CHEMPRENEURS - ENTREPRENEURSHIP IN THE CHEMICAL INDUSTRY IN POLAND: A POST-COVID-19 PERSPECTIVE

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ABSTRACT

Universities with chemistry faculties should be capable of producing chempreneurs in order to support the necessary transformation not just of the Polish chemical industry. Poland has a reMaykable history in the chemical industry within an ever-changing industrial, societal and entrepreneurial landscape. The chemical industry is the second largest industrial sector in Poland and the third largest in terms of employment.

This article focuses on the world of chemical entrepreneurship in Poland, examining the strength of factors influencing the entrepreneurial intentions of chemistry students. Previous analyses of the student sample show significant differences between Germany and Poland in all areas such as subjective norm, entrepreneurial knowledge, perceptions, intentions and motives as well as barriers related to student culture. Using a sample of students from Poland with significant differences in age, gender, origin, migration background and nationality, hypotheses on the influence of these factors with regard to the intentions, perceptions, motives and barriers of chemistry students were developed and tested. We found a number of significant effects on the start-up behaviour of chemistry students and the factors influencing them. We discuss the results and propose new approaches for the education of chemistry students and for future research approaches. We also explore how the chemistry landscape has changed in the wake of the COVID-19 pandemic, presenting new challenges and opportunities for aspiring chempreneurs.

Keywords: Innovation and Infrastructure, Chempreneurs, Entrepreneurs, Chemistry Students, Poland.

INTRODUCTION

The history of the chemical industry is Mayked by innovations, discoveries and industrial activities. Mayia Skłodowska Curie, for example, can be considered one of Poland's most famous chemists due to her groundbreaking research on radioactivity earning her the nobel prize twice. Examples of Poland's innovative strength include the founding and growth of Ciech, a chemical company with international reach and economic orientation (Wysocki, 2021).

The need for innovation is evident in view of the latest regulatory changes for all industries. The aim is to achieve climate neutrality throughout Europe by 2050 (europa commission, 2023). Both new production processes and new products are playing a key role in the significant reduction of the human carbon footprint (Confalone, 2014). Since nearly every production process includes products from the chemical industry, innovations from the chemical industry have a major influence on the entire carbon footprint of a country. To this end, the

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European Commission wants to support areas of the economy, companies and sectors for the transition to low-emission technologies, the creation of attractive conditions for public and private investors, facilitating access to credit and loans as well as financial support, investment in the creation of new companies, SMEs and start-ups, and investment in research and innovation. The European Union is providing a total of 1.5 trillion euros for this purpose (Europäische Kommission , 2020). Technology transfer, playing a major role in the formation of chemistry start-ups, can take place through patents, university spin-offs or, for example, company start-ups (Wolf et al ., 2021). Entrepreneurship is thus a way of promoting innovation and competitiveness in the chemical industry (Walther et al., 2023). The COVID-19 pandemic changed learning, implementation and practice in all areas of business, education, healthcare and technology. The need for independent action and initiative changed the mindset of learners, which should be considered in studies and research on their impact (Maheshwari et al., 2022). Within a change process, the way of thinking patterns can be subject to change, thus the likelihood of students starting a business may be increased by the potential loss of income and jobs (Cruz et al., 2022).

LITERATURE REVIEW

Entrepreneurship in Poland

Entrepreneurship plays a crucial role in fostering innovation and competitiveness in the chemical industry. Start-ups and small companies contribute to technological advances and economic growth and are therefore an essential part of the industry's ecosystem. The potential applications for chemical products and concepts are both available and necessary in light of global challenges such as human health, crop production, energy conversion and storage, safe and abundant water and climate change. For the chemical industry to survive, the gap between science and entrepreneurship must be bridged, for example through technology transfer (Sachse & Maytinez, 2016). Technology transfer can take the form of patenting, licensing or start-ups. As a means of technology transfer, entrepreneurship has attracted the attention of many different disciplines (Kirzner, 1985). With globalisation and its impact on cultural diversity, entrepreneurship has become an important area of research in its own right. Due to the belief of many authors that entrepreneurship can be learned, many studies have been conducted on the entrepreneurial intentions of university students from different disciplines, such as business administration (Abigail et al., 2022; Ajzen I. , 1991; Franke & Lüthje, 2004). Due to the specificity of STEM students in terms of their learning patterns, behaviours and self-efficacy, it is not advisable to generalise from other study programmes or cultures (Rittmayer & Beier, 2009). The present study focuses on identifying the action gap between the idea and starting a business among chemistry students in Poland.

The differences in entrepreneurial intentions of 18-64 year olds have been widely analyzed. The annual survey Global Entrepreneurship Monitor (GEM) has monitored entrepreneurial activity in more than 59 countries since 1997. These reports show the development of entrepreneurial activity in a representative cross-section of a population group for the respective year (Bosma et al., 2012; Iakovleva et al., 2011). This allows us to understand the impact of various effects. Poland shows a stable economy, which showed faster recovery effects after the Corona pandemic than other EU countries. At the same time, Poland has shown a declining TEA rate from 10.7 to 1.6 since 2016. The TEA rate is the probability of starting or running a business by 18-64 year olds. This puts Poland in the worst position of all countries

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analysed in 2023.

Theoretical Framework

The evaluation of entrepreneurship studies can vary depending on the research question and objective. Consequently, there are studies with different focal points. Some studies address the issue of cultural differences in entrepreneurial motivation, which can be defined by comparing countries of origin, nationalities and places of residence. The willingness to start a business can be assessed by surveying individual population groups, as in comparative studies, or by combining cross-sectional studies from different country reports into an overall survey, as in the case of the Global Entrepreneurship Monitor. The best-known models for investigating the willingness to start a business and its influencing factors include the Entrepreneurial Event Model (EEM) (Shapero, 1985) and the Theory of Planned Behaviour (TPB) (Ajzen I. ,1985). The explanatory power of the models and the elements applied can vary from country to country and from discipline to discipline (Engle, et al., 2008). The TPB is considered the most frequently cited model (Walther, et al., 2023). Depending on the methodology, both the willingness to establish a company and the reasons for the differences were analysed. For example, significantly higher start-up intentions were analysed among Greek IT students than among male study participants. A negative influence of entrepreneurial barriers, such as knowledge and skills for entrepreneurship, and internal barriers, such as time and risk, were identified as influencing factors for the general intention to start a business (Sitaridis, 2019). As a further research focus, the immediate environment of the study participants is described as a social norm or perceived social norm. Positive influences are described by a positive attitude of the environment or a positive perception of the attitude of the environment on the willingness of study participants from e.g. South Korea, Malaysia or Vietnam to start a business (Koe & Majid, 2021; Nguyen, 2020). Other demographic variables analysed in the literature include income, the respective occupation of a parent, educational background and age (Singh, 2014; Pinazo Dallenbach & Castelló Sirvent, 2023).

In this paper, the Theory of Planned Behaviour (TPB) is used as a theoretical framework to understand the psychological factors that influence entrepreneurial intentions and behaviours. The TPB comprises three key components: Attitude, Subjective Norm and Perceived Behavioural Control. We will examine these components in the context of entrepreneurship among chemistry students in Poland. The TPB model includes the intention of starting a business as a dependent variable, and the mediators attitude, subjective norm, and perceived behavioural control as factors (Ajzen 1991, p. 182). For this study, the model was extended to include the factors such as start-up knowledge, perceived educational support, perceived support from the university/research institution and perceived career opportunities. The adapted model can be seen in Figure 1.

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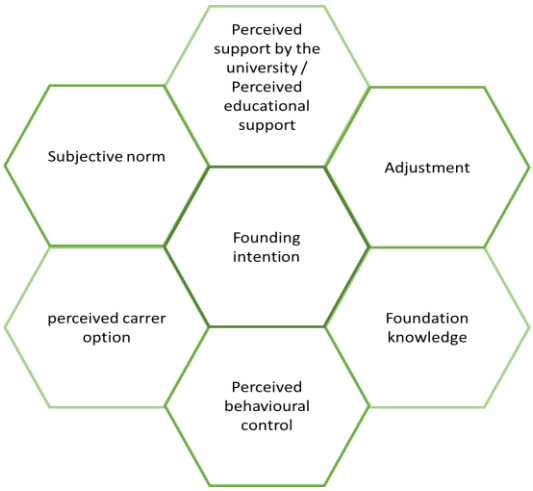

FIGURE 1
ADAPTED RESEARCH MODEL ACCORDING TO THE THEORY OF PLANNED BEHAVIOUR

Founding Knowledge

Founding knowledge refers to a person's understanding of the fundamental aspects of founding and running a company. This is a decisive factor for entrepreneurial intentions based on basic knowledge of business management and entrepreneurship. In the context of educational programmes, imparting entrepreneurial knowledge can be a suitable method for increasing the number of potential start-ups. Start-up knowledge can influence potential founders in two areas, on the one hand in the corresponding attitude and on the other via the general knowledge of business start-ups through entrepreneurship courses. The necessary knowledge for business start-ups is not taught as part of a traditional chemistry degree programme, which can deter interested students from potentially starting a business due to the lack of knowledge and preparation. For example, respondents who would like to start their own business are aware that their technical and business knowledge is not sufficient (Teixeira, 2008). A general dependency of entrepreneurship on attainable factors is described in other studies and models (Kolvereid & Moen, 1997). Entrepreneurship education has already been investigated among Polish schoolchildren and showed a positive effect on their willingness to start a business (Packham et al., 2010). Based on the representative survey by Gem, Poland shows a very undervalued assessment of foundation knowledge (Doan, 2022). This effect cannot be confirmed by the comparative study of chemistry students in Germany and Poland, in which sometimes Germany and sometimes Poland show higher ratings with significant differences (Walther et al., 2023).

Based on these described correlations, we hypothesise that general knowledge about business start-ups has a positive influence on the willingness of chemistry students in Poland to start a business (H1).

Perceived Educational Support (PES) & Perceived Support of the University (PSU)

The role of education in promoting entrepreneurship cannot be underestimated. On the one hand, future experts are needed to impart knowledge and, on the other hand, there is a need for workers in industry. In this regard, the Polish government has already tried to increase the number of first-year students in STEM subjects through funding and support (FUNDACJA PAP, 2010). Perceived educational support and university support can have a significant impact on the

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likelihood of individuals pursuing entrepreneurial ventures. In this regard, the university can argue, for example, through cognitive support (Trivedi, 2016). At the same time, the university can also take measures to increase or raise awareness of entrepreneurship as a career option. This can increase self-confidence in starting one's own business (Gorman et al., 1997). The studies show different results, in some cases significant influences are described (Schwarz et al., 2009) in others not (Trivedi, 2016). A study of students in Saudi Arabia in 2022 found a strong moderating relationship between perceived university support and Goal Setting, Environment Structuring, Task Strategies, Self-evaluation, and students' entrepreneurial intentions which becomes higher when students perceive high university educational entrepreneurship support (Mahgoub et al., 2023). The comparison of Germany and Poland revealed significant differences in Perceived Educational Support (PES) & Perceived Support of the University (PSU) with higher ratings in Germany.

Therefore, we hypothesise that university entrepreneurship education has a positive influence on the willingness of chemistry students in Poland to start a business (H2).

Subjective Norm

Within the framework of the TPB, the subjective norm is described as the second predictor. This defines the perceived social pressure triggered by the family, and the close environment of persons and peers. The direction and effect depends on the opinion of the reference persons (Ajzen 1991, p. 188; cf. Ajzen 1985, p. 14). However, students' perceptions can be changed or influenced (Nanda & Sørensen, 2008). The literature points to different socialisations among the sexes, so that women are socialised differently and therefore perceive opportunities differently (DeTienne, 2007). Different assessments were also found among male and female chemistry students in Poland and Germany (Walther et al., 2023). This means that women indicated less of a rigid social norm for a possible business start-up. At the same time, scientific studies show that regions with higher social acceptance also have more entrepreneurial activities (Kibler, 2013). For example, among Polish students, no significant influence of the subjective norm after the Covid period on entrepreneurial intention could be proven, which, however, was justified with the province of Podlaskie as the region of the survey, which is not known for innovative entrepreneurial activities (Kobylińska, 2022).

We therefore hypothesise that the acquaintance with a company founder in the students' circle of acquaintances has a positive influence on the willingness of chemistry students in Poland to start a company (H3).

Perceived Career Options

Chemists have a variety of career options, including traditional employment in industry, public service, academia or entrepreneurship. The perceived career option is the personal attitude towards a career path. This can be based on individual beliefs and experiences (Roy et al., 2017). In this context, a deeper understanding of personal career ambitions and desired work activity can be developed based on individual analysis and consideration in relation to one's own interests, values and experiences (Zikic & Klehe, 2006). When comparing perceived career options, individuals choose the option with the greatest personal benefit based on attributes such as risk taking, workload, financial success or recognition (Roy et al., 2017). Perceptions of one's own skills and abilities play a crucial role (Douglas & Shepherd, 2002). As a result, individuals with confidence in a career option may feel that their skills are not sufficient in some respects to

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succeed which is tantamount to excluding that career option. The initial economic situation can also influence career options, for example, starting a business is more likely if there are few vacancies in existing companies (Dyer Jr., 1995).Due to the quick access to jobs with perceived career opportunities in Poland, it can be assumed that starting a business as a career option is less likely (Zając et al., 2023).

We therefore hypothesise that the perceived career opportunities of chemistry students in Poland have a negative influence on their willingness to start a business (H4).

Motives and Barriers

Understanding what motivates people to start a business is as important as understanding the barriers to doing so. Previous comparative studies between countries and occupational groups show clear differences (Doanh, 2018; Giacomin, et al., 2011). A distinction can be made between extrinsic factors, which mainly relate to economic activities, and intrinsic factors, such as some personality-related characteristics. The study by (Walther et al., 2023), which compares different studies, found that “implementing my own idea”, “being independent” and “creating something of my own” are the strongest motivating factors, while “lack of start-up capital2”, “too high risk” and “lack of knowledge” are the biggest obstacles to entrepreneurial activities. The comparative study of German and Polish chemistry students revealed that the strongest motives were “to create something on my own”, “the opportunity to be financially independent”, and “the opportunity to realise my own ideas” for the Polish participants. While "the current economic situation", "a lack of initial capital" and "a lack of knowledge of the Mayket" were the strongest barriers for the chemistry students from Poland (Walther et al., 2023). Other comparative studies point to the significant differences in intentions and perceptions of motives or barriers due to cultural differences between nations (Pruett et al., 2009; Giacomin, et al., 2011). Wach & Bilan suggest that Polish students' entrepreneurial intention is significantly positively influenced by the Polish culture of negative barriers and experiences with a family business in their own household. Based on these results, we assume that there is a connection between high perceptions of motives and barriers and the willingness of chemistry students to start a business (Boissin et al., 2009; Confalone, 2014).

We therefore hypothesise that this effect is positive for motives (H5) and negative for barriers (H6).

METHODOLOGY

This study is part of a comparative study of German and Polish chemistry students that examines innovation-oriented technology transfer from the students’ perspective. Due to time and cost constraints, a longitudinal design was chosen for our study. The chosen method was a survey with one measurement point (August 2022 - January 2023) to collect prospective and current data using an online questionnaire.

Additional questions were added to the questionnaire used in this article. The questionnaire was translated into English, French, Spanish and Polish by specialised staff and then checked for loss of meaning. The target group for the survey was students from the departments of chemistry as well as related fields (biochemistry, analytics, industrial chemistry, process engineering, industrial biology and food chemistry) who were contacted by mail, personally in lectures or via online social media networks like Instagram.

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Survey

This study is part of a comparative study of German and Polish chemistry students that examines innovation-oriented technology transfer from the students' perspective. Due to time and cost constraints, a longitudinal design was chosen for our study. The method chosen was a survey with one measurement point (August 2022 - January 2023) to collect prospective and current data using an online questionnaire. Additional questions were added to the questionnaire used in this article. The questionnaire was translated into English, French, Spanish and Polish by specialised staff and then checked for loss of meaning. The target group for the survey was students from the departments of chemistry as well as related fields (biochemistry, analytics, industrial chemistry, process engineering, industrial biology and food chemistry) who were contacted by mail, personally in lectures or via online social media networks like Instagram.

Questions

The questionnaire used in this study is composed of questions from different studies. The questions are divided into demographic factors, the probability of founding or career intentions and the assumed influencing factors from the TBP with supplemented questions. The questions were asked in the fixed order of demographic questions, external influencing factors, start-up probability and personal influencing factors. After the demographic questions on gender, migration, nationality and age, participants were excluded due to their student status in order to obtain the desired data. Subsequently, study-relevant characteristics such as place of study, field of study, intended degree, total duration of study, type of employment or the presence of founders in the environment were recorded and questions were asked to determine the latent constructs. For this, questions from different studies were used, which were adapted to a 6-point Likert scale to force selection. Absolute ignorance (1) to comprehensive knowledge (6) for questions on basic knowledge, or I don't know (0), don't agree at all (1) to completely agree (6) for the others. The probability of founding a company was asked through two different types of questions, on the one hand the probability of founding a company after graduation ranged from very unlikely (1) to very likely (6) and on the other hand the career intentions with the options public service, employment and founding a company. Based on career intentions, the entrepreneurial intentions (TEA rate) for the students are determined by percentage calculation. An overview with the question categories used, the number of questions, the presence of the answer option "*I don't know*" as well as the question source can be found in Table 1.

Table 1
OVERVIEW OF APPLIED STUDY QUESTIONS WITH SOURCES, NUMBER AND ADDITIONS

Question Categories	Number Of Questions	Answer option "I don't know"	Question source	Addition of own questions
Foundation knowledge	3	no	(Cook, Heath, & Thompson)	no
Perceived educational support (PES) & Perceived Support of the university (PSU)	10	yes	(Roy, Akhtar, & Das)	yes
subjective norm (SN)	2	no	(Saeed, Yousafzai, Yani-De-Soriano, & Muffatto)	no
Founding intention	2	no	(Saeed, Yousafzai, Yani-De-Soriano, & Muffatto)	no

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Question Categories	Number Of Questions	Answer option "I don't know"	Question source	Addition of own questions
Perceived Career options (WCO)	6	yes	(Cook, Heath, & Thompson)	no
Perceived Behavioural control (PBC)	9	yes	(Zapkau, Schwens, Steinmetz, & Kabst)	no
Self-assessment for the foundation (SF)	3	yes	(Krueger, Reilly, & Carsrud)	no
Motives for Starting a Business	17	yes	(Pruett, Shinnar, Toney, Llopis, & Fox, 2009), (Solesvik)	yes
Barriers to Starting a Business	19	yes	(Pruett, Shinnar, Toney, Llopis, & Fox, 2009), (Solesvik)	yes

Participants

A total of 4,367 people and 120 professors or student representatives were contacted. In February 2023, we received completed questionnaires from 1,287 participants, a response rate of 29.4 %, which is acceptable compared to other web-based studies (Cook et al, 2000). Before conducting our statistical analyses, we excluded 320 participants due to incomplete data. We also excluded participants who reported that they were not currently a student (n = 135), or belonged to another field (such as teaching or electrical engineering), or were studying in another country (n = 21). The final sample thus consisted of 811 students, 498 from Germany and 313 from Poland. The average time spent in the questionnaire was 9.25 minutes. A sumMayy of the distribution of study participants can be found in Table 2.

Table 2
SUMMAYY OF THE STUDY PARTICIPANTS

Types		Number (n)
total		1,287
exluded		476
included		811
Poland		313
SUB groups		
Gender	Male	88
	Female	219
Migration Background	yes	64
	no	249
desired degree	Bachelor	224
	Master	64
income	no income	187
	Part time job	109
Founder-approved	yes	196
	no	117

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The students from Germany were on average 22.8 years old (SD = 3.42, range 17-39) and not homogeneously distributed between men (27.5 %) and women (69.9 %). Almost a quarter (21.9%) had an immigrant background. Most participants (72.2%) are enrolled in a Bachelor's degree programme (20.9% in a Master's degree programme, 6.9% in a doctoral programme). 59.9 % of students (n = 209) have no income from employment, while 4.3 % (n = 15) report full-time employment. Most students have a founder in their circle of acquaintances (n = 213, 61.0 %).

Statistical analysis

Statistical analysis was carried using IBM SPSS Statistics version 28.0.1. The data was tested for normal distribution using Shapiro-Wilk tests. Not all variables in the data set have a normal distribution and some variables have an ordinal scaling. The (Fisher & Yates, 1938) logistic ordinal model is used to study the effect of continuous and categorical variables on a dependent variable (Reed & Wu, 2013). First, an exploratory factor analysis (EFA) is carried out with the maximum likelihood extrusion method. Variables with a factor loading of less than 0.5 are excluded for further calculations. As a further parameter, the reliability measure Cronbach's Alpha (CA) is used, which is considered reliable if it exceeds the threshold value of 0.7 (Nunnally, 1978). This allows 12 variable factors to be generated from 69 variables.

To prepare an ordinal logistic regression (OLR), the results are coded as Y = 1 or Y = 0, where the result either occurs (1) or does not occur (0). Further, OLR is performed as an analysis on the factor variables. Thus, OLR is used to determine the effect size (Exp(B)) as 95 % Wald confidence interval, predict effects, detect trends and help predict the relationship between an endogenous variable at the ordinal level and two or more categorical or continuous exogenous variables. Chi-square test and goodness-of-fit according to Person and Deviance as well as pseudo R-squared according to Nagelkerke and Cox I Snell are given as further parameters for the OLR.

The significance level was defined as 5 %. The calculation of the probability of founding a company is based on the percentage of participants who selected founding a company as a career option. The results are presented as a table showing the factor, country, number of "I don't know" statements, proportion of "I don't know" statements, sample size (n), mean, median, Wald chi-square and p-value (p).

RESULTS

Entrepreneurial Intentions

The readiness of chemistry students in Germany to start a business is shown for all subgroups in Figure 2.

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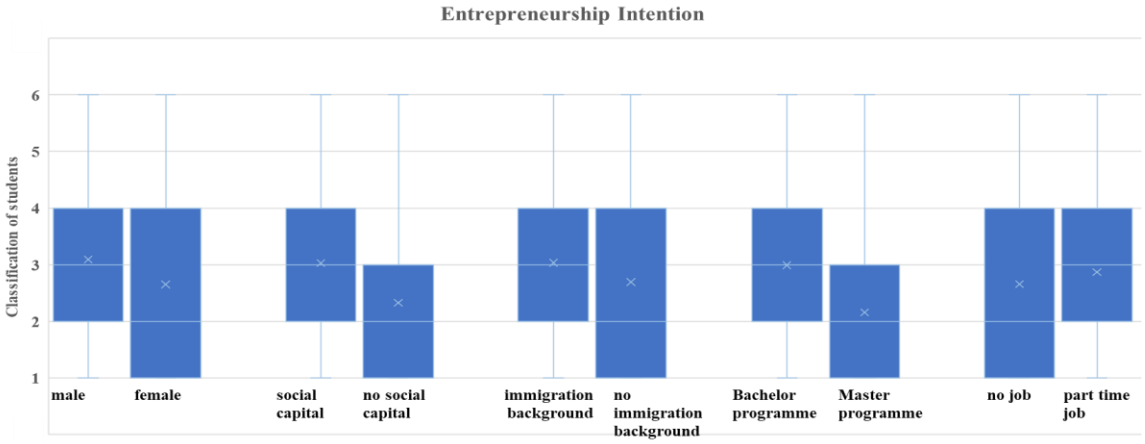

FIGURE 2
BOXPLOT FORT HE FOUNDING INTENTIONS OFT HE (SUB) GROUPS OF STUDENTS

As Figure 2 shows, the intention of chemistry students in Poland to start a business is rather low across all groups, with median and mean values around 2, which indicates a low probability of starting a business. Only the SUB groups of students without social capital and participants in a Master's degree programme show a lower mean, median and third quartile.

After selecting variables with a factor loading of at least 0.5 and a Cronbach's alpha (CA) of at least 0.7, the factor analysis resulted in 13 factor variables. The further course of the ordinal regression was thus limited to the variable factors (Table 3):

Table 3
QUESTIONS IN THE VARIABLE FACTORS

Variable factors	Questions from survey
foundation knowledge	To what extent do you know about the tasks involved in setting up a business?
	To what extent can you distinguish between a "good" and a "bad" start-up idea?
	Do you know of any funding organisations that can help you with your start-up?
Education support 1	My college/university offers lectures on the topic of start-up/entrepreneurship.
	My college/university offers projects on the topic of start-up/entrepreneurship.
	My college/ university hosts conferences /workshops on startup/entrepreneurship.
	My college/university puts students interested in starting a business in touch with each other.
	My college/university has a start-up center.
	My university has clear rules for the transfer of ideas from research to a start-up company.
Education support 2	My college/university motivates students to start a new business.
	My college/university provides students with ideas for starting a new business.
	I am aware of foundation events outside my university for people interested in foundation their own business.
Subjective norm	People I care about expect me to start a business after I graduate.
	People who are important to me think that I should start a business after I graduate.
Perceived career options	The choice between the different career options is so complicated that I can't decide.
	The more I try to find out about different career options, the more confused I get.
	I think a lot about choosing the right career.
Motives 1	earn more money than through wage labour
	to work in a varied profession
	the building of personal wealth
	to have more free time
	attainment of a high social status

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Variable factors	Questions from survey
Motives 2	the continuation of a family tradition
	to contribute to the economy
	contribute to regional economic development
Motives 3	to be at the head of an organisation
	the creation of jobs
	to lead people
Motives 4	the opportunity to realize my own ideas
	to create something on my own
	my personal independence
Barriers 1	lack of experience of accounting
	the lack of guidance
	lack of support in setting up a business
	paperwork and bureaucracy when setting up
	lack of support from people around me.
Barriers 2	excessive risk
	the lack of initial capital
	my own fear of failure
	lack of experience in management
	too much work in setting up a business
Barriers 3	the lack of credit for start-ups
	the applicable state laws (rules and regulations)
	the fiscal charges (taxes, court fees, etc.)
Barriers 4	a of knowledge in the business world
	a lack of knowledge of the Mayket

The results for the ordinal regression with the 12 factor variables and the 8 subgroups can be found in Table 4.

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Table 4
THE ORDINAL REGRESSION RESULTS - CONTRAST RATIOS

Parameters			Exp(B)	95 % Wald confidence Interval		Hypothesis test	
				Lower	Upper	Wald chi-square	p
SUB-groups	Gender	Male	1.41	0.84	2.35	1.7	0.192
		Female	1				
	Social capital	Social capital	1.44	0.88	2.36	2.15	0.143
		No social capital	1				
Parameters			Exp(B)	95 % Wald confidence Interval		Hypothesis test	
				Lower	Upper	Wald chi-square	p
SUB-groups	Immigration Background	immigration background	1.05	0.58	1.91	0.03	0.864
		no immigration background	1				
	Study Programme	Bachelor	1.64	0.95	2.83	3.19	0.074
		Master	1				
	Income	No income	0.94	0.58	1.51	0.06	0.8
		Part time job	1				
Factor variables		Foundation knowledge	1.28	1.13	1.44	14.86	< 0.001
		Education support 1	1.02	0.98	1.06	0.91	0.341
		Education support 2	1.03	0.96	1.11	0.78	0.376
		Subjective norm	1.9	1.56	2.32	39.82	< 0.001
		Perceived career options	1.07	0.98	1.17	2.1	0.147
		Motives 1	1.13	1.07	1.19	18.51	< 0.001
		Motives 2	0.94	0.87	1.01	2.54	0.111
		Motives 3	1	0.91	1.1	0	0.945
		Motives 4	0.99	0.88	1.11	0.02	0.882
		Barriers 1	1.03	0.94	1.13	0.47	0.493
		Barriers 2	0.98	0.91	1.06	0.34	0.56
		Barriers 3	1.06	0.98	1.15	1.96	0.162
		Barriers 4	0.9	0.79	1.02	2.77	0.096

Among the subgroups, only the comparison between Bachelor's and Master's students shows a significant difference, which was already shown in the boxplot in Figure 2. It can therefore be assumed that chemistry students in Poland are more likely to start a business when they are still at the beginning of their academic career. Our survey thus confirms the results of previous surveys of other students (Kanama, 2021).

The factor variables show a significant influence in the subjective norm, foundation knowledge and motives 1. The subjective norm thus confirms the influence of the students'

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immediate environment on their willingness to start a business (Nanda & Sørensen, 2008; Kautonen et al., 2011). In the results, the subjective norm is the factor with the strongest effect (1.90), which shows a direct correlation between the start-up behaviour of students and the attitude of their environment. Analogous to another study, no direct significant influence of the subjective norm was found, only an indirect influence (Kobylińska, 2022), which cannot be explained by the location of the universities.

The positive influence of start-up knowledge confirms the research (Doan, 2022). It can therefore be assumed that chemistry students do not differ in this respect from other students such as business administration students. The effect size shows a moderate effect of 1.28. It makes sense here to specifically strengthen start-up knowledge and identify SUB groups with deficiencies as in the gender comparative study by (Walther et al., 2023).

Motive 1 from the factor variables stands for "the opportunity to be financially independent", "to improve my quality of life", "to earn more money than through wage labour", "to work in a varied profession", "to build up personal wealth", "to have more free time" and "to achieve a high social status". The direct influence of these variables points to the desire for independence, freedom and fulfilment through something of one's own. These driving factors for starting a business have already been demonstrated by Walther et al.,(2023) and Pruett (2009).

Male and female students in Poland show no significant difference in their start-up behaviour, which can be attributed to a high degree of equality (DeTienne, 2007). At the same time, additional analysis is required to further clarify the non-significant effect, e.g. by comparing the genders individually using an ANOVA analysis (Walther et al., 2023). This reveals fundamental differences in the assessment of genders in Poland. These should be taken into account when implementing any processes and changes in education.

Table 5 sumMayizes the key figures for the model used.

Table 5
STATISTICAL KEY FIGURES FOR THE ORDINAL REGRESSION PERFORMED IN THE APPLIED MODEL

Test	Model	-2 Log Likelihood	Chi-Square	df	sig	Pseudo R-square
Test of Parallel Lines	Null Hypotheses	758.548				
	General	748.548[b]	12.018	72	1	
Model fitting information	Intercept only	920.561				
	Final	758.566	166.995	18	0	
Goodness-of-Fit	Pearson		1310.759	1347	0.755	
	Deviance		758.566	1347	1	
Pseudo R-squared	Cox / Snell					0.446
	Nagelkerke					0.462
	McFadden					0.176

As Table 3 shows, the model applied fits the data well, which is confirmed by the

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confounded measures used. The -2 log-likelihood, the chi-square tests and the pseudo R-squared measures show that the model explains the variation in the data well and has a good model fit. The pseudo R-squared values indicate that the independent variables can explain about 44.6 % to 46.2 % of the variance in entrepreneurial intentions. The test for parallel lines shows that the assumption of parallel regression effects is fulfilled.

The results can be used to confirm hypotheses 1 “general knowledge about business start-ups has a positive influence on the willingness of chemistry students in Poland to start a business”, H3 “the acquaintance with a company founder in the students’ circle of acquaintances has a positive influence on the willingness of chemistry students in Poland to start a company” and H5 “A positive correlation between a high perception of motives and the willingness of chemistry students to start a business”. Hypothesis 2 “university entrepreneurship education has a positive influence on the willingness of chemistry students in Poland to start a business”, hypothesis 4 “the perceived career opportunities of chemistry students in Poland have a negative influence on their willingness to start a business” and hypothesis 6 “A negative correlation between a high perception of barriers and the willingness of chemistry students to start a business” were rejected.

DISCUSSION

The distribution across the subgroups shows that the willingness to start a business is lower among participants in a Master’s degree programme. Possible effects such as good career prospects for chemists may have an influence here (Zając et al., 2023). At the same time, the gender subgroups show an increased willingness to start a business among women and chemistry students with founders in their circle of acquaintances, even if this is not significant. This indicates, on the one hand, cultural influences in relation to nationalities (Giacomin, et al., 2011) and, on the other hand, positive experiences from the students' immediate environment.

The results of the factor groups clearly show a connection between the willingness of chemistry students to start a business and their start-up knowledge, their perception of the subjective norm and their motives for starting a business. We therefore recommend the establishment of at least one compulsory course on entrepreneurship. In this way, knowledge of how start-ups work can be increased and barriers broken down. One possible approach is to invite founders to speak to the students as part of the university curriculum. This would allow students to build a network with founders and at the same time benefit from positive experiences. This would be in line with the findings of (Abigail et al., 2022). Critical authors state that the greatest learning success is achieved through practical application (Gendron, 2004). The factors with a positive effect on the willingness of chemistry students in Poland to set up a company can be a good starting point for a successful technology transfer after the Covid pandemic. The impact of EE on Polish chemistry students should be investigated directly and examined in detail. Our survey thus confirms the results of previous surveys of other students Wolf et al., 2021.

This study merely serves to provide an initial overview of the willingness of Polish chemistry students to start a business and the factors influencing this. As this is not a representative study but a random sample, only tendencies can be explained. For future research, we therefore recommend a larger number of participants in addition to representative studies in order to be able to carry out effect analyses for other SUB groups. Future analyses can explain how differently the different SUB groups of chemistry students see the influence of the various

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factors on the start-up intentions of chemistry students or classify them in order to be able to derive more targeted measures.

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