.64	1.06	2; 86	0.350	0.02

Note. M—average; SD—standard deviation F—test statistic value; p—statistical significance; df—degrees of freedom; η^2 —Eta-squared; effect size.

5. Discussion

An important finding of this study is the discrepancy between the theoretically identified competence domain and the empirically validated competence structure. While the literature review led to the identification of 25 competences associated with technology commercialisation, only 10 demonstrated sufficient psychometric robustness to form a coherent empirical construct within the analysed research network organisation. Rather than contradicting previous studies, this finding highlights the multidimensional and context-dependent nature of commercialisation competences [25,107].

The literature suggests that competence requirements vary across organisational settings, institutional environments, and actor categories involved in commercialisation processes, including technology transfer professionals, innovation intermediaries, academic entrepreneurs, and open innovation teams [11,14,17,26,27]. Consequently, not all theoretically relevant competences necessarily emerge as empirically distinct dimensions within a particular organisational context. This distinction reflects the difference between the broader theoretical competence domain and its empirical operationalisation within a specific organisational setting.

Particularly noteworthy is the fact that competences such as networking, communication, cooperation skills, knowledge mobilisation, and intellectual property management, despite being consistently recognised in the literature as important determinants of commercialisation success [108–111], were not retained in the final factor structure. This should not be interpreted as evidence of their limited importance. Rather, it may indicate that these competences function as threshold competences within research network organisations, representing capabilities that are widely shared, institutionally embedded, or organisationally expected among employees engaged in commercialisation activities. As a consequence, they may contribute to the effectiveness of commercialisation processes while simultaneously exhibiting limited discriminatory power at the individual level.

The results therefore suggest that successful commercialisation may depend not only on the presence of specific competences but also on the extent to which particular competences differentiate individuals and organisational roles within a given institutional environment. From this perspective, the final ten-competence model should be interpreted as an empirically validated core competence structure that differentiates commercialisation capability in research network organisations rather than as a universal representation of all competences relevant to technology commercialisation.

These findings contribute to the ongoing discussion regarding the contextual nature of commercialisation competences and support the argument that competence frameworks should be viewed as contingent upon organisational missions, governance structures, and commercialisation practices rather than as universally applicable models.

Research on commercialisation competences has thus far focused primarily on interpersonal (soft) competences, such as communication, collaboration, creativity, and flexibility [11,52,112,113]. These competences are widely recognised as essential for functioning successfully within knowledge-based economies and VUCA environments. Con-

versely, considerably less attention has been devoted to job-related commercialisation competences directly associated with technology commercialisation processes. Bayley et al. (2018) [55] argue that existing studies on knowledge brokers predominantly emphasise roles, functions, and personal characteristics, while paying limited attention to “job-related competences”, which are defined as the specific skills required to carry out commercialisation activities. Similar conclusions emerge from studies of technology transfer professionals, which emphasise the importance of competences relating to market analysis, entrepreneurship, intellectual property management, and technology assessment [11,107]. Against this background, the present study contributes to the literature by integrating both interpersonal (soft) competences and job-related competences directly linked to technology commercialisation. The results of this study are consistent with existing literature on the labour market in the knowledge economy and Industry 4.0/5.0 era. This literature emphasises the growing importance of interpersonal skills such as communication, collaboration, problem-solving and creativity as a means of achieving employability and adapting to a rapidly changing technological environment [112,113]. From the authors’ perspective, this suggests that, in the organisations studied, soft skills are considered a “baseline”, whereas specialised, job-related competences directly related to commercialisation are decisive.

A second important aspect concerns the scope of the competences analysed in previous studies. Existing research has generally focused on selected competences or narrow competence sets. For example, Mom et al. [107] examined a limited range of soft and business skills among technology transfer professionals, whereas Turdalina and Kozhakhmet [11] primarily identified competence gaps related to entrepreneurship, marketing, and business knowledge. Similarly, Lim et al. [7] proposed competence clusters within training models for technology transfer professionals. Bayley et al. (2018) [55] adopted a more comprehensive perspective, proposing a framework comprising 80 competences across 11 categories. However, this framework concerns knowledge mobilisation and research impact more broadly rather than technology commercialisation specifically. In contrast, the present study identifies a comprehensive set of key competences specifically related to technology commercialisation within research network organisations. These competences encompass both interpersonal competences and job-related specialist technical and business competences, and the findings indicate that respondents considered job-related commercialisation competences to be more important than interpersonal competences. This hierarchy of importance is consistent with research on TTP competences, which shows that, in addition to soft skills, entrepreneurship, business knowledge and IP and marketing-related competences are crucial for effectively bridging the “Valley of Death” in the innovation commercialisation process [11,114]. From the authors’ perspective, this suggests that, in the context of research networks, market- and strategy-oriented competences constitute a critical bottleneck for successful commercialisation and should therefore be prioritised in development policies. This interpretation is in line with the specific nature of technology commercialisation processes, which primarily require the ability to conduct market analysis, analyse and understand customer needs and create commercialisation strategies.

A third aspect concerns how competences are conceptualised and measured in the existing literature. While most studies focus on identifying the necessary competences for commercialisation processes, they largely overlook the actual level of competence possessed by individuals [55,112]. Bayley et al. [55] explicitly distinguish between the skills required to perform specific activities and the capability of individuals to successfully perform those activities. The authors emphasise that existing frameworks mainly identify required competences but do not assess the extent to which individuals actually possess them, namely their proficiency in competences. Similar discrepancies between the importance assigned to competences and the level of proficiency achieved are also evident in

other areas of applied research, such as translational medicine and clinical trials. These areas have been identified as having deficiencies in intellectual property, business planning, regulatory compliance, and project management skills [115,116]. According to the authors, this confirms that the competence gap identified in this study is not coincidental but rather reflects a broader systemic deficit in staff preparation for advanced technology commercialisation processes. A similar limitation can be observed in studies of technology transfer professionals, which identify desirable skills or indirectly highlight competence gaps but rarely analyse the perceived importance of competences and their actual level of possession simultaneously [11]. In this context, the contribution of the present paper lies in the simultaneous examination of both the perceived importance of commercialisation competences and the level of proficiency in these competences among employees of a research network organisation. The results show that the level at which these competences are possessed is significantly lower than their perceived importance, indicating a competence gap in technology commercialisation.

6. Conclusions

This study contributes to the literature on commercialisation competences by identifying the key competences required for the implementation of technology commercialisation processes within research network organisations. As a result of an extensive literature review, 25 commercialisation competences made up the model in its initial form, of which 10 were selected as key competences. These were regarded as the most essential and compulsory competences for this type of organisation.

The results suggest that successful commercialisation requires a combination of interpersonal and job-related competences that enable business operations and technology commercialisation processes. The following job-related commercialisation competences are identified as a result of empirical investigations: commercially oriented R&D, economic analyses, market analyses, creation of commercialisation strategies, the ability to analyse customer needs and innovation popularisation. The interpersonal competences identified are: creativity, self-confidence, change management, and training and capacity building. This result is consistent with research indicating that the successful transformation of research results into commercially viable products and services depends on possessing an integrated set of skills, comprising technical knowledge and experience in technology commercialisation, called basic or functional skills by different authors, as well as soft skills [11,117]. It should also be noted that many of the key commercialisation competences identified through empirical research overlap with those associated with sustainability-oriented innovation. These competences directly facilitate sustainability-oriented commercialisation by integrating environmental and social considerations into innovation processes [44–52].

The research results also suggest that job-related commercialisation competences are particularly important in the context of technology commercialisation. This observation is consistent with research results indicating a significant relationship between strategic and organisational competences, competences related to market opportunity identification, and business competences, and the results of innovative activities and organisational effectiveness [118,119]. The relatively high importance attributed to job-related commercialisation competences may be due to the specific nature of technology commercialisation processes. These processes require the ability to assess market potential, identify commercialisation opportunities, and transform research results into marketable solutions.

Another significant contribution of this study is its simultaneous analysis of the perceived importance of competences and employee proficiency in competences. This approach aligns with the research trend of competence gap analysis, which identifies devel-

opment priorities by analysing the differences between expected and actual competence levels [120,121]. A similar approach was also employed in research investigating the alignment of labour market expectations with the competences acquired through entrepreneurial education [122]. The results of this study suggest that competences were rated significantly less important than they were perceived to be, which may indicate the existence of competence gaps in technology commercialisation. The results of investigations run by this paper's authors suggest a significant discrepancy between the perceived importance of competences and employees' self-assessed proficiency levels, indicating the existence of competence gaps in technology commercialisation.

The findings should be interpreted with caution. The final ten-competence model represents an empirically validated core set of commercialisation competences identified within a specific research network organisation. It does not imply that the remaining competences identified in the literature are theoretically unimportant. Rather, the results indicate that commercialisation competence structures are context-dependent and shaped by organisational roles, institutional arrangements, and commercialisation practices. Consequently, the findings support a configurational perspective on commercialisation competences, suggesting that successful commercialisation is enabled not by a single universally applicable competence framework but by context-specific competence architectures reflecting the characteristics of a given organisational environment [25,107]. The proposed model should therefore be interpreted as an empirically validated representation of the core competences differentiating commercialisation capability within the investigated research network organisation rather than as a universal hierarchy of competence importance.

It should also be stressed that the sample size is relatively small, particularly from the perspective of multi-group confirmatory factor analysis. While the results obtained support the proposed measurement model and the assumptions of measurement invariance, dividing the respondents into two subgroups ($n = 55$ and $n = 34$) may have reduced the statistical power of the analyses and the ability to identify more subtle differences between the groups. Therefore, future research should seek to replicate these findings using larger samples drawn from different organisations.

The study has practical implications. The identified set of competences could inform the design of competence development programmes, training activities and HR systems to support employees engaged in technology commercialisation processes within research network organisations. In this respect, the results are consistent with literature emphasising the importance of a systematic approach to developing entrepreneurial competences and implementing competence frameworks such as EntreComp [123,124]. At the same time, previous research indicates that programmes designed to develop interpersonal competences can foster innovative capabilities and competences related to entrepreneurial activity, as well as readiness to operate in an environment of cooperation between science and business [60,125].

Although the study provides important conclusions regarding commercialisation competences in research network organisations, its results should be interpreted in light of the specific research conditions. The study was conducted within the context of an organisation operating within a research network focused on technology commercialisation. This context provides valuable insights, as it enables the analysis of competences in an environment that is strongly focused on implementation and collaboration with the economic sector. At the same time, however, the literature emphasises the contextual nature of the development of entrepreneurial competences, pointing to the need for broader comparative analyses across organisations and countries [122,125]. Therefore, future research could encompass different types of research organisation and technology commercialisation systems.

The study examined how important respondents perceived competences to be and how well they thought they possessed them; in other words, it examined their proficiency in competences. This approach is widely used in competence research, enabling the identification of perceived competence gaps and development priorities. At the same time, the literature suggests that self-assessment and competence checklists do not adequately capture the multidimensional and behavioural nature of competences. Therefore, future research could consider more complex definitions of competences that encompass not only the declared level of proficiency in a competence but also behavioural manifestations of competences and the level of proficiency—understood as the ability to perform commercialisation activities independently and successfully—as well as the practical ability to use competences in actual technology commercialisation processes [120,126].

Therefore, future research could adopt more complex and fully operationalised definitions of competences that capture not only self-reported proficiency levels but also observable behavioural manifestations, the ability to perform commercialisation activities independently and successfully, and the practical ability to use competences in real technology commercialisation processes [120,126].

The dynamic nature of commercialisation competences is also worth emphasising, as they are subject to change alongside developments in technologies, business models and the market environment. Further research could therefore focus on analysing the evolution of these competences and identifying new ones related to digitalisation, artificial intelligence and open innovation models, among other things.

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Abbreviations

The following abbreviations are used in this manuscript:

Ł-RNO	Łukasiewicz Research Network
VUCA	Volatility, Uncertainty, Complexity and Ambiguity
IP	Intellectual Property
CAWI	Computer-Assisted Web Interviewing
R&D	Research and Development
TTP	Technology Transfer Professional
CFI	Comparative Fit Index
CFA	Confirmatory Factor Analysis
MGCFA	Multi-Group Confirmatory Factor Analysis
SRMR	Standardised Root Mean Square Residual
RMSEA	Root Mean Square Error of Approximation

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