Management
2024
Vol. 28, No. 1
DOI: **10.58691/man/186076**

MACIEJ ZASTEMPOWSKI
ALEKSANDRA KALOCIŃSKA-SZUMSKA
JUSTYNA ŁASKOWSKA

Roles in Research Teams: The Perspective of University Commercialisation

Maciej Zastempowski,
Department of Enterprise Management,
Faculty of Economic Sciences
and Management,
Nicolaus Copernicus University
in Toruń, Poland,
ORCID: 0000-0001-8196-3236.
Aleksandra Kalocińska-Szumska,
Centre for Academic Entrepreneurship
and Technology Transfer,
Nicolaus Copernicus University
in Toruń, Poland,
ORCID: 0000-0002-2231-281X.
Justyna Łaskowska,
Centre for Academic Entrepreneurship
and Technology Transfer,
Nicolaus Copernicus University
in Toruń, Poland,
ORCID: 0000-0002-7962-5040.

1. Introduction

Scientific research has delved into team roles for an extended period (Bednár & Ljudvigová, 2020; Belbin, 2010; Mathieu et al., 2014; Savelsbergh et al., 2012). From one perspective, this is because this issue is at the interface of many scientific disciplines, including management, psychology, and sociology; on the other hand, it has a convenient dimension, as it translates into the effectiveness of the work of individuals, teams and, consequently, entire organisations.

One of the less recognised issues in this area is the functioning of research teams (García-Sánchez et al., 2017), especially in the context of commercialising their scientific results (Dezi et al., 2018). For example, interesting research in this area, conducted by Mendoza-Silva, studies shaping innovative abilities through analysing social capital and sharing knowledge in research teams and informal networks (Mendoza-Silva, 2021). However, it should be emphasised that while the methods of shaping teams working on innovations in companies were, for example, indicated by de

Bes and Kotler in 'The A-to-F Model' (de Bes & Kotler, 2015), the issue of the innovative effectiveness of research teams is still an exciting research area.

Looking from the perspective of the still-developed entrepreneurial university concept (Etzkowitz, 2004; Leydesdorff, 2010), focusing in recent years on the ability of universities to commercialise (direct and indirect) research results (Battaglia et al., 2021; Jonek-Kowalska et al., 2021; Temel et al., 2021), it seems interesting to try to look at the roles in research teams using the de Bes and Kotler model. Being aware that this model indicates team roles contributing to the creation of innovation, we decided to focus on the critical aspect of universities' innovation, namely commercialisation. Our research seeks to shed some light on this issue. Consequently, this paper aims to broaden the knowledge about the research team's roles and their influence on commercialising their research results.

To do this, in the empirical part, we use the data from a quantitative study conducted at one of the leading research universities in Poland. The study was completed in 2021 on a representative sample of 496 scientists employed in research and research-teaching positions. To investigate the relationship between the roles in research teams and the commercialisation of their results, we used the probit model and marginal effects to interpret the results.

The arrangement of the paper is as follows: In Section 2, the theoretical foundation is introduced, along with a systematic overview of the literature. Section 3 delves into the gathered research data, providing a comprehensive display of the analysed variables and their descriptive statistics. The subsequent section encompasses the outcomes of probit estimations, followed by a detailed discussion. Ultimately, in Section 5, conclusions and recommendations are drawn.

2. Theoretical background

2.1. Roles in research teams

To present an extensive literature overview, we used a systematic literature review (SLR) (Tranfield et al., 2003). We analysed two science databases – Web of Science and Scopus. A search covered the period from 1980-2023. The article title field used the phrase "team* AND role*" to find appropriate research.

In the initial search on February 20, 2024, Scopus yielded 4215 results, and Web of Science produced 3265 results. The second search involved the inclusion of another phrase, *research* OR *scientific* OR "*research team**" OR "*scientific team**", applied in the article title, abstract, or keywords fields, resulting in 1333 and

1019 outcomes for each respective database. In the third search, an additional phrase, *"technology transfer"* OR *technology* OR *transfer* OR *commercialization* OR *spin-off* OR *"spin off"* was introduced in the same fields. This generated 144 and 142 results. In the next step, the following inclusion and exclusion criteria were applied: (1) document type: article; (2) subject area (this varies according to the databases); (3) source type: journal; and (4) Language: English. Finally, as shown in table 1, 126 articles were identified for further analysis after removing duplicates.

Table 1. Details of systematic literature review

Criterion	Scopus	Criterion	WoS
team* AND role* in article title	4 215	team* AND role* in article title	3265
research OR scientific OR "research team*" OR "scientific team*" in the article title, abstract or keywords	1 333	research OR scientific OR "research team*" OR "scientific team*" in topic	1019
"technology transfer" OR technology OR transfer OR commercialization OR spin-off OR "spin off" in article title, abstract or keywords	144	"technology transfer" OR technology OR transfer OR commercialization OR spin-off OR "spin off" in topic	142
Published between 1980 and 2023	141	Published between 1980 and 2023	142
Document type: Article	91	Document type: Article	118
Subject area: Social sciences; Psychology; Decision Sciences; Economics, Econometrics and Finance; Business, Management and Accounting; Mathematics; Environmental Science Engineering; Computer Science; Arts and Humanities; Medicine	88	Research Areas: Business Economics; Psychology; Information Science Library Science; Communication; Education Educational Research; Operations Research Management Science; International Relations; Social Sciences Other Topics; Engineering; Computer Science; Health Care Sciences Services; Science Technology Other Topics; Medical Informatise	112
Source type: Journal	87	Source type: Journal	109
Total	196		
Net total, after removal duplicates	126		

Source: own study

The literature review highlights an extreme gap in the area of roles in a scientific research team from the perspective of commercialising their results. Only a part of the studies was concentrated on groups functioning within spin-off companies. Still, even there, the focus was not on identifying team roles but only on the team functioning (De Cleyn et al., 2015; Diánez-González & Camelo-Ordaz, 2016; Grandi & Grimaldi, 2003; Nikiforou et al., 2018; Rosa & Dawson, 2006; Vanaelst et al., 2006; Visintin & Pittino, 2014).

The key concept on which the study of roles in teams is based is that of R. M. Belbin. A team role is characterised as *"a tendency to behave in a certain way, participate in the work of the team and interact with other team members* "(Belbin, 2010). Belbin argues that for teams to achieve high performance, there must be a well-rounded representation of all team roles (Belbin, 2010). This hypothesis assumes that the most successful teams consisted of different people (different team roles).

In turn, Bednár and Ljudvigová indicate that Belbin's team role typology has not been applied to the study of start-ups and their founder's (Bednár & Ljudvigová, 2020).

It's worth noting that Aritzet et al. propose that the connections among team roles in Belbin's framework could contribute to the creation of more resilient and precise approaches for assessing the structure and makeup of teamwork, leading to a deeper understanding of team dynamics (Aritzeta et al., 2007). The way an individual engages with fellow team members may be associated with a cognitive style, conflict resolution behaviours, power dynamics, or Machiavellian behaviours. This linkage, in turn, is expected to contribute to problem-solving within a team, fostering effective teamwork, team building, recruitment initiatives, and team training (Aritzeta et al., 2007).

Prichard and Stanton suggest that *"if teams are to be formed based on team role profiles, then the dynamics of how these roles interact with the environment, tasks and experiences, must be better understood"* (Prichard & Stanton, 1999).

Aritzeta et al.'s perspective is intriguing as it suggests that the equilibrium of team roles can be influenced by the gender composition of teams (Aritzeta et al., 2003). This aspect can impact interpersonal adjustments within groups, contributing to a balanced representation of natural roles and influencing the overall performance of the team. The presence of women in a group significantly enhances team collaboration, with this effect primarily attributed to the positive impact on group processes (Aritzeta et al., 2003). In a study focusing on business simulation group performance, Fenwick and Neal (Fenwick & Neal, 2001) discovered that groups with an equal distribution of men and women, or those with more women than men, outperformed homogeneous groups in a management simulation task. The rationale behind this effect was attributed to more efficient group processes and cooperative norms. Similarly, Jehn and Bezrukov observed that gender diversity led to an increase in constructive group processes (Kochan et al., 2003).

The data concerning the influence of gender diversity on team performance is more ambiguous and contingent on different contextual factors. Bear and Woolley propose that, given the significance of collaboration in science, advocating for the involvement of women in the field may yield positive practical outcomes for science and technology (Bear & Woolley, 2011).

Conversely, Dougherty highlights that research teams aiming to commercialise their scientific solutions need to amalgamate distinct 'worlds of thought' - the realms of science and business. This fusion can lead to misconceptions regarding the team's vision, strategy, and daily operations (Dougherty, 1992). Such dynamics may result in conflicts of interest as team members find themselves torn between their research and entrepreneurial pursuits (Nelson, 2014), potentially encountering tensions in deciding whether to maintain a researcher role, transition into entrepreneurship, or balance part-time commitments in both spheres (Wright et al., 2004).

Vanaelst et al. emphasise that the intersection of these two core modes of thinking has the potential to impede knowledge sharing, instigate tensions within the team, and give rise to issues in communication and collaboration. Therefore, it is crucial to investigate the circumstances and mechanisms leading to conflicts arising from interactions between academics of diverse statuses within the university or between academic and non-academic team members (Vanaelst et al., 2006).

Conversely, Diánez-González and Camelo-Ordaz concentrated on examining the influence of the composition of management teams in academic spin-offs and the potential conflicts within these teams on the entrepreneurial orientation of academic spin-offs (Diánez-González & Camelo-Ordaz, 2016). Their findings revealed that the presence of non-academic managers is a pivotal factor contributing to higher levels of entrepreneurial orientation in these academic spin-offs. Simultaneously, the conflict plays a full mediating role in the connection between the age heterogeneity of management teams and the entrepreneurial orientation (Diánez-González & Camelo-Ordaz, 2016).

Hence, one might inquire whether a 'typical' team arrangement exists that could foster an 'optimal' equilibrium between conflict and pragmatic discourse concerning the generated ideas. In simpler terms, what degree of diversity can enhance team performance? The response is not straightforward, as there are advantages and drawbacks associated with both homogenous and heterogeneous teams. Within homogenous teams, concepts tend to converge, resulting in group conformity, the emergence of minor conflicts, and suboptimal decision-making (Janis, 1982). Conversely, as proposed by Nikiforou et al., the amalgamation of individuals from diverse backgrounds and identities can yield a more profound exchange of ideas but may also weaken group cohesion and lead to collaboration challenges (Nikiforou et al., 2018).

Another issue that emerges from the conducted literature review in the context of roles in teams is knowledge transfer. However, it is noteworthy to emphasise the scarcity of research dedicated to comprehending the factors that impact knowledge transfer within teams. Addressing this void, a study conducted by Joshi et al. endeavours to explore the elements influencing knowledge transfer within information systems development teams (Joshi et al., 2007). The theoretical framework they introduced posits that the potency, credibility, and extent of communication play a crucial role in determining the quantity of knowledge transmitted to recipients. The findings of an empirical investigation involving student teams validated the significance of credibility and the scope of communication. Intriguingly, the team's potential did not emerge as a significant factor in the knowledge transfer (Joshi et al., 2007).

As Lucas points out, knowledge is not a resource that can be easily discarded and replaced by (Lucas, 2010). Consequently, organisations must recognise that knowledge management can only succeed if a collaborative environment is created and the organisation builds on what it already knows (Lucas, 2010).

Also interesting are the results of Alsharoa et al. research, which focused on examining the social effects of knowledge sharing in virtual teams (Alsharo et al., 2017). The findings indicate that the positive impact of knowledge sharing extends to fostering trust and cooperation among members of virtual teams. Conversely, while confidence has a positive influence on collaboration within a virtual team, it lacks a notable direct effect on the team's overall effectiveness (Alsharo et al., 2017).

In turn, the study by Lucas highlights how the use of teams, the application of a collaborative culture, and ownership of capabilities affect the knowledge transfer process and provide insights into better management of the process (Lucas, 2010). Lucas affirms that building a collaborative environment where knowledge is shared and viewed as an organisational asset is critical to success.

Utilising a survey conducted among students participating in innovation teams in China, Zhao et al. constructed a theoretical model focusing on team development orientation and team scientific creativity. Their investigation delved into the connections between team development orientation, team goal orientation, leader behavioural feedback, and team scientific creativity (Zhao et al., 2021). The outcomes revealed a positive correlation between team development orientation and team scientific creativity, with team goal orientation acting as a mediator in this relationship. Additionally, the leader's behavioural feedback played a moderating role in the association between team development orientation and team goal attainment orientation, as well as between team development orientation and team scientific creativity (Zhao et al., 2021).

Conversely, Hu et al. discovered, using data gathered from IT firms in China, that the correlation between leader humility and team information sharing was notable and positive solely within teams characterised by a low power distance. Additionally, leader humility exhibited a negative association with team psychological safety in teams with a high-power distance value. Simultaneously, this relationship was positive but lacked significance in teams with low power distance. Furthermore, both team information sharing and psychological safety exhibited significant connections with team creativity (Jia Hu et al., 2017).

The literature review under consideration also indicates that the exploration of scientific teams' role in academic spin-offs is still in its early phases. In order to spur dialogue and prompt further investigations, Nikiforou et al. conducted a comprehensive review of past research on teams within the academic spin-offs (Nikiforou et al., 2018). After critically assessing the current state of affairs, they propose that scholars should take into account the temporal context of academic spin-offs and the nature of the technology being commercialised. While most studies have examined the characteristics of teams by scrutinising the human and social capital resources of employees in academic start-ups, considerably less attention has been directed towards issues related to team formation and evolution, with very few studies focusing on team functioning. Furthermore, they advocate for research on founder identities and the establishment of a positive social environment within academic spin-off companies. Such inquiries would enable researchers to move beyond the conventional notions of academic spin-off teams, which primarily emphasise personal wealth creation, licensing income, and financial gain (Nikiforou et al., 2018). Our research aims to contribute insights to this discussion.

2.2. The commercialisation of scientific research

The commercialisation of scientific research has been an important study area for many years (Dezi et al., 2018). It pertains to the contemporary notion of an open innovation (Bogers et al., 2019; Chesbrough, 2003) and an entrepreneurial university (Etzkowitz, 2004).

Prior investigations within the realm of university entrepreneurship have concentrated, among other things, on stimulating innovation, developing incubation, and conducting joint ventures with business entities (Etzkowitz & Leydesdorff, 1995; Etzkowitz, 2010). Currently, the emphasis is on three key aspects. First, university managers are expected to be entrepreneurial in formulating and implementing strategies (Novela et al., 2021). Secondly, the ability to commercialise (direct and indirect) results of scientific research is emphasised (Battaglia et al., 2021). Third, attention is being paid to encouraging and empowering academics, students, and graduates to be more entrepreneurial (Guerrero et al., 2019). As a result of this approach, contemporary academic institutions are adapting their conventional responsibilities in education and research to create and share knowledge, facilitating growth.

The view of Roden et al. should also be shared, pointing out that cooperation between universities and industry is perceived as fundamental for innovation in contemporary world economies (Roden et al., 2020).

It is also worth emphasising that the modern commercialisation of scientific research results has many faces. It can be listed here, e.g., creating a spin-off or spin-out company, granting a license, selling research results, patent application or patent registration, and a utility pattern or trademark application or registration.

2.3. 'The A-to-F Model'

The above analysis has strongly highlighted the research gap in examining scientific teams' performance in commercialising their research results.

Therefore, we decided to present and use 'The A-to-F Model' by de Bes and Kotler in the empirical part (de Bes & Kotler, 2015). This model lists the key roles de Bes and Kotler have found in the global enterprises that have shown the best innovation results. They suggested that if an enterprise wants to innovate, it must define and assign these roles to specific individuals and let them interact freely to create their process (de Bes & Kotler, 2015). These roles are (A) activators (initiate the innovation process), (B) browsers (provide information), (C) creators (produce ideas), (D) developers (turning ideas into products and services), (E) executors (implementation), and (F) facilitators (instrumentation) (de Bes & Kotler, 2015). It should be emphasised that this model applies to the roles performed in R&D or innovative teams.

It is also worth adding that innovative projects are typically carried out within the process field (Tidd & Bessant, 2018). A process is a set of tasks occurring in a specific time sequence (Rothwell, 1994). This led researchers to conclude that during the creation of innovation, a project should go through a certain number of stages. De Bes and Kotler argue that, in reality, the creation of innovation does not occur in this way, and each organisation develops its own approach (de Bes & Kotler, 2015). They point out that the stages and phases of the innovation process must result from interactions among the individuals involved. These individuals play specific roles in this process, as identified and indicated by them (de Bes & Kotler, 2015).

We believe that this approach is adequate to attempt to describe the roles played by individual people in research teams aiming to commercialise their research results. This is supported by both the diversity of scientific fields in which research teams operate and the often-pioneering nature of their research—difficult to attribute to a formalised innovation process, in this case, commercialisation. As far as we know, this model has not yet been used to describe the roles played by research teams in the context of commercialising their research.

2.4. Theoretical model

Analysis of the literature on roles in a scientific research team from the commercialisation perspective and de Bes and Kotler's concept of the 'The A-to-F Model' prompted us to propose the following theoretical model (figure 1). As a result, we formulated the subsequent hypotheses:

- H_1 – The activator's role in a research team positively affects the commercialisation of the team's research results.
- H_2 – The browser's role in a research team positively affects the commercialisation of the team's research results.
- H_3 – The creator's role in a research team positively affects the commercialisation of the team's research results.
- H_4 – The developer's role in a research team positively affects the commercialisation of the team's research results.

- H_5 – The executor's role in a research team positively affects the commercialisation of the team's research results.
- H_6 – The facilitator's role in a research team positively affects commercialising the team's research results.

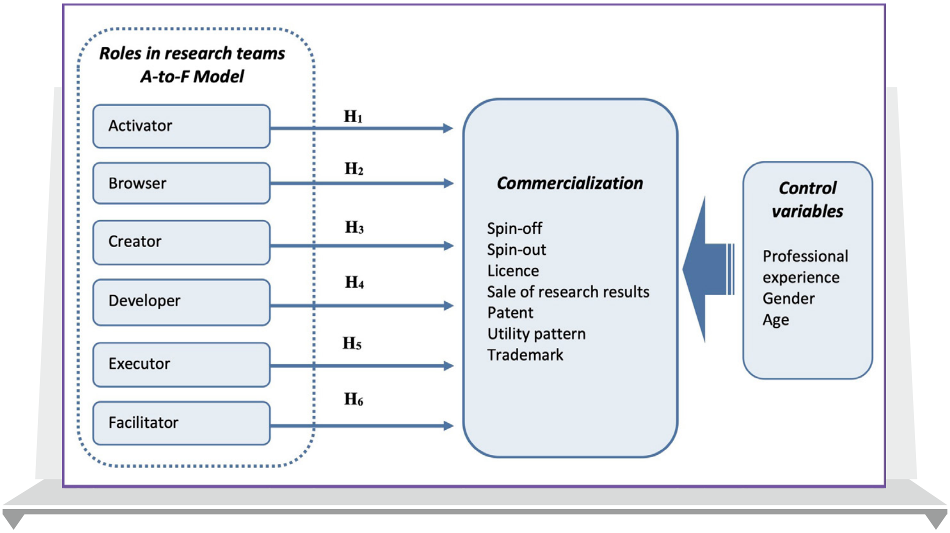

Figure 1. Theoretical model

Source: own study

The literature review also suggests taking into account some control factors. Usually, the gender (Zastempowski & Cyfert, 2021), age of the respondent (Felgueira & Rodrigues, 2020), and professional experience (Romero & Martínez-Román, 2012) are taken into account. Therefore, we decided to use such variables in the proposed model.

3. Methods and data

3.1. Data collection and respondent characteristics

The data were obtained during a quantitative study conducted at one of the leading research universities in Poland – Nicolaus Copernicus University

MACIEJ ZASTEMPOWSKI
ALEKSANDRA KALOCIŃSKA-SZUMSKA
JUSTYNA ŁASKOWSKA

(NCU). NCU is one of the largest universities in Poland, currently comprising 16 faculties. It provides graduate and postgraduate courses for 18 331 students, offering education in over 100 fields of study and 55 postgraduate courses. The university employs 4453 staff on both campuses (in Toruń and Bydgoszcz), over half of whom are academic teachers. NCU alumni now number around 200,000. In 2020, as part of the competition of the Minister of Science and Higher Education "Excellence Initiative - Research University", NCU was one of 10 Polish universities that obtained the status of a research university. NCU is also among the five best universities in Poland and among the 4% of the best universities in the world, according to the QS World University Ranking.

We used the indirect survey measurement method. The study was conducted from October 20 to November 19, 2021, using the computer-assisted telephone interviewing (CATI) method. The survey was non-interventional, in which ethical approval was not required.

It was assumed that the study would be conducted on a minimum sample of 329 people. The determination of the research sample size was grounded on the assumption that:

- in 2021, the number of all university employees (at 16 Faculties) was 2,284, including 456 teaching staff and 1,828 research and research-teaching staff; finally, 1828 people were taken as the population,
- the confidence level - 95%,
- the size of the estimated fraction - 10%,
- the maximum error – is 3%.

Finally, 828 respondents took part in the survey. Because some responses were incomplete (332), the final dataset was 496 observations. This represents 27.1% of all research and research-teaching staff. This means it can infer the entire population with a 97% confidence level and a maximum error of +/- 2%.

The characteristics of the respondents based on the following criteria: professional experience, age, and gender are presented in table 2.

Table 2. Demographics of survey respondents

Variable	Category	N	Percentage (%)
Education	Master's degree	67	13.5
	Doctoral degree	149	30.1
	Postdoctoral degree	228	45.9

	Professor title	52	10.5
Professional experience	up to 10 years	165	33.3
	11-20	164	33.1
	21-30	106	21.4
	31-40	42	8.4
	41 and more	19	3.8
Age	up to 30 years	30	6.1
	31-40	152	30.6
	41-50	180	36.3
	51-60	83	16.7
	61 and more	51	10.3
Gender	Female	218	43.9
	Male	243	49.0
	No answer	35	7.1

Source: own study

3.2. Variables

3.2.1. 'The A-to-F Model'

Measurement of the roles played by scientists in research teams was based on the concept of 'The A-to-F Model' proposed by de Bes and Kotler (de Bes & Kotler, 2015). Because this concept does not provide tools to identify the proposed roles, using the descriptions offered by de Bes and Kotler, we have created the following list of features that could identify these roles in research teams:

- Activator_1 (x_1) - *I initiate ideas but do not develop them further,*
- Activator_2 (x_2) - *I indicate the team's composition and assign roles,*
- Browser_1 (x_3) - *I search for information in a given field of research for team members and participate in every research stage, but I do not create new knowledge,*

- Browser_2 (x_4) - *I obtain information from external research institutions / other specialists,*
- Creator_1 (x_5) - *I create ideas for the needs of other team members regarding new concepts and commercialisation opportunities,*
- Creator_2 (x_6) - *I am looking for new projects and solutions at every research stage,*
- Developer_1 (x_7) - *I translate the created ideas into ready-made solutions,*
- Developer_2 (x_8) - *I plan and develop ideas for implementation,*
- Executor (x_9) - *I implement new ideas in practice (e.g., at university, in business),*
- Facilitator_1 (x_{10}) - *I select the best solutions for implementing a new idea and approve the necessary expenses,*
- Facylitator_2 (x_{11}) - *I help the team "get off the ground" when implementing new ideas is challenging.*

The respondents answered based on a 5-point Likert scale ranging from 1 – "strongly disagree" to 5 – "strongly agree". Reliability analysis (Cronbach's alfa) showed a result of 0.819, which, according to Nunnally, allows the scale to be considered reliable (Nunnally, 1978).

3.2.2. Commercialisation

In terms of commercialisation of the results of scientific activity and know-how, the theoretical background is created, above all, by Latif et al. (Latif et al., 2016) or the Polish Act of 20 July 2018 - *Law on higher education and science* (Law on Higher Education and Science, 2018).

As a consequence, when measuring the state of commercialisation of the results of scientific activity and the know-how of researchers, the following possible types of activities undertaken in this area were taken into account:

- y_1 - *I run or manage a spin-off company,*
- y_2 - *I run or manage a spin-out company,*
- y_3 - *I have been granted a license for a spin-off company,*
- y_4 - *I sold the research results,*
- y_5 - *I have entered into a license agreement for research results,*
- y_6 - *I have concluded a contract for the lease of research results,*
- y_7 - *I have submitted a patent application,*
- y_8 - *I have obtained a patent,*
- y_9 - *I have applied for a utility pattern/trademark registration,*
- y_{10} - *I have received a utility pattern/trademark registration,*

- y_{11} - *I founded a start-up,*
- y_{12} - *I work as part of an incubator.*

It should be noted that each form of activity in commercialisation mentioned above may take place independently, in sequence, or conjunction with other activities. Therefore, we decided that each undertaken activity is vital in light of the conducted research. These activities may constitute a "communicating vessel system," and any initiative a scientist takes in commercialising research results may be the first step in the commercialisation path.

Consequently, we employed the subsequent dummy variable to characterise the commercialisation endeavours of researchers:

- Commercialisation (y_{com}) – this variable takes the value of 1 if the researcher has undertaken any of the possible types of commercialisation activity (y_1 -y_{12}) in the previous three years and 0 if not.

3.2.3. Control factors

The control variables employed in the study included professional experience (x_{12}), respondents' age (x_{13}), and gender (x_{14}). Professional experience (x_{12}) and age (x_{13}) data were gathered using an ordinal scale ranging from 1 to 5, corresponding to the categories outlined in table 2. On the other hand, for gender, a dummy variable labelled 'Female' (x_{14}) was generated. It assumes a value of 1 if the researcher is female and 0 otherwise.

3.2.4. Descriptive statistics

The descriptive statistics of all analysed variables (divided into two categories: explained and explanatory) are presented in table 3.

Table 3. Descriptive statistics of variables

Variable	% - yes	Mean	Std. Err.	Std. Dev.	Variance	Min	Max
Explained							
y_{com}	25.0	0.250	0.019	0.433	0.188	0	1
y_1	5,2	0.052	0.010	0.223	0.050	0	1

y_2	2.4	0.024	0.007	0.154	0.024	0	1
y_3	0.2	0.002	0.002	0.045	0.002	0	1
y_4	8.5	0.085	0.013	0.279	0.078	0	1
y_5	2.4	0.024	0.007	0.154	0.024	0	1
y_6	0.8	0.008	0.004	0.090	0.008	0	1
y_7	8.7	0.087	0.013	0.282	0.079	0	1
y_8	6.0	0.060	0.011	0.239	0.057	0	1
y_9	1.4	0.014	0.005	0.118	0.014	0	1
y_{10}	1.0	0.010	0.004	0.100	0.010	0	1
y_{11}	1.6	0.016	0.006	0.126	0.016	0	1
y_{12}	3.8	0.038	0.009	0.192	0.037	0	1
Explanatory							
x_1		2.465	0.053	1.071	1.147	1	5
x_2		3.234	0.062	1.259	1.584	1	5
x_3		2.727	0.057	1.149	1.321	1	5
x_4		3.589	0.050	1.021	1.043	1	5
x_5		3.141	0.060	1.210	1.463	1	5
x_6		3.803	0.045	0.909	0.827	1	5
x_7		3.545	0.041	0.826	0.683	1	5
x_8		3.287	0.053	1.075	1.156	1	5
x_9		3.331	0.057	1.161	1.349	1	5
x_{10}		3.297	0.056	1.141	1.302	1	5
x_{11}		3.769	0.047	0.959	0.920	1	5
x_{12}		2.165	0.049	1.098	1.205	1	5
x_{13}		2.946	0.048	1.061	1.126	1	5
x_{14}		0.440	0.022	0.497	0.247	0	1

Source: own study

3.3. Method

Because the explained variable is dichotomous, the probit regression model was used. In this model, are the values of the normal distribution of N (0,1) in points :

$$p_i = F(x_i'\beta) = \int_{-\infty}^{x_i'\beta} \frac{1}{2\pi} \exp\left(-\frac{t^2}{2}\right) dt = \Phi(x_i'\beta) \qquad (1)$$

Values of the function inverse to F that is $x'\beta = F - 1(p)$, called probits, are the values of the linear combination $x'\beta$ for a certain level of probability, assuming that the combination has a distribution of N (0,1).

We employed the marginal effects (dy/dx) to interpret the outcomes of the probit model estimation. It can be expressed as:

$$\frac{\partial p_i}{\partial X_{ji}} = \beta_j \phi(x_i'\beta) = \beta_j \frac{1}{2\pi} \exp\left(-\frac{(x_i'\beta)^2}{2}\right) \qquad (2)$$

All models were estimated using the maximum likelihood estimation method and the STATA16.1 software.

4. Results

Our analysis commenced with evaluating the correlation among all variables incorporated in the model – the results of Kendall’s tau-b correlation are displayed in table 4.

Table 4. Correlation matrix

Variables	y_{com}	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}	y_{11}	y_{12}
y_{com}	1.000												
y_1	0.407**	1.000											
y_2	0.273**	-0.037	1.000										
y_3	0.078	0.191**	-0.007	1.000									
y_4	0.527**	0.188**	0.141**	-0.014	1.000								
y_5	0.273**	0.081	0.061	-0.007	0.282**	1.000							
y_6	0.156**	0.080	-0.014	-0.004	0.054	0.279**	1.000						
y_7	0.534**	0.153**	0.091*	-0.014	0.009	-0.049	-0.028	1.000					
y_8	0.439**	0.130**	0.125**	-0.011	-0.016	-0.040	-0.023	0.473**	1.000				
y_9	0.207**	0.049	0.092*	-0.005	0.025	-0.019	-0.011	0.388**	0.185**	1.000			
y_{10}	0.175**	0.067	0.115*	-0.005	-0.031	-0.016	-0.009	0.328**	0.228**	0.443**	1.000		
y_{11}	0.222**	-0.030	0.292**	-0.006	0.134**	-0.020	-0.012	0.131**	0.102*	0.120**	0.147**	1.000	
y_{12}	0.346**	0.000	-0.031	-0.009	0.015	0.037	-0.018	0.088	0.037	-0.024	-0.020	-0.026	1.000
x_1	0.049	-0.040	0.034	-0.071	-0.049	0.034	-0.036	0.103*	0.025	0.078	0.084	0.088	0.015
x_2	0.150**	0.094*	0.052	0.068	0.032	0.023	0.075	0.126**	0.085	0.059	0.078	0.032	0.050
x_3	0.098*	0.029	0.012	-0.031	0.069	0.078	0.022	0.034	-0.040	-0.041	-0.021	-0.046	0.026
x_4	0.143**	0.038	0.104*	-0.039	0.097*	0.059	0.063	0.020	0.037	-0.027	0.039	0.026	0.054
x_5	0.266**	0.159**	0.119**	0.035	0.137**	0.027	0.024	0.166**	0.131**	0.040	0.110*	0.080	0.143**
x_6	0.147**	0.092*	0.115*	0.068	0.074	0.017	.106*	0.066	0.069	-0.069	-0.009	0.021	0.077
x_7	0.084	0.076	0.087	0.030	0.077	0.045	0.025	-0.017	0.011	-0.054	-0.027	0.004	0.080
x_8	0.140**	0.086	0.121**	0.033	0.094*	0.052	0.022	0.025	0.007	-0.034	0.028	0.078	0.092*
x_9	0.198**	0.118**	0.142**	0.028	0.185**	0.072	-0.010	0.041	0.040	-0.010	0.055	0.101*	0.096*
x_{10}	0.122**	0.063	0.125**	0.030	0.066	-0.008	0.018	0.086	0.044	0.035	0.043	0.075	0.072

x_{11}	0.155**	0.156**	0.040	0.009	0.058	0.054	0.046	0.134**	0.104*	0.054	0.071	0.067	0.094*
x_{12}	0.164**	0.091*	-0.021	0.000	0.076	0.048	0.042	0.106**	0.085*	0.004	-0.027	0.026	0.017
x_{13}	0.109**	0.047	0.017	-0.043	0.058	0.030	0.069	0.046	0.070	-0.033	0.012	0.020	0.000
x_{14}	-0.023	0.047	-0.034	0.051	-0.065	-0.007	0.011	-0.013	-0.037	-0.003	-0.049	-0.081	0.035

** p-value ≤ 0.01. * p-value ≤ 0.05

Table 4. Correlation matrix – continued

Variables	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}
y_{com}														
y_1														
y_2														
y_3														
y_4														
y_5														
y_6														
y_7														
y_8														
y_9														
y_{10}														
y_{11}														
y_{12}														
x_1	1.000													
x_2	-0.059	1.000												
x_3	0.188**	0.110**	1.000											

x_4	-0.043	0.309**	0.132**	1.000										
x_5	-0.025	0.398**	0.113**	0.378**	1.000									
x_6	-0.139**	0.372**	-0.023	0.416**	0.428**	1.000								
x_7	-0.118**	0.265**	0.062	0.299**	0.302**	0.410**	1.000							
x_8	-0.016	0.309**	0.131**	0.307**	0.391**	0.374**	0.437**	1.000						
x_9	0.010	0.310**	0.107**	0.347**	0.347**	0.301**	0.386**	0.455**	1.000					
x_{10}	-0.047	0.431**	0.180**	0.326**	0.366**	0.385**	0.370**	0.438**	0.448**	1.000				
x_{11}	-0.088*	0.411**	0.014	0.335**	0.384**	0.478**	0.391**	0.379**	0.343**	0.408**	1.000			
x_{12}	0.093*	0.179**	0.070	0.050	0.108**	0.040	0.047	-0.023	0.014	0.104*	0.097*	1.000		
x_{13}	0.074	0.205**	0.106**	0.125**	0.181**	0.099*	0.083	0.026	0.043	0.142**	0.140**	0.688**	1.000	
x_{14}	-0.152**	0.026	0.026	-0.024	-0.010	0.025	0.016	0.069	0.007	0.048	0.019	-0.174**	-0.217**	1.000

** p-value ≤ 0.01. * p-value ≤ 0.

Source: own study

The results indicate several issues. First, there are statistically significant correlations between y_{com} and extrinsic y_1 – y_{12}. This is because y_{com} is a dummy variable based on y_1 – y_{12}. Second, certain correlation coefficients between the explained and explanatory variables demonstrate statistical significance. However, they do not surpass 0.26, indicating minimal dependence. Third, you can observe correlations between the explanatory variables (x_1-x_{11}). However, the coefficients do not exceed 0.5, which means no collinearity. Fourth, there is a relationship between the other explanatory variables being the control variables (x_{12}-x_{14}). A clear correlation emerges between professional experience (x_{12}) and the researcher's age (x_{13}), a connection that is inherently evident. With this in mind, however, it was decided that the model would consider one of these variables – professional experience (x_{12}).

Subsequently, we investigated the potential presence of common method variance (CMV) bias. Utilizing the one-way Harman's test and considering variables x_1-x_{11}, we observed that a singular factor accounts for 41.8% of the variance. As per Podsakoff et al., this outcome suggests the absence of CMV bias (Podsakoff et al., 2003).

Table 5 displays the outcomes of the probit model estimations, while the marginal effects are presented in table 6.

Table 5. Probit regression

	Model y_{com}	
Variable	**β**	**S.E.**
x_1	0.024	0.062
x_2	-0.004	0.075
x_3	0.089	0.065
x_4	-0.029	0.085
x_5	0.294**	0.077
x_6	0.042	0.117
x_7	-0.131	0.124
x_8	-0.081	0.105
x_9	0.268**	0.091
x_{10}	-0.119	0.096
x_{11}	0.110	0.111
x_{12}	0.165**	0.063
x_{14}	0.073	0.145
Constant	-2.471**	0.458
N	411†	
Log pseudo-likelihood	-220.93432	
Wald chi2 (13)	46.61	
Prob > chi2	0.0000	
Pseudo R2	0.1099	

** p-value ≤ 0.01. * p-value ≤ 0.05. † The number of observations was limited to 411 as only research team respondents were included. *Note:* Robust standard error in S.E. column.

Source: own study

The findings illustrated in table 5 underscore the significance of the model, as evidenced by the likelihood ratio chi-square of 46.61 and a p-value of 0.0000. Consequently, the null hypothesis positing the model's insignificance was rejected.

The estimated parameters, all of which demonstrated statistical significance, exclusively assumed positive values. This implies that the influence of the explanatory variables on the explained variable elevates the probability of commercialising the team's research outcomes.

As can be seen, only two variables are statistically significant determinants that positively affect the commercialisation of the team's research results. These are Creator_1 (x_5) and Executor (x_9).

Additionally, it's worth noting that one of the control variables, namely professional experience (x_{12}), also demonstrated statistical significance.

Table 6. Marginal effect

	Model y_{com}	
Variable	**dy/dx**	**S.E.**
x_1	0.008	0.021
x_2	-0.001	0.024
x_3	0.029	0.021
x_4	-0.009	0.027
x_5	0.096**	0.024
x_6	0.013	0.038
x_7	-0.043	0.041
x_8	-0.026	0.034
x_9	0.088**	0.029
x_{10}	-0.039	0.031
x_{11}	0.036	0.036
x_{12}	0.054**	0.021
x_{14}	0.024	0.048

** p-value ≤ 0.01. * p-value ≤ 0.05. Note: (~) dy/dx is for discrete change dummy variable from 0 to 1.

Source: own study

5. Discussion

The results suggest that four out of the six roles indicated in 'The A-to-F Model' are not statistically significant in the context of undertaking commercialisation activities by scientists. These roles are activator, browser, developer, and facilitator. So, there are reasons for rejecting the H_1, H_2, H_4, and H_6 hypotheses.

In the case of the role of a creator, i.e., a team member who creates ideas for the needs of other team members regarding new concepts and commercialisation opportunities, the obtained results indicate a positive impact of this role on the commercialisation of the team's research results. Stated differently, there is no basis for rejecting H_3 ($p \le 0.01$).

Also, in the case of the role of the executor, i.e., the person implementing new ideas in practice (e.g., at the university, in business), a positive impact of this role on the commercialisation of the team's research results was observed. Therefore, in this case, there are no reasons to reject H_5 ($p \le 0.01$).

Based on the data from Table 6, we also know that for the mean values of the explanatory variables, the team in which the role of the creator is more strongly marked has a probability of about 0.09 more that it commercialises its result than the team without this role. In turn, in the case of the executor role, the likelihood is higher by 0.08.

The results obtained are interesting.

First, it draws attention to the inconsistency with 'The A-to-F Model' proposed by de Bes and Kotler (de Bes & Kotler, 2015). De Bes and Kotler, based on the observation of the most innovative companies in the world, suggest that if a company wants to be innovative, it must define and assign these roles to specific people and then have set goals, resources, and deadlines for completing the project, let them establish free interaction to develop one's innovation process (de Bes & Kotler, 2015), in the case of research involving research teams, it turns out that only two roles are crucial for commercialisation. Of course, a team of scientists is not a team working on an innovative solution in the company. Nevertheless, we thought that in both cases, the roles in the teams would be similar and at least that more would turn out to be statistically significant. However, this suggests a particular specificity of scientific groups.

At the same time, analysing all six roles defined by de Bes and Kotler, it is worth noting that two key trends emerge there: generating solutions (the role of activator, researcher, and creator) and implementing solutions (executor, developer, facilitator). The specificity of conducting university activities, particularly administrative ones, forces scientists-researchers to play several roles, as in the assumptions of Belbin's concept (Belbin, 2010).

Secondly, it emphasises the role of the creator in research teams seeking commercialisation. A creator is a person whose task is to develop ideas throughout the entire innovation process - or commercialisation, in this case. As de Bes and Kotler suggested, it is worth emphasising that there is a contradiction in this role (de Bes & Kotler, 2015). On the one hand, they initiate the innovation process (in the case of research teams - a research project); on the other hand, they are the source of ideas. It is worth remembering that the world is full of ideas that are often worthless by themselves. The ability to transform them into fresh, valuable, and practical concepts matters. In other words, creators should develop ideas and convincing concepts that can be commercialised. This, in turn, is not that simple.

The significance of the creator's role in scientific teams from the perspective of commercialisation may arise from several premises.

It seems worth noting that the creator often contributes highly original and innovative ideas, which is crucial for the development of new concepts and technologies (Dutka et al., 2021). Their ability for creative thinking can open new perspectives and create opportunities for unique solutions that may be more easily commercialised (Amabile, 2012; Csikszentmihalyi, 1996; Revilla & Rodríguez-Prado, 2018).

Another reason may be that the creator often plays an integrating role in the team, assisting in combining different fields of knowledge and skills among team members. This may lead to interdisciplinary approaches, subsequently enhancing the attractiveness of potential products or services in the market (Dyer et al., 2011).

It's also worth noting that the creator's ability to generate inspiring concepts can serve as a motivational factor for other team members (Ballesteros-Rodríguez et al., 2022). The creator's commitment and enthusiasm can foster more effective collaboration and steer the team towards a common goal (Sattler et al., 2023), such as the commercialisation of research outcomes.

Furthermore, it seems that the creator, being one of the originators, may better understand the real needs of the market. Their ability to identify practical applications for research findings can increase their chances of success in the commercial market.

Finally, it's also valuable to consider the creator's role in terms of unique leadership in the commercialisation process (Tweheyo et al., 2023). Thanks to their role as a visionary, the creator can take on a leadership role in the commercialisation process (Krabel & Schacht, 2014). Their commitment and vision can be crucial for effectively transforming scientific achievements into products or services that can be commercialised.

Therefore, it seems that if universities want to commercialise the results of their research, i.e., be entrepreneurial (Aldawod, 2022; Arroyabe et al., 2022), they must create appropriate conditions for the creativity of their employees (Schaeffer et al., 2024; Thomas et al., 2023). The more such people there are in research teams, the greater the probability of commercialising their results.

Thirdly, an indication of the role of the executor in research teams seeking to commercialise their results. Executor, i.e., responsible for the practical and effective introduction of commercialisation of research results. That person plays a vital role in all matters related to implementation. Here, it is also worth asking about the possible reasons for this result.

This role appears to be significant in the context of commercialisation primarily because the executor is a key figure when it comes to translating theoretical concepts and research findings into practice (Dyer et al., 2011). Their abilities to implement ideas in a real-world environment, for example, in academia or business, are essential for effective commercialisation.

Another important aspect is that the executor typically possesses a high ability to optimise implementation processes (Dyer et al., 2011), undoubtedly expediting commercialisation. Their practical approach to project execution can enhance efficiency and reduce the time needed to bring products or services to market.

It is also worth noting that while the creator often contemplates abstract ideas and concepts, the skills and actions of the executor allow for the adaptation of these abstract concepts to real needs and market conditions (de Bes & Kotler, 2015). This usually enables a better understanding of how research results can be practically utilised and tailored to meet market requirements.

Executors are also frequently individuals who take on the role of project manager, coordinating efforts in the implementation and commercialisation (de Bes & Kotler, 2015). Their skills in time management, resource allocation, and team coordination are, therefore, crucial for the effective transformation of ideas into products or services.

It is worth remembering that discovering a new solution is only the beginning of the difficult path of commercialisation. There is also a suggestion for universities here. Indicating the executor as one of the two critical rules in research teams commercialising their results allows stimulating these processes. The executor maybe someone from outside the research team - e.g., an employee of a university unit dedicated to commercialisation. Perhaps it is worth helping research teams with the promise of commercialisation by offering them the inclusion of such an external person in the team.

Finally, it is also worth emphasising that only one of the contextual factors proved to have a significant impact on the commercialisation of scientific research results, and that is professional experience. The higher the professional experience, the higher the probability of commercialising their research results increases by 0.05. The reasons for this are also worth considering.

Firstly, it is important to highlight that experienced scientists often have a deep understanding of industry realities related to their research area. This enables a better understanding of how innovations can find practical applications in the market, which is crucial for effective commercialisation.

It can also be pointed out that scientists with extensive work experience generally have more extensive networks in their field. This network can be a valuable source of collaboration, funding, and business support, significantly facilitating the commercialisation process.

Experienced scientists also tend to be better at communicating their research results. Effective communication is crucial in convincing potential business partners, investors, and customers of the commercial value of a given innovation.

It is also noteworthy that the significant role of professional experience in commercialisation may result from the fact that long-term scientific experience often goes hand in hand with developed practical skills in the researched area. This, in turn, can significantly facilitate the process of adapting and implementing research results in commercial practice.

6. Conclusions

This paper aims to broaden knowledge about the research team's roles and their influence on commercialising their research results. In the theoretical underpinnings, based on a systematic review of the literature, we have indicated, according to 'The A-to-F Model' proposed by de Bes and Kotler (de Bes & Kotler, 2015), six possible roles in research teams that can affect the commercialisation of their research results.

Using the data from a quantitative study conducted in 2021 at one of the research universities in Poland - NCU, we investigated the relationship between the roles in research teams and the commercialisation of their results.

The estimated probit regression model results showed that two of the six roles indicated in 'The A-to-F Model' are statistically significant in the context of undertaking commercialisation activities by scientists. Those roles are creator and executor. The role of the activator, browser, developer, and facilitator was statistically insignificant.

The importance of the curator's role in the process of commercialisation of scientific research results may result, among others, from the ability to generate innovative ideas, integrate the knowledge of the research team, motivate and lead it, as well as understand market needs. In the case of the executor, it is worth paying attention to the ability to transfer theory into practice, optimise processes, adapt to real needs and manage projects.

It is worth emphasising that the role of the executor in undertaking executive and implementation activities is astonishing. It is not evident for the tasks set for university researchers. It seems that the indicated dependence is forced by environmental factors, mainly administrative tasks related to implementing scientific research results. These tasks are not directly assigned to other persons or units at the university. It seems that it is worth pointing out this as an important problem to be considered by the authorities of the examined NCU. We believe this also requires further research.

The study also offers practical contributions in two dimensions. From the perspective of the entrepreneurial university concept perspective (Etzkowitz, 2004; Leydesdorff, 2010), it is worth pointing to two conclusions.

Firstly, there should be an increased emphasis on stimulating employees' creativity, thanks to which such roles will appear more often in research teams, which may increase the commercialisation of their research results. It is, therefore, worth encouraging the university authorities (not only the one under study) to use various methods stimulating creativity, i.e. providing an environment conducive to creativity, organising workshops and creative training, interdisciplinary activities, creating platforms for sharing ideas or encouraging experimentation,

Secondly, the result indicating the critical role of the executor in research teams suggests trying to include in teams people who perform such roles but come from outside them. For example, they may be specialists in this field who are employees of organisational units dedicated to commercialisation (e.g. form technology transfer unit).

It should also be pointed out that certain limitations exist in this study, paving the way for potential future research.

First, our research was limited to scientists from one university in Poland - NCU. Because the sample was representative, we concluded only in the context of this university. However, it is worth considering researching a more comprehensive selection of scientists - not only from one country.

Second, when analysing team roles, we focused on 'The A-to-F Model' by de Bes and Kotler as a model describing the roles in teams striving for innovation. Nevertheless, the literature review showed that in the case of roles in groups, Belbin's model is an interesting concept (Belbin, 2010). Exploring the relationship between these roles and commercialising scientific research results seems no less attractive.

Abstract

Although the investigation of team roles has been a focus of scientific research over an extended period, one of the less recognised issues in this area is the functioning of research teams, especially in commercialising their scientific results. Drawing from a comprehensive examination of the literature and the concept of 'The A-to-F Model' by de Bes and Kotler, this paper aims to broaden the knowledge about the research team's roles and their influence on commercialising their results. To do this, in the empirical part, we use the data from a study of 496 scientists from one of the leading research universities in Poland. The results of the estimated probit regression models showed the inconsistency with 'The A-to-F Model'. Only two of the six roles, i.e., creator and executor, are essential. The activator, browser, developer, and facilitator were statistically insignificant.

Keywords: *Research teams, Team roles, Commercialisation, Innovation.*

JEL Classification: I23, L26, M13, O39.

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