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# WHAT STIMULATES SCIENTISTS TO RESEARCH RESULTS COMMERCIALIZATION? DISCOVERY AND DELIVERY SKILLS PERSPECTIVE

## Introduction

Innovation is the driving force of the modern economy and a strategic priority for almost every company [Dyer et al., 2011] In the context of universities, this emphasis is distributed among three complementary processes: entrepreneurship [Qiu et al., 2023], innovation [Andrade et al., 2022], and commercialization [Woodfield et al., 2023]. These processes fall within an entrepreneurial university theory [Etzkowitz, 2004], which remains a highly developed concept [Klein & Pereira, 2021]. Within this framework, the university is seen as one of the main driving forces of the social system, with entrepreneurship understood as both a process and a result [Klofsten, 2008]. It plays a central role in guiding innovation, creativity, and economic growth [Fayolle & Redford, 2014].

An exciting and little-researched aspect of an entrepreneurial university is the commercialization of research results, especially when examined from the perspective of scientists' characteristics. It is worth emphasizing that many studies show a strong relationship between personality traits and the tendency of employees, managers, or entrepreneurs to undertake innovative activities. Most of these studies examine

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human personality through the concept of the Big Five [McCrae & Costa, 1996]. They indicate, among others, that openness, conscientiousness, extraversion, and neuroticism are relevant to individual innovation competencies [Saatci & Ovaci, 2020], that openness to experience influence on innovative behaviour at work [Mustafa et al., 2021], or that openness and extroversion affect creativity [Abdullah et al., 2016]. Interesting results were also reported by Dyer *et al*. who explored the key features of breakthrough innovators [Dyer et al., 2011]. They pointed out that we can discuss a specific Innovator's DNA based on behavioral (questioning, observing, experimenting, networking) and cognitive features (associational thinking) [Dyer et al., 2011]. While features conducive to innovation have been examined in the context of entrepreneurs and employees, there is a need for more research regarding scientists and commercialization.

The conducted systematic literature review allowed us to conclude that in this respect, the Dyer *et al.* concept of Innovator's DNA [Dyer et al., 2011] is an outstanding inspiration for studying the features of scientists that stimulate the commercialization of their research results. This is also a cognitive gap that we want to fill with our research. Consequently, the article's main aim is to identify, using the Innovator's DNA concept, the characteristics of scientists that stimulate them to commercialize research results.

## 1. Literature review

The systematic literature review method was applied to investigate the characteristics of scientists who are active in knowledge transfer and commercialization. To receive a comprehensive overview of the literature, two databases were searched: Scopus and Web of Science, covering the period from 1970 to 2022. A few selected terms were used in the different fields to identify the relevant studies. The first search with the terms identified the area of interest: *personality OR personality trait* OR behavior* OR skill* OR trait* OR motivation** in the article title, which gave the result of about 684,802 records. Then the results were limited using the next group of terms identifying the subject group: *scientist* OR scholar* OR academic* OR researcher* OR "research worker*" OR inventor OR university OR academia* in the article title, abstract, or keywords. The search produced 56,316 records. In the next step, the area of interest was further limited to the following terms, i.e., *commercialisation* OR commercialization* OR technology transfer* OR patent* OR entrepreneurial university* in article title, abstract, or keywords, which resulted in 205 records, with period limitation from 1970 to 2022. The following inclusion criteria were then applied: (a) document type: article (126), (b) subject area: Social Sciences; Psychology; Decision Sciences; Engineering; Economics, Econometrics and Finance; Business, Management and

Accounting; Environmental Science; Computer Science; Medicine; Agricultural and Biological Sciences; Biochemistry, Genetics, and Molecular Biology (123), (c) source type: journal (120), and (d) language: English (111). Finally, after removing the duplicates and two articles (not relevant to the search subject), 109 articles left for analysis. The most important and interesting results are presented below.

Academic entrepreneurship fosters economic growth, social development, cohesion, and innovation. However, the motivation for academics to cooperate with businesses is not very obvious, as the willingness to be an entrepreneur often seems naturally connected with financial benefits. Surprisingly, there is significant effort required from universities to create an entrepreneur-friendly academic environment. Especially nowadays, there is intense economic pressure on universities to develop the idea of an entrepreneurial university and flipped knowledge transfer [De Cleyn & Festel, 2016].

At the same time, scientific knowledge is the primary driver of entrepreneurial activity in academia [Morales-Gualdrón et al., 2008]. The human factor is decisive in such relations, which is why it is important to discover what makes researchers to venture into business and commercialize their work.

D'Este and Perkmann confirm that most academics engage with industry to further their research rather than to commercialize their knowledge [D'Este & Perkmann, 2011]. Hayter also notes that many academic entrepreneurs have little immediate interest in the growth of their spin-offs and have instead established their firms to pursue other development funding sources [Hayter, 2011].

Analyzing the above, it seems crucial to identify the factors that affect scientists' research commercialization. Antoniolli et al., emphasize that although works on academic scientists' intentions are in their infancy, some argue that only a few entrepreneurially intentioned academics ultimately engage in entrepreneurial behavior [Antonioli et al., 2016]. Their results show that both the academic position and the scientific area of each researcher influence the intention to bring research outcomes to the market. Additionally, the experience of having founded a spin-off plays an essential role, positively impacting the likelihood of developing the intention to pursue a venture [Antonioli et al., 2016].

Although all the publications above point out the importance of the university's entrepreneurial environment, they also strongly indicate the significance of personal motivations. This is confirmed by studies by Autio et al., showing that internal personal motivations may be crucial in establishing a new company [Autio et al., 1996].

Baldini shows another point of view related to patenting, which is very close to commercialization [Baldini, 2011]. The study shows that researchers' primary motivations for patents are prestige, reputation and knowledge exchange. Researchers are sensitive to diverse incentives, whose importance varies according to personal characteristics and context.

Research by Lenzi presents mobility as one of the most influential channels of knowledge transmission that might be important for commercialization [Lenzi, 2009]. The connection between inventors' characteristics, inventive productivity, and mobility makes mobility essential in initiating innovative actions.

Kolb and Wagner's findings highlight the beneficial influence of personality traits on the probability of engaging in entrepreneurship [Kolb & Wagner, 2015]. An entrepreneur is expected to possess higher levels of conscientiousness, extraversion, emotional stability, openness to experience, and lower levels of agreeableness. However, analyzing scientists founding businesses in the university context suggests that this does not hold for all kinds of entrepreneurs. They found that the university context is associated with lower levels of openness to experience and might be inhibited efficiently through barriers in the early stages.

A different approach is presented in Liebenberg and Matthews's study, which highlights that the twenty-first-century engineer needs to be technically competent, socially and culturally aware, innovative, and entrepreneurial [Liebenberg & Mathews, 2012].

In other studies, Mom *et al.* were convinced about the importance of technology transfer skills at the individual level if commercialization is supposed to be successful [Mom et al., 2012]. The results show that the most relevant skills are communication, knowledge of intellectual property rights (and licensing), networking, negotiation, and commercial awareness.

Regarding personality traits, there is also interesting research conducted by Liu et al. among nursing students [Liu et al., 2020]. The results show no significant association between creativity and creative personality. However, the positive relationship between innovation and curiosity suggests that implementing methods to increase interest and innovation could improve nursing students' abilities to create innovative products.

Anwar showed linkages between personality and knowledge-sharing behavior in the workplace, finding relations between university teachers' personality traits (Big Five), proactive personality, creative self-efficacy, and knowledge-sharing behavior [Anwar, 2017].

In turn, Filipetti and Savona point out that the number of studies addressing science-to-business linkages in European countries increased significantly [Filippetti & Savona, 2017]. Most of these studies have focused on personal characteristics such as gender, age, seniority, and academic standing of the scholar as drivers of academic entrepreneurship.

In the context of commercializing scientists' research results, interesting conclusions were presented by Dyer *et al.* [Dyer et al., 2011]. Their research indicated that innovative entrepreneur differs from an executive in a few traits, namely behavioral patterns when collecting information, such as questioning, observing, experimenting, and idea networking.

Questioning is the ability to ask the right questions, often ones that challenge the status quo [Dyer et al., 2011]. Observation is the ability to carefully observe the surrounding world, allowing one to notice that people in different environments have discovered different – often better – ways of solving problems [Dyer et al., 2011]. Experimenting involves the functional testing of new ideas, prototyping, and pilot testing [Dyer et al., 2011]. Idea networking is a feature inextricably linked to out-of-the-box thinking, often requiring the combination of ideas from one specialization with those from other people's specialties [Dyer et al., 2011]. Dyer et al., also considered two cognitive patterns: associational thinking and a desire to change the status quo [Dyer et al., 2011]. The results show that innovative entrepreneurs are more likely than managers to engage in questioning, observing, experimenting, and idea networking behaviors.

Dyer et al. developed this idea into the Innovator's DNA concept [Dyer et al., 2011]. Their subsequent research has shown that innovators differ not only in terms of the level of discovery skills, i.e., questioning, observing, experimenting, networking, and associational thinking, but also in terms of delivery skills such as analyzing, planning, detail-oriented implementing, and discipline executing [Dyer et al., 2011].

It is worth emphasizing that the research of Dyer et al. [Dyer et al., 2011] inspired other studies in the field of innovators' DNA. Examples include studies on engineering students [Hess et al., 2015], students who took innovation education [Aburai & Takeyasu, 2020], healthcare educators [Armstrong & Barsion, 2013], and students and researchers in China [Ri et al., 2020].

In conclusion, the above literature review indicates the significant importance of people's personalities in acting innovatively. Researchers study their traits, intentions, motivations, and other factors in different configurations and circumstances. While commercialization represents an essential way for academic research to contribute to society's wellness, there are many ways to achieve knowledge and technology transfer.

However, the literature review also presents a cognitive gap: a lack of or insufficient research on scientists and their personalities in the context of successful commercialization. In this regard, the Innovator's DNA tools seem to be the perfect inspiration to study scientists' personalities and their innovative actions to push the university's research results into the market.

The above prompted us to formulate the following research questions:
*RQ1: Can we observe the Innovator's DNA skills among scientists?*
*RQ2: Do the Innovator's DNA skills affect scientists' commercialization activities?*

# 2. Material and methods

## 2.1. Data collection and respondent characteristics

The data was collected using the CAWI method from October 20 to November 19, 2021. The study population consisted of research and research-teaching staff at a university – totaling 2,284 people across 16 faculties. The minimum sample size was set at 329 scientists, assuming a 95% confidence level, 10% fraction share and a 3% maximum error.

Finally, 828 scientists participated in the study. However, because some answers were incomplete, the final sample size was 496 respondents. This result indicates an examination of 27.1% of the total population and allows for statistically significant conclusions at the 97% confidence level and a 2% maximum error. Table 1 presents the main characteristics of the respondents.

Table 1. Respondents' characteristics

| 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.

## 2.2. About constructs

### 2.2.1. The Innovator's DNA

We measured the skills resulting from the concept of the Innovator's DNA using a 20-statement *"Delivery- and Discovery-Skills Quiz"* presented by Dyer et al. [Dyer et al., 2011]. Since it is aimed at managers, we modified two statements ($x_7$ and $x_{19}$) for research in academia. The respondents answered based on a 5-point Likert scale ranging from 1 – "strongly disagree" to 5 – "strongly agree". Their list is presented below:

- Frequently, my ideas or perspectives diverge radically from others' perspectives
- I am very careful to avoid making any mistakes in my work ($x_2$).
- I regularly ask questions that challenge the status quo ($x_3$).
- I am extremely well organized at work ($x_4$).
- New ideas often come to me when I am directly observing how people interact with products and services ($x_5$).
- I must have everything finished "just right' when completing a work assignment ($x_6$).
- I often find solutions to problems by drawing on solutions or ideas developed in other fields, or disciplines ($x_7$).
- I never jump into new projects and ventures and act quickly without carefully thinking through all of the issues ($x_8$).
- I frequently experiment to create new ways of doing things ($x_9$).
- I always follow through to complete a task, no matter what the obstacles ($x_{10}$).
- I regularly talk with a diverse set of people (e.g., from different business functions, organizations, industries, and geographies) to find and refine new ideas ($x_{11}$).
- I excel at breaking down a goal or plan into the micro tasks required to achieve them ($x_{12}$).
- I attend conferences (in my areas of expertise as well as unrelated areas) to meet people and understand what issues are facing them ($x_{13}$).
- I pay careful attention to details at work to ensure that nothing is overlooked ($x_{14}$).
- I actively seek to identify emerging trends by reading books, articles, magazines, blogs, and so on ($x_{15}$).
- I hold myself and others strictly accountable for getting results ($x_{16}$).
- I frequently ask "what if" questions that provoke exploration of new possibilities and frontiers ($x_{17}$).
- I consistently follow through on all commitments and finish what I've started ($x_{18}$).
- I regularly observe the activities of others to get new ideas ($x_{19}$).
- I consistently create detailed plans to get work done ($x_{20}$).

### 2.2.2. Commercialization measurement

The analysis of the commercialization activity of scientists was based on the concept of the *Perception on Commercialization of University research products* described by Latif et al. [Latif et al., 2016] and commercialization guidelines resulting from the Polish Act of 20 July 2018 – *Law on Higher Education and Science.* To measure various forms of commercialization activity of scientists, we compiled a list of 12 specific types. The respondents answered on a dichotomous scale. The list is as follows:

- I run or manage a spin-off company ($y_1$).
- I run or manage a spin-out company ($y_2$).
- I have been granted a license for a spin-off company ($y_3$).
- I sold the research results ($y_4$).
- I have entered into a license agreement for research results ($y_5$).
- I have concluded a contract for the lease of research results ($y_6$).
- I have submitted a patent application ($y_7$).
- I have obtained a patent ($y_8$).
- I have applied for a utility pattern/trademark registration ($y_9$).
- I have received a utility pattern/trademark registration ($y_{10}$).
- I founded a start-up ($y_{11}$).
- I work as part of an incubator ($y_{12}$).

In our opinion, each indicated commercialization activity ($y_1$-$y_{12}$) can take place independently, or in combination with other activities. Therefore, we assumed that each undertaken activity is equally essential, constituting a kind of "connected vessel system". Any initiative of a scientist in the field of commercialization of research results may be the first step on the commercialization path. Consequently, we created the following dummy variable to describe the commercialization activities of researchers:

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

### 2.2.3. Control variables

The following three variables were used as control ones: work experience ($x_{21}$), age ($x_{22}$), and gender ($x_{23}$). For $x_{21}$ and $x_{22,}$ the observations were collected on an ordinal scale from 1 to 5, according to the categories presented in Table 1. For gender, we created a dummy variable named 'Female' ($x_{23}$), which takes the value 1 if the researcher was female and the value 0 if not.

### 2.2.4. Descriptive statistics

Table 2 presents the descriptive statistics of all analyzed variables.

Table 2. Descriptive statistics of variables

| Variable | % – yes | Mean | Std. Err. | Median | Mode | Std. Dev. | Variance |
|---|---|---|---|---|---|---|---|
| Y | 25.0 | 0.250 | 0.019 | 0 | 0 | 0.433 | 0.188 |
| $y_1$ | 5.2 | 0.052 | 0.010 | 0 | 0 | 0.223 | 0.050 |
| $y_2$ | 2.4 | 0.024 | 0.007 | 0 | 0 | 0.154 | 0.024 |
| $y_3$ | 0.2 | 0.002 | 0.002 | 0 | 0 | 0.045 | 0.002 |
| $y_4$ | 8.5 | 0.085 | 0.013 | 0 | 0 | 0.279 | 0.078 |
| $y_5$ | 2.4 | 0.024 | 0.007 | 0 | 0 | 0.154 | 0.024 |
| $y_6$ | 0.8 | 0.008 | 0.004 | 0 | 0 | 0.090 | 0.008 |
| $y_7$ | 8.7 | 0.087 | 0.013 | 0 | 0 | 0.282 | 0.079 |
| $y_8$ | 6.0 | 0.060 | 0.011 | 0 | 0 | 0.239 | 0.057 |
| $y_9$ | 1.4 | 0.014 | 0.005 | 0 | 0 | 0.118 | 0.014 |
| $y_{10}$ | 1.0 | 0.010 | 0.004 | 0 | 0 | 0.100 | 0.010 |
| $y_{11}$ | 1.6 | 0.016 | 0.006 | 0 | 0 | 0.126 | 0.016 |
| $y_{12}$ | 3.8 | 0.038 | 0.009 | 0 | 0 | 0.192 | 0.037 |
| $x_1$ | - | - | - | 3 | 3 | 1.047 | 1.096 |
| $x_2$ | - | - | - | 4 | 4 | 1.080 | 1.166 |
| $x_3$ | - | - | - | 3 | 4 | 1.103 | 1.217 |
| $x_4$ | - | - | - | 4 | 4 | 0.949 | 0.900 |
| $x_5$ | - | - | - | 4 | 4 | 0.994 | 0.988 |
| $x_6$ | - | - | - | 4 | 4 | 0.873 | 0.763 |
| $x_7$ | - | - | - | 4 | 4 | 0.950 | 0.902 |
| $x_8$ | - | - | - | 3 | 4 | 1.216 | 1.478 |
| $x_9$ | - | - | - | 4 | 4 | 0.929 | 0.864 |
| $x_{10}$ | - | - | - | 4 | 4 | 0.803 | 0.644 |
| $x_{11}$ | - | - | - | 4 | 4 | 1.118 | 1.249 |
| $x_{12}$ | - | - | - | 4 | 4 | 0.983 | 0.967 |
| $x_{13}$ | - | - | - | 4 | 4 | 1.081 | 1.169 |
| $x_{14}$ | - | - | - | 4 | 4 | 0.811 | 0.657 |
| $x_{15}$ | - | - | - | 4 | 4 | 0.899 | 0.808 |
| $x_{16}$ | - | - | - | 4 | 4 | 0.795 | 0.633 |
| $x_{17}$ | - | - | - | 4 | 4 | 0.842 | 0.709 |
| $x_{18}$ | - | - | - | 4 | 4 | 0.875 | 0.765 |
| $x_{19}$ | - | - | - | 4 | 4 | 0.890 | 0.791 |
| $x_{20}$ | - | - | - | 4 | 4 | 1.039 | 1.080 |
| $x_{21}$ | - | - | - | 2 | 1 | 1.098 | 1.205 |
| $x_{22}$ | - | - | - | 3 | 3 | 1.061 | 1.126 |
| $x_{23}$ | 44.0 | 0.440 | 0.022 | 0 | 0 | 0.497 | 0.247 |

Source: own study.

## 2.3. Methods

We used exploratory factor analysis (EFA) to test the factors underlying the Innovator's DNA scale in the context of scientists' skills. The IBM SPSS 26 software package was used to create the EFA matrix. To extract the relevant factors, Varimax was used as the rotation method. We did not want the selected factors to be correlated with each other because we analyzed the regression in the next stage.

The second method used was logistic regression. It can be written as:

$$logit\ (p_i) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} \tag{1}$$

where $logit\ (p_i)$ is denoted $\ln\frac{p_i}{1-p_i}$. The subject of estimation is the parameters $\beta_0, \beta_1, \beta_2, \ldots, \beta_k$ being elements of the vector $\beta$.

As an estimation technique, we used the maximum likelihood method. For the interpretation of the obtained results, we used odds ratios (OR). All the calculations were performed using the STATA.16.1 software.

# 3. Results

As a first step to discovering the basic factor structure of 20 assessed items describing scientists' discovery and delivery skills, we examined the factor matrix of loadings for the unrotated factor matrix. Table 3 presents the unrotated principal component analysis factor matrix.

Table 3. Unrotated component analysis factor matrix

| | Factor | | | | | |
|---|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | 5 | Communality |
| $x_{12}$ | 0.699 | –0.006 | 0.007 | 0.245 | –0.271 | 0.623 |
| $x_{18}$ | 0.688 | –0.367 | 0.030 | –0.079 | –0.231 | 0.669 |
| $x_{15}$ | 0.683 | 0.164 | –0.016 | –0.355 | 0.137 | 0.638 |
| $x_{16}$ | 0.681 | 0.035 | 0.175 | –0.259 | –0.060 | 0.566 |
| $x_{14}$ | 0.681 | –0.350 | 0.124 | –0.201 | 0.104 | 0.652 |
| $x_{20}$ | 0.666 | –0.205 | –0.221 | 0.247 | –0.143 | 0.616 |
| $x_{19}$ | 0.648 | 0.183 | –0.089 | –0.272 | 0.248 | 0.597 |
| $x_6$ | 0.639 | –0.438 | 0.051 | 0.087 | –0.057 | 0.614 |
| $x_{10}$ | 0.634 | –0.157 | 0.234 | –0.069 | –0.372 | 0.625 |
| $x_{11}$ | 0.616 | 0.416 | –0.217 | 0.129 | 0.000 | 0.616 |
| $x_4$ | 0.607 | –0.417 | –0.171 | 0.246 | –0.014 | 0.633 |

| | Factor | | | | | |
|---|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | 5 | Communality |
| $x_{13}$ | 0.567 | 0.169 | –0.245 | –0.201 | 0.332 | 0.561 |
| $x_{17}$ | 0.550 | 0.329 | 0.250 | –0.254 | 0.175 | 0.568 |
| $x_7$ | 0.449 | 0.351 | –0.330 | 0.311 | 0.207 | 0.573 |
| $x_8$ | 0.003 | –0.533 | 0.248 | 0.180 | 0.459 | 0.589 |
| $x_9$ | 0.473 | 0.496 | 0.133 | –0.040 | –0.225 | 0.539 |
| $x_2$ | 0.264 | –0.480 | 0.252 | 0.131 | 0.322 | 0.484 |
| $x_1$ | 0.130 | 0.310 | 0.657 | 0.308 | –0.118 | 0.654 |
| $x_3$ | 0.125 | 0.356 | 0.635 | 0.228 | 0.224 | 0.648 |
| $x_5$ | 0.442 | 0.290 | –0.233 | 0.539 | 0.160 | 0.650 |
| | | | | | | Total |
| Eigenvalue | 6.125 | 2.252 | 1.502 | 1.215 | 1.022 | 12.116 |
| % of variance explained | 30.624 | 11.258 | 7.511 | 6.075 | 5.112 | 60.579 |
| KMO test | 0.883 | | | | | |
| Bartlett's test of sphericity | 3504,693 | | | | | |
| Significance | 0.000 | | | | | |

Source: own study.

When evaluating assumptions in factor analysis, we examined the Bartlett test of sphericity and the Kaiser-Meyer-Olkin (KMO) test for sampling adequacy. Collectively, Bartlett's test finds that the correlations are significant at 0.000 (see Table 3). In turn, the measure of sampling adequacy – KMO – indicates that sampling is appropriate (0.883, meritorious level).

Based on the opinion that variables with commonalities less than.50 do not have a sufficient explanation, we decided to omit variable $x_2$.

In the second step, given that the unrotated matrix did not have a completely clean set of factor loadings, we applied the Varimax rotation technique. Considering the sample size (496), we assumed 0.4 as a significant factor loading. The results are presented in Table 4.

Table 4. Simplified varimax-rotated factor-loading matrix

| | Factor | | | | |
|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | Communality |
| $x_6$ | 0.764 | | | | 0.614 |
| $x_{18}$ | 0.741 | | | | 0.643 |
| $x_4$ | 0.726 | | | | 0.634 |
| $x_{14}$ | 0.653 | | | | 0.621 |
| $x_{20}$ | 0.630 | | 0.432 | | 0.608 |
| $x_{10}$ | 0.578 | | | | 0.505 |

cont. Table 4

| | Factor | | | | |
|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | Communality |
| $x_{12}$ | 0.555 | | 0.417 | | 0.573 |
| $x_8$ | 0.445 | | | | 0.376 |
| $x_{15}$ | | 0.714 | | | 0.612 |
| $x_{17}$ | | 0.678 | | | 0.551 |
| $x_{19}$ | | 0.664 | | | 0.546 |
| $x_{16}$ | 0.426 | 0.600 | | | 0.565 |
| $x_{13}$ | | 0.558 | | | 0.467 |
| $x_9$ | | 0.535 | | | 0.499 |
| $x_5$ | | | 0.769 | | 0.626 |
| $x_7$ | | | 0.700 | | 0.539 |
| $x_{11}$ | | | 0.625 | | 0.615 |
| $x_1$ | | | | 0.816 | 0.669 |
| $x_3$ | | | | 0.755 | 0.585 |
| | | | | | Total |
| Eigenvalue | 6.067 | 2.107 | 1.466 | 1.208 | 10.848 |
| % of variance explained | 31.929 | 11.090 | 7.718 | 6.358 | 57.095 |
| KMO test | 0.885 | | | | |
| Bartlett's test of sphericity | 3360.049 | | | | |
| Significance | 0.000 | | | | |

Source: own study.

As the results show (Table 4), the solution still needs improvement. First, three variables – $x_8$, $x_{13}$, and $x_9$ – have commonalities less than 50, which suggests omitting them. Second, in the case of variables $x_{14}$, $x_{20}$, $x_{12}$, $x_{16}$, and $x_{11}$, the problem of cross-loading should be addressed. We decided to omit those variables based on the ratio of variance comparison. The final rotated factor-loading matrix is presented in Table 5.

Table 5. Final varimax-rotated factor-loading matrix

| | Factor | | | | |
|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | Communality |
| $x_{18}$ | 0.814 | | | | 0.727 |
| $x_6$ | 0.787 | | | | 0.652 |
| $x_4$ | 0.729 | | | | 0.608 |
| $x_{10}$ | 0.708 | | | | 0.609 |
| $x_{19}$ | | 0.776 | | | 0.679 |
| $x_{17}$ | | 0.751 | | | 0.637 |
| $x_{15}$ | | 0.750 | | | 0.674 |

| | Factor | | | | |
|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | Communality |
| $x_5$ | | | 0.846 | | 0.754 |
| $x_7$ | | | 0.788 | | 0.692 |
| $x_1$ | | | | 0.844 | 0.722 |
| $x_3$ | | | | 0.784 | 0.659 |
| | | | | | Total |
| Eigenvalue | 3.536 | 1.617 | 1.231 | 1.030 | 7.414 |
| % of variance explained | 32.148 | 14.698 | 11.191 | 9.364 | 67.402 |
| KMO test | 0.778 | | | | |
| Bartlett's test of sphericity | 1428.419 | | | | |
| Significance | 0.001 | | | | |

Source: own study.

The final results led to the extraction of four factors with factor loadings above 0.7 and commonalities above 0.6, cumulatively explaining 67.4% of the total variance. Factor 1 has four variables with significant loadings; factor 2 has three, and factors 3 and 4 have two.

The first factor included variables that Dyer *et al.* attributed to the delivery skills [Dyer et al., 2011]. This factor accounts for 32.1% of the total variance and includes the following variables:

- $x_{18}$ – *I consistently follow through on all commitments and finish what I've started*,
- $x_6$ – *I must have everything finished "just right' when completing a work assignment*,
- $x_4$ – *I am extremely well organized at work*,
- and $x_{10}$ – *I always follow through to complete a task, no matter what the obstacles.*

These variables reflect characteristics associated with detail-oriented implementation and disciplined execution. We named this factor ($F_1$) as disciplined, detail-oriented implementation.

The second factor loads three variables:

- $x_{19}$ – *I regularly observe the activities of others to get new ideas*,
- $x_{17}$ – *I frequently ask "what if" questions that provoke exploration of new possibilities and frontiers*,
- $x_{15}$ – *I actively seek to identify emerging trends by reading books, articles, magazines, blogs, and so on*,

and represents 14.6% of the total variance. These three variables correspond to two discovery skills described by Dyer et al.: questioning and observing [Dyer et al., 2011]. Regarding scientists' skills, we have named this factor ($F_2$) as searching for new ideas.

The third factorial solution loads two variables:

- $x_5$ – *New ideas often come to me when I am directly observing how people interact with products and services*,

- and $x_7$ – *I often find solutions to problems by drawing on solutions or ideas developed in other fields or disciplines*,

representing more than 11% of the total variance. According to Dyer et al., this factor corresponds to associational thinking and observing [Dyer et al., 2011]. We propose that in the case of scientists, we name this factor ($F_3$) the skill of drawing inspiration.

Finally, the last factor brings together two variables, that is:

- $x_1$ – *Frequently, my ideas or perspectives diverge radically from others' perspectives*,
- and $x_3$ – *I regularly ask questions that challenge the status quo*.

It represents more than 9% of the variance and corresponds to the questioning skill according to the Dyer et al. concept [Dyer et al., 2011]. This is also how we define this factor ($F_4$).

To examine whether the skills of scientists defined in this way (factors $F_1$–$F_4$) affect their commercialization activity (Y), we used a logistic regression model. Variables corresponding to factors $F_1$–$F_4$ were introduced into the model as arithmetic means of partial loading variables for each factor. We also introduced the previously mentioned three control variables ($x_{21}$, $x_{22}$ and $x_{23}$) into the model.

We started the analysis by evaluating the correlations between all the variables that we planned to include in the model. The Pearson correlation coefficients are presented in Table 6.

Table 6. Correlation matrix

| Variables | Y | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $X_{21}$ | $X_{22}$ | $X_{23}$ |
|---|---|---|---|---|---|---|---|---|
| Y | 1 | | | | | | | |
| $F_1$ | 0.055 | 1 | | | | | | |
| $F_2$ | 0.090* | 0.244** | 1 | | | | | |
| $F_3$ | 0.172** | 0.268** | 0.259** | 1 | | | | |
| $F_4$ | 0.021 | 0.006 | 0.167** | 0.097* | 1 | | | |
| $X_{21}$ | 0.172** | –0.106* | –0.072 | 0.009 | –0.017 | 1 | | |
| $X_{22}$ | 0.104* | –0.144** | –0.041 | –0.017 | –0.013 | 0.748** | 1 | |
| $X_{23}$ | –0.023 | 0.239** | 0.069 | 0.096* | –0.226** | –0.204** | –0.242** | 1 |

* p-value ≤ 0.05, ** p-value ≤ 0.01.

Source: own study.

The results indicate some conclusions. First, some correlation coefficients between the dependent variable (Y) and independent variables are statistically significant. However, they do not exceed 0.17, indicating a practically negligible dependence. Second, we observe correlations between $F_1$-$F_4$ variables. However, these correlations are weak with coefficients not exceeding 0.3 (except for the correlation between $x_{21}$ and $x_{22}$). The variance inflation factors are all below 10, with the highest VIF being

2.34, indicating that collinearity is not a threat. Third, there is a strong positive correlation between work experience ($x_{21}$) and the researcher's age ($x_{22}$), which is expected. Consequently, we decided that the model would consider only one of these variables – work experience ($x_{21}$).

Next, we examined the possibility of a common method variance (CMV) bias. One-way Harman's test was verified by taking into account the variables $F_1$–$F_4$. The results showed that a single factor explains 43.8% of the variance, indicating no CMV bias.

The results of logistic regression estimation and odds ratios (OR) are presented in Table 7.

Table 7. Logistic regression

| Variables | Coef. | S.E. | OR |
|---|---|---|---|
| $F_1$ | 0.063 | 0.199 | 1.065 |
| $F_2$ | 0.134 | 0.204 | 1.144 |
| $F_3$ | 0.486** | 0.147 | 1.625** |
| $F_4$ | –0.009 | 0.121 | 0.991 |
| $x_{21}$ | 0.366** | 0.095 | 1.442* |
| $x_{23}$ | –0.031 | 0.236 | 0.969 |
| Cons_ | –4.456** | 0.881 | 0.012** |
| Log pseudolikelihood | –263.379 | | |
| Wald chi-square (6) | 31.08 | | |
| Prob > chi2 | 0.0001 | | |
| Pseudo R2 | 0.0557 | | |

Note: Robust standard error in S.E. column.

* p-value ≤ 0.05, ** p-value ≤ 0.01.

Source: own study.

The results indicate that the model is significant, with a Wald chi-square of 31.08 and a p-value of 0.0001. Therefore, the null hypothesis that the model is insignificant was rejected.

The results show that only one variable, $F_{3-}$the skill of drawing inspiration, is a statistically significant factor at a confidence level of 0.01, explaining the commercialization activities of researchers. This result indicates that a higher assessment by scientists of their drawing inspiration skills increases the chance of their undertaking commercialization activities by an average of 62.5% (OR).

It is worth adding that one of the control variables also turned out to be statistically significant: work experience ($x_{21}$).

# 4. Discussion

The primary purpose of this article was to identify the characteristics of scientists that stimulate them to commercialize research results using the Innovator's DNA concept. Examining the results obtained from the perspective of the first research question – *Can we observe the Innovator's DNA skills among scientists?* – several issues are worth highlighting.

The self-assessment made by the surveyed scientists indicates that for three features, namely $x_1$ – *Frequently, my ideas or perspectives diverge radically from others' perspectives*, $x_3$ – *I regularly ask questions that challenge the status quo*, and $x_8$ – *I never jump into new projects and ventures and act quickly without carefully thinking through all of the issues*, their opinion is ambiguous (M=3) (see Table 2). The first two are questioning skills, and the third is related to analyzing (one of the delivery skills). This result is somewhat surprising because one would assume that questioning the status quo ($x_3$) and expressing different views ($x_1$) are inherent characteristics of scientists. These characteristics form the basis of Khun's scientific revolutions. On the other hand, an ambiguous assessment of $x_8$ may suggest a certain element of caution in scientific work, perhaps even a specific fear of the unknown.

It is also surprising that for all other features that make up the Innovator's DNA concept of discovery and execution skills, the surveyed scientists generally agreed that they observe these features in themselves (M=4) (see Table 2).

The conducted exploratory factor analysis showed that in the case of scientists, the analyzed features focused on four factors, unlike in the Innovator's DNA concept (Table 4). We defined the first factor as disciplined, detail-oriented implementation ($F_1$), the second as searching for new ideas ($F_2$), the third as the skill of drawing inspiration ($F_3$), and the fourth as questioning skills ($F_4$). It should be emphasized, however, that individual features grouped into these defined factors differently than in the study described by Dyer et al. concept [Dyer et al., 2011]. This suggests that, for scientists, as opposed to managers and innovators, the configuration of discovery and delivery skills is slightly different. The conducted EFA did not identify factors, such as observing, networking, and experimenting, which are fundamental to the concept of Dyer et al. [Dyer et al., 2011].

Answering the research question, it can be stated that in the case of the researched scientists, not all the discovery and delivery features suggested in the Innovator's DNA can be observed. Their structure is definitely different.

Also, the answer to the second research question – *Do the innovator's DNA skills affect scientists' commercialization activities?* – is not unambiguous. This is due to several issues.

First, as we indicated above, the characteristics of the scientists surveyed differ from those indicated in the Innovator's DNA concept.

Secondly, the regression model estimation results (Table 6) showed that only one of the identified factors, namely the skill of drawing inspiration ($F_3$), has a significant impact on undertaking commercialization activity by the surveyed scientists. This factor is the ability to find surprising connections in different areas of knowledge. In other words, it is a kind of creative catalyst for change. However, it is worth emphasizing that association is a cognitive skill, unlike the other identified skills, which are behavioral in nature. This distinction is quite important because cognitive skills are more difficult to develop than behavioral skills. Dyer et al. indicate that the ability to associate can be improved by more frequent use of other discovery skills [Dyer et al., 2011]. Translating this suggestion into the obtained results, it can be proposed that scientists should develop the ability to search for new ideas ($F_2$) and questioning skills ($F_4$). This should contribute to the development of the skill of drawing inspiration (association skill) and, in turn, increase in the commercialization of research results.

## Conclusion

This primary purpose of this article was to identify the characteristics of scientists that stimulate them to commercialize research results using the innovator's DNA concept. In the theoretical background, based on a systematic literature review, we suggested that the discovery and delivery skills indicated in the Innovator's DNA concept may affect the commercialization of scientists' research results. However, we emphasized that Dyer et al.'s concept pertains to managers and disruptive innovators, not scientists. Hence the two key research questions we formulated.

Using the data from a quantitative study conducted in 2021 at one of the research universities in Poland, we tested the factors underlying the Innovator's DNA scale in the case of scientists' skills and interpreted the relationship between the identified scientist's skills and the commercialization of their results.

The results of EFA showed that, unlike in the Innovator's DNA concept, the analyzed skills focused on four factors. We defined the first as disciplined, detail-oriented implementation, the second as searching for new ideas, the third as drawing inspiration skills, and the fourth as questioning skills.

In turn, the logistic regression estimation showed that only one of the identified factors affects the commercialization activity of the surveyed scientists. It is worth noting that one of the control variables, work experience, also turned out to be a statistically significant factor influencing commercialization activity.

The crucial conclusions are as follows.

First, in the case of academia, not all the discovery and delivery features suggested in the Innovator's DNA can be observed. Their structure is definitely different. The conducted EFA did not reveal factors such as observing, networking and experimenting, which are fundamental to the concept of Dyer et al. [Dyer et al., 2011].

Second, among the identified factors, only the drawing inspiration skill has a significant impact on the commercialization activity of scientists.

In our opinion, this study contributes to practice in several ways. From the perspective of the entrepreneurial university concept, it is worth pointing to two key conclusions.

Firstly, it is worth stimulating the ability to draw inspiration in scientists by encouraging them to observe and make associations with their environment. Scientists often implement solutions differently or in novel ways. The results show that this skill significantly increases the chance of commercializing their research. Therefore, it is worth improving their skills in this area through various means: training in forcing new associations, creating metaphors and analogies, the SCAMPER technique, or encouraging internships in other scientific and commercial institutions. The theory of inventive problem solving (TRIZ) is another effective method to overcome creative weaknesses and find new solutions.

Secondly, based on Dyer et al.'s suggestions that the development of other discovery skills contributes to the development of the association thinking [Dyer et al., 2011], it is worth enhancing skills also in other behavioral areas identified in scientists, such as searching for new ideas and questioning. Among the possible techniques, the following are worth suggesting: QuestionStorming, Brainstorming or Ideation. It is also essential to exchange good practices and present success stories to inspire others. Analyzing patent databases can also be a huge inspiration for researchers.

Thirdly, the results showed that the skills of scientists, which we call disciplined, detail-oriented implementation, also play an essential role. We believe that it is worth suggesting that research teams working on commercially viable research should be formed in such a way that they include individuals with high skills in searching for new ideas, drawing inspiration and questioning, as well as disciplined, detail-oriented implementation.

This study has certain limitations which may give rise to possible future research.

First, our research was limited to scientists from one university in Poland. Because the sample was representative, we drew conclusions 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, we focused on Dyer et al. Innovator's DNA model when analyzing discovery and delivery skills. Nevertheless, a literature review showed that in the case of features and skills that could stimulate innovative and commercialization behavior, it is also worth reaching for personality traits, analyzed using the Big Five model. We believe that it also sets out further possible research directions.

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# WHAT STIMULATES SCIENTISTS TO RESEARCH RESULTS COMMERCIALIZATION? DISCOVERY AND DELIVERY SKILLS PERSPECTIVE

## Abstract

Based on a systematic literature review and the concept of 'Innovator's DNA' by Dyers et al., this paper aims to broaden the knowledge about scientists' discovery and delivery skills that stimulate them to commercialize research results. We use the data from a quantitative study conducted at one of the leading research universities in Poland. The survey was completed on a representative sample of 496 scientists. We used the EFA to test the factors underlying the Innovator's DNA scale and the logistic regression to interpret the relationship between the identified scientist's skills and the commercialization of their results. The EFA results showed that, in the case of scientists, unlike in the Innovator's DNA concept, the analyzed skills focused on four factors. We defined them as disciplined, detail-oriented implementation, searching for new ideas, drawing inspiration, and questioning skills. The logistic regression estimation showed that only the drawing inspiration skills affected the commercialization activity of the surveyed scientists.

**Keywords: commercialization, innovation, entrepreneurial university, skills.**

**JEL Classification Codes: I23, J24, L24, M13**

# CO STYMULUJE NAUKOWCÓW DO KOMERCJALIZACJI WYNIKÓW NAUKOWYCH? PERSPEKTYWA UMIEJETNOŚCI ODKRYWCZYCH I WYKONAWCZYCH

## Streszczenie

Bazując na systematycznym przeglądzie literatury oraz koncepcji DNA Innowatora Dyera i in., niniejszy artykuł ma na celu poszerzenie wiedzy o umiejętnościach odkrywczych i wykonawczych naukowców, które stymulują ich do komercjalizacji wyników badań. Wykorzystano dane z badania ilościowego przeprowadzonego na jednym z wiodących uniwersytetów badawczych w Polsce. Badanie przeprowadzono na reprezentatywnej próbie 496 naukowców. Do przetestowania czynników leżących u podstaw skali DNA Innowatora wykorzystano metodę analizy czynnikowej (EFA), z kolei aby ocenić związek między zidentyfikowanymi umiejętnościami naukowców a komercjalizacją wyników badań, zastosowano model regresji logistycznej. Wyniki EFA pokazały, że w przypadku naukowców, inaczej niż w koncepcji DNA Innowatora, analizowane umiejętności koncentrowały się na czterech czynnikach. Zdefiniowaliśmy je jako: 1) zdyscyplinowane, zorientowane na szczegóły wdrażanie, 2) poszukiwanie nowych pomysłów, 3) czerpanie inspiracji oraz 4) umiejętność zadawania pytań. Oszacowanie regresji logistycznej wykazało, że jedynie umiejętność czerpania inspiracji wpływała na aktywność komercjalizacyjną badanych naukowców.

**Słowa kluczowe: komercjalizacja, innowacje, przedsiębiorczy uniwersytet, umiejętności**

**Kody klasyfikacji JEL: I23, J24, L24, M13**