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Small but innovative: Unveiling the impact of micro-entrepreneurs' personality traits on a spectrum of innovations

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ABSTRACT

This article investigates whether a micro-entrepreneur's personality influences their innovativeness. Using the Big Five theory and a broad definition of innovation from the 4th version of the Oslo Manual (two types and nine categories of innovations in total), the study analyses data from 1,848 Polish micro-entrepreneurs. Since innovativeness is a complex process with several interdependencies, and previous research shows that introducing one type of innovation is not independent of introducing other types, Multivariate Probit (MVP) regression was used to estimate the models. The results allow two conclusions to be drawn. Firstly, in the case of product innovations implemented by micro-entrepreneurs, three personality traits have a positive impact. These are Openness to experience, Conscientiousness and Extroversion. Secondly, in the case of business process innovations, all 7 types are positively influenced by two personality traits, namely Openness to experience and Extroversion.

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Introduction

Although Schumpeter indicated small, entrepreneurial companies as constituting a certain source of creative destruction, and thus of innovative processes in the economy (Schumpeter, 1912), the innovativeness of micro-entrepreneurs is still on the margins of research into innovation (Mahto et al., 2018; Zastempowski, 2022). Despite Schumacher's (1973) suggestion that "small is beautiful" and Taleb's (2012) opinion indicating that small is less fragile (or antifragile), companies with fewer than ten employees are still overlooked in most research on innovativeness (among others in the Eurostat Community Innovation Survey conducted in every European Union member state). Roper and Hewitt-Dundas (2017, p. 559) even suggest that "(...) micro-enterprises are a neglected part of Schumpeter's creative army".

Based on resource theory (Barney, 1991; Teece et al., 1997), the literature highlights that innovativeness is strongly related to innovation capability (Martínez-Román et al., 2011; Mendoza-Silva, 2020, 2021). In the case of micro-enterprises, it is worth focusing on the innovation capability of their owners, i.e. micro-entrepreneurs. Their innovativeness is, in turn, perceived as one of the components of human character and can be associated with more general personality traits (Marcati et al., 2008).

Personality is the unique way of thinking and feeling that persists throughout a person's life, and should not be confused with character (the moral and ethical value judgments about a person's behaviour) or temperament (a person's constant, innate characteristics, such as impetuousness or adaptability) (Kagan, 2010). Based on psychology, personality theory has evolved along four traditional approaches: the psychodynamic (Adler, 1954; Freud, 1904; Jung, 1933), the behavioural (Bandura, 1989; Dollard & Miller, 1950; Rotter, 1990), the humanistic (Maslow, 1987; Rogers, 1961) and the trait-based (Allport & Odbert, 1936; Cattell, 1950; McCrae & Costa, 1997). In the context of personality description and the possibility of predicting behaviour based upon it (i.e., innovativeness), the trait-based theory seems to be particularly interesting. In treating a trait as a coherent, permanent way of thinking, feeling and behaving, this theory attempts to describe personality based on individual human traits.

However, despite the importance of personality in predicting possible innovative behaviour (Ahmed, 1998; Ali, 2019), only a limited number of studies have examined the relationship between

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personality and innovation (Marcati et al., 2008; Shane & Nicolaou, 2015; Stock et al., 2016).

Therefore, to address the call for work on the effect of personality traits on innovation capability (Mendoza-Silva, 2020), and to seek more precise personality associations with basic innovation activities (Stock et al., 2016), this article aims to examine the role of personality in the implementation of innovations by micro-entrepreneurs. In particular, perceiving personality in terms of the five primary factors of the widely accepted personality theory (Goldberg, 1990; McCrae & Costa, 1987), we pose the following research question: *Does a micro-entrepreneur's personality affect their innovativeness?*

This paper is organised as follows. As part of the literature review, the first section explores the Five-Factor Model of Personality, micro-entrepreneurs' innovativeness and the links between personality traits and innovativeness. The second and third sections present, respectively, the research methodology and the results, while the final section discusses the results and their practical implications.

Literature review

The five-factor model of personality

Research on personality traits dates back to the work of Allport and Odbert (1936), who indicated 200 possible traits. Later research, however, led to the development of a more concise approach to the description of personality. Cattell's (1950) research seems fundamental here, dividing personality traits into two basic types: surface and source. The former are superficial behavioural tendencies that exist "on the surface" and thus can be observed directly. Meanwhile, the latter represent deeper psychological structures that underlie the surface traits and explain their correlations (Matz et al., 2016). Cattell's (1973) research led to the identification of 16 such essential source traits. However, 16 traits are still too many when it comes to discussing and describing someone's personality. Therefore, further research aimed to limit the number of dimensions of personality traits to values that are easier to describe. Several research groups obtained five similar dimensions for the traits (Botwin & Buss, 1989; Goldberg, 1990; Jang et al., 1998; McCrae & Costa, 1987). These make up the so-called Five Factor Model or the Big Five. This assumes the existence of five independent personality traits, including openness to experience, conscientiousness, extraversion, agreeableness and neuroticism (McCrae & Costa, 1999). A brief description of the Big Five traits is presented below.

Openness to experience is described as the readiness to try new things and openness to new experiences (Stock et al., 2016; Zhao & Seibert, 2006). In other words, openness distinguishes imaginative and creative people from those who are down-to-earth and conventional (Matz et al., 2016). People who score high on openness to experience are usually described as curious, seeking intellectual challenges, endowed with an artistic soul, creative and non-conformist (Faullant et al., 2016; Feist, 1998; McCrae & Costa, 1997). They have rich imaginations and often engage in fantasies. Such people also enjoy daydreaming and thinking about alternative realities (Schnack et al., 2021). People who are open to experience typically appreciate beauty and art, and are deeply interested in music, literature, visual art and other forms of artistic expression (McCrae & Costa, 1997; Schnack et al., 2021). Conversely, low scorers may be characterised as traditionalists and conservatives who will likely prefer the familiar to the unusual (McCrae & Costa, 1987).

Conscientiousness refers to a person's organisation, motivation, perseverance and diligence in achieving a goal (Stock et al., 2016). The higher the level of conscientiousness, the more often we are dealing with trustworthy, ambitious and pedantic people (McCrae & Costa, 1990) who prefer planned behaviours over spontaneous ones (Barrick & Mount, 1991; Feist, 1998). Conscientious people are well-organised and systematic in planning their activities. They are determined and persistent in pursuing their goals (Saatci & Ovaci, 2020). They pay great attention to details and try to perform their duties as best as possible. They are also reliable and responsible (Abbas et al., 2018). It is worth emphasising that such people usually have a strong work ethic and are willing to work hard to achieve their goals. Conscientiousness also goes hand in hand with controlling impulses and focusing on long-term goals (Faullant et al., 2016; Feist, 1998; McCrae & Costa, 1997). Individuals with low conscientiousness typically have difficulties with organisation and may be less reliable, more impulsive and less persistent in pursuing their goals. They may also be less inclined to work hard and more prone to avoiding responsibilities (McCrae & Costa, 1990).

Extroversion (and its opposite, introversion) illustrates the level of subjective predisposition (or aversion) to social interaction and activity (Marcati et al., 2008). Extroverts are talkative, optimistic, sociable and emotional people. People who show high levels of extroversion also tend to be active and full of energy. They like to engage in various activities and often lead busy lives. They are also usually self-confident and willing to express their opinions. They are not afraid to lead and make decisions. They are assertive (Jackson, 2014). Extroverts also seek adventure, are open to new challenges, and can easily make new friends and build relationships (Schnack et al., 2021). Their opposite - introverts - are rather withdrawn, "blend into the background", and like solitude (McCrae & Costa, 1990). Introverts often prefer quieter and less stimulating environments. They may feel drained after prolonged social interactions, prefer to work independently, and usually value time spent alone or with a close-knit group of friends (McCrae & Costa, 1987).

Agreeableness refers to a person's basic emotional style (McCrae & Costa, 1990) and describes their interpersonal orientation, including the tendency to prefer positive interpersonal relationships and cooperation (Stock et al., 2016; Zhao & Seibert, 2006). A high level of agreeableness suggests a tolerant, friendly, polite, well-disposed, trusting and helpful person (Chollet et al., 2016; McCrae & Costa, 1990). They are also empathetic people, i.e. sensitive to the needs and feelings of other people, able to empathise with their situation and show them understanding and compassion. They also value harmony in interpersonal relationships and are willing to help others - they prefer cooperation over competition (McCrae & Costa, 1987). Agreeable people are relatively modest and do not like to brag, appreciating simplicity and authenticity (Marcati et al., 2008). They will also try to avoid conflicts and disputes, striving to solve problems peacefully and through compromise (McCrae & Costa, 1990). At the same time, a low level of agreeableness indicates a person who is grumpy, self-centred, suspicious, uncooperative, irritable, aggressive and hostile (Feist, 1998; McCrae & Costa, 1990).

Finally, *neuroticism* refers to emotional stability (or instability). People who are worried, anxious, temperamental and capricious get a high score in this area. Neurotic people also tend to feel sad and depressed. They may be prone to pessimistic thinking and low self-esteem. They can also often be easily irritated and quick to anger (McCrae & Costa, 1990). Minor difficulties or obstacles can provoke strong emotional reactions in them. Neuroticism is also a feature of individuals who tend to be strict with themselves, self-critical and over-analyse their mistakes and imperfections (Stock et al., 2016; Zhao & Seibert, 2006). Individuals with low levels of neuroticism, or those who are more emotionally stable, generally handle stress better, have a more positive outlook on life, and less frequently experience intense negative emotions (Schnack et al., 2021). They are more balanced, confident, relaxed and calm, and obtain a low score in this area (Diller et al., 2020; McCrae & Costa, 1990).

It is worth emphasising that despite the debate on the adequacy of the Big Five model (Borman, 2004; Karimi et al., 2022; Pervin, 1994), the literature provides several convincing instances of proof of its robustness (Conley, 1985; McCrae & Costa, 1987). Previous research has not only shown that as personality traits, the Big Five

are consistent across cultures (Hofstede & McCrae, 2004), but that they also seem to be hereditary (Jang et al., 1998) and are stable in time (Wagner et al., 2019).

Micro-entrepreneurs' innovativeness

Although innovations are currently perceived as an important factor in increasing competitiveness and achieving a competitive advantage (Bratianu et al., 2023), and Faherty and Stephens's (2016) research has shown that the innovativeness of micro-entrepreneurs is more reality than fiction, there are still only a few studies that address the issue of micro-entrepreneurs' innovativeness. Plotnikova et al. (2016), describing the results of research on self-employed people in Andalusia, indicate the existence of a relationship between their education (secondary and higher professional education and business education), their previous experience as a worker, and their process innovation. Similar conclusions, only in relation to product innovations, are suggested by Romero and Martínez-Román (2012) in a Spanish study of the self-employed. Roper and Hewitt-Dundas (2017) also draw attention to the role of education. Based on a Northern Ireland survey of innovation among micro-enterprises, their research showed a link between a STEM background and new-to-the-market innovation. Similarly, studies of micro-enterprises in Indonesia suggest a relationship between the owners' level of education and the digital technology innovativeness of the company (Trinugroho et al., 2022).

Another indicated factor influencing micro-enterprises' innovativeness is their entrepreneurial capital (including, among others, risk-taking, courage and initiative). Crespo et al. (2021) suggest the existence of a relationship between entrepreneurial capital and absorptive capacity, which in turn was found to be an antecedent to innovation in Brazilian micro-enterprises. In the opinion of Raghuvanshi et al. (2019), components of the innovative capacity of Indian micro-enterprises are also elements of entrepreneurial capital. The key elements in the authors' micro-enterprise innovation capability measurement scale are resources, risk-taking, networking and involvement. Also, Wahid et al. (2017) showed the role of networking in the innovativeness of Malaysian micro-enterprises. Interesting conclusions regarding the innovativeness of micro-enterprises are also shown in the research of Baumann and Kritikos (2016), suggesting that in the case of micro-enterprises investing in R&D, the intensity of innovation is greater the smaller the companies are. In turn, Audretsch et al. (2020) show that the relationship between R&D, innovative output and productivity differs depending on whether the micro-enterprise deals with production or operates in knowledge-intensive services. Some studies also suggest that in the case of micro-enterprises, their innovativeness is strongly related to the role of cultural components in innovation processes (van Oostrom & Fernández-Esquinas, 2017) and owners' motivation (Kozubíková & Zoubková, 2016).

It is also worth adding that innovativeness is a comprehensive concept defined and measured in various ways. For example, Dziallas and Blind's (2019) analysis of scientific publications on innovation indicators published in the years 1980–2015 identifies 82 unique indicators for assessing innovation. In turn, Mendoza-Silva (2020), also as a result of a systematic review of the literature, indicates seven input and eight output measures of innovative capabilities. There is also considerable definitional diversity in the field of innovation. However, this proves the constant evolution of this concept. Therefore, we decided to focus on the way of understanding innovation proposed in the last - fourth - edition of the OSLO Manual - a methodological guide on how to measure innovation, widely used by statistical offices in OECD and EU countries. According to this, we distinguish two basic types of innovations: product and business processes (OECD & Eurostat, 2018).

In this context, it is worth asking whether a micro-entrepreneur's personality affects their innovativeness.

Links between personality traits and innovativeness

Previous research conducted in various disciplines has shown that stable personality traits can be used to identify people who behave creatively and innovatively (Ahmed, 1998; Ali, 2019). Nevertheless, the findings are far from conclusive (Jirasek & Sudzina, 2020), and Mendoza-Silva (2020) has called for research into the effect of personality traits on innovation capability as there still remains a significant research gap in this regard. In line with these recommendations, the possible impact of each Big Five personality trait on innovativeness is presented below.

Among the Big Five personality traits, openness to experience exerts the most significant and thoroughly documented impact on innovativeness. Openness to experience is a personality trait characteristic of intellectually curious people with a broad imagination and originality (Ali, 2019) who have wide interests and are constantly looking for new information (Bozionelos et al., 2014). Previous research has shown the existence of a positive relationship between openness to experience and various aspects of innovation, including innovativeness, measured as an element of the Torrance Creativity Test (Azami & Kaikhavani, 2017), individual innovativeness tendency (Ali, 2019), individual innovation competencies (Saatci & Ovaci, 2020), creativity (I. Abdullah et al., 2016; McCrae, 1987; Shalley et al., 2004; Zhou & George, 2001), innovative work behaviour (H. Abdullah et al., 2019), success of radical new product development teams (Aronson et al., 2008), innovation capability (Hsieh et al., 2011), innovations created in the open doing-using-interacting mode (Runst & Thomă, 2021), and national levels of innovation (Steel et al., 2012). In addition, previous studies have also suggested a relationship between openness to experience and innovation performance (Weele, 2013). Furthermore, high levels of openness in teams have also been found to support innovative task performance (Buchanan, 1998). Similarly, openness has been found to be a strong predictor of innovation-supporting national cultural practices regarding innovation inputs and outcomes (Rossberger, 2014).

It is also worth pointing out that some studies show other relationships. Contrary to expectations, Ciavarella et al. (2004) found a negative relationship between the entrepreneur's openness and long-term venture survival. In turn, Hsieh's et al. (2011) research interestingly did not confirm the relationship between openness and technological (processes) innovation.

Openness was also found to be a moderator of the relationship between job satisfaction and innovative work behaviour, and between job satisfaction and the sub-dimensions of idea generation, idea promotion and idea realisation (Mustafa et al., 2021). Finally, it is also worth pointing out studies showing that the motivation to become self-employed based on the willingness to take risks and seize opportunities, i.e. creativity, a feature so crucial for openness, is a significant predictor of the introduction of process innovations in SMEs (Martínez-Román et al., 2011) and among the self-employed (Plotnikova et al., 2016). Consequently, the first hypotheses were proposed:

H1 - *Openness to experience, as a personality trait of microentrepreneurs, positively impacts their introduction of product innovations*.
H2 - *Openness to experience, as a personality trait of microentrepreneurs, positively impacts their introduction of business process innovations*.

Conscientiousness is a feature that determines the level of organisation, perseverance and motivation at work. The lower the level of conscientiousness, the more disorganised a person is and the faster the onset of discouragement (Chollet et al., 2016). It is worth noting that the literature on the impact of conscientiousness on innovation is divided (Ali, 2019). Although conscientious individuals' propensity to

plan, organise and focus on achievement (Weele, 2013) might hinder innovative behaviour, the qualities of competence, persistence and self-discipline (McCrae & Terracciano, 2005) are crucial for developing successful innovations. Among the literature providing evidence of a positive relationship, we can point to the relationship between conscientiousness and innovativeness as a feature of creativity (Azami & Kaikhavani, 2017), individual innovativeness (Ali, 2019), individual innovation competencies (Saatci & Ovaci, 2020), success of radical new product development teams (Aronson et al., 2008), long-term venture survival (Ciavarella et al., 2004), and innovation capability (Hsieh et al., 2011). Additionally, Buchanan (1998) discovered that elevated conscientiousness significantly predicts a team's performance on innovative tasks. Interestingly, Hsieh et al. (2011) also showed a positive relationship between conscientiousness and technological (processes) innovation. However, based on a qualitative literature review, I. Abdullah et al. (2016) showed that people with high levels of conscientiousness are less creative. Also, other studies have found an insignificant relationship between conscientiousness and innovativeness (Kirton & De Ciantis, 1986; Steel et al., 2012). Ultimately, we believe that positive traits of conscientiousness may be essential to bringing innovative product and business process ideas to fruition. Accordingly, the following hypotheses were formulated:

H3 - *Conscientiousness, as a personality trait of microentrepreneurs, positively impacts their introduction of product innovations*.
H4 - *Conscientiousness, as a personality trait of microentrepreneurs, positively impacts their introduction of business process innovations*.

Extroversion describes a person's relationship with the outside world (Chollet et al., 2016). It characterises individuals who tend to be outgoing, sociable, energetic (Marcati et al., 2008), assertive and active (Weele, 2013). These characteristics allow extroverted people to effectively build and engage with their social network (Ali, 2019). Consequently, this fosters opportunities for knowledge exploration and exploitation (Judge et al., 1999; Weele, 2013), which are crucial for innovation. Moreover, the traits of enthusiasm and positive emotions (Rossberger, 2014) empower extroverted individuals to experiment with new ideas. Some prior research shows that extraversion has a positive impact on innovativeness (Azami & Kaikhavani, 2017), individual innovativeness (Ali, 2019), individual innovation competencies (Saatci & Ovaci, 2020), creativity (I. Abdullah et al., 2016), innovation capability (Hsieh et al., 2011), innovations created in the closed doing-using-interacting mode (Runst & Thomä, 2021), and stronger entrepreneurial intentions (Eastman et al., 2001). Additionally, Buchanan (1998) discovered that teams with moderate levels of extraversion tend to excel in innovative task performance. Some studies, such as those by Hsieh et al. (2011), have also suggested a positive relationship between extroversion and technological (process) innovation. It is worth noting, however, that some studies have not confirmed that extraversion has a significant impact on innovativeness (Kirton & De Ciantis, 1986; Steel et al., 2012). Taking into account the above, two further hypotheses were proposed:

H5 - *Extroversion, as a personality trait of microentrepreneurs, positively impacts their introduction of product innovations*.
H6 - *Extroversion, as a personality trait of microentrepreneurs, positively impacts their introduction of business process innovations*.

Agreeableness as a personality trait indicates whether a person is trustworthy, altruistic, caring, manipulative, self-centred, cautious or lacking in compassion (Chollet et al., 2016). The link between agreeableness and individual innovativeness is rather complex. On the one hand, traits such as cooperativeness, good nature and flexibility (Weele, 2013) seem to foster innovation, while on the other hand, traits such as tolerance and compliance (McCrae & Terracciano, 2005) might hinder an individual's innovative inclinations. Consequently, it is unsurprising that some studies have identified agreeableness as having an insignificant impact on innovation capability (Hsieh et al., 2011). Meanwhile, the results presented by I. Abdullah et al. (2016) suggest a negative relationship - high levels of agreeableness result in less creativity. Similarly, Patterson (2002) also showed the existence of a negative relationship. On the other hand, however, some prior studies have indicated a positive relationship between agreeableness and individual innovativeness (Ali, 2019), technology innovation (Hsieh et al., 2011) and national levels of innovation (Steel et al., 2012). Agreeableness is also a significant predictor of innovation-supportive national cultural practices (Rossberger, 2014). While certain aspects of agreeableness might hinder innovative behaviour, successfully implementing innovations relies on managing social networks and business partners effectively, where the positive trait of agreeableness plays a crucial role (Rossberger, 2014). As Ali (2019) suggests, agreeableness plays a key role in whether the individual is welcomed by social groups and can successfully sustain social and business relationships, which are essential for the success of innovative projects. Finally, it is worth emphasising that Hsieh et al. (2011) showed that there is a positive relationship between agreeableness and technological (process) innovation. Consequently, the following hypotheses were proposed:

H7 - *Agreeableness, as a personality trait of microentrepreneurs, positively impacts their introduction of product innovations*.
H8 - *Agreeableness, as a personality trait of microentrepreneurs, positively impacts their introduction of business process innovations*.

Neuroticism points to individual differences in adjustment and emotional stability. The higher its level, the more often people tend to have negative emotions. A lower level characterises confident, calm and balanced people (Chollet et al., 2016). The impact of neuroticism on innovativeness is more clearly understood. Traits such as anxiety, hostility and self-consciousness (McCrae & Terracciano, 2005), along with a tendency to experience negative emotions (Rossberger, 2014), suggest that individuals with high levels of neuroticism may struggle to engage in innovative behaviours and pursue new ideas (Eastman et al., 2001). Innovative individuals are often self-assured (Kirton & De Ciantis, 1986) and emotionally stable (Hsieh et al., 2011), traits that are linked to lower levels of neuroticism. Prior research has suggested a negative relationship between neuroticism and innovativeness among engineers (Azami & Kaikhavani, 2017), individual innovativeness (Ali, 2019), creativity (I. Abdullah et al., 2016), success of radical and incremental new product development teams (Aronson et al., 2008), innovative performance (Rodrigues & Rebelo, 2019), and innovations created in the open doing-using-interacting mode (Runst & Thomä, 2021). Interestingly, Hsieh's et al. (2011) research did not confirm the relationship between emotional stability and technological (process) innovation. The arguments presented above lead to the formulation of the following hypotheses:

H9 - *Neuroticism, as a personality trait of microentrepreneurs, negatively impacts their introduction of product innovations*.
H10 - *Neuroticism, as a personality trait of microentrepreneurs, negatively impacts their introduction of business process innovations*.

As a consequence, the following conceptual model was proposed, as shown in Fig. 1.

Material and methods

Data set

The data constituting the basis for the analysis was collected in the period from August to October 2022. Based on the recommendation of the European Commission (2003), enterprises employing up

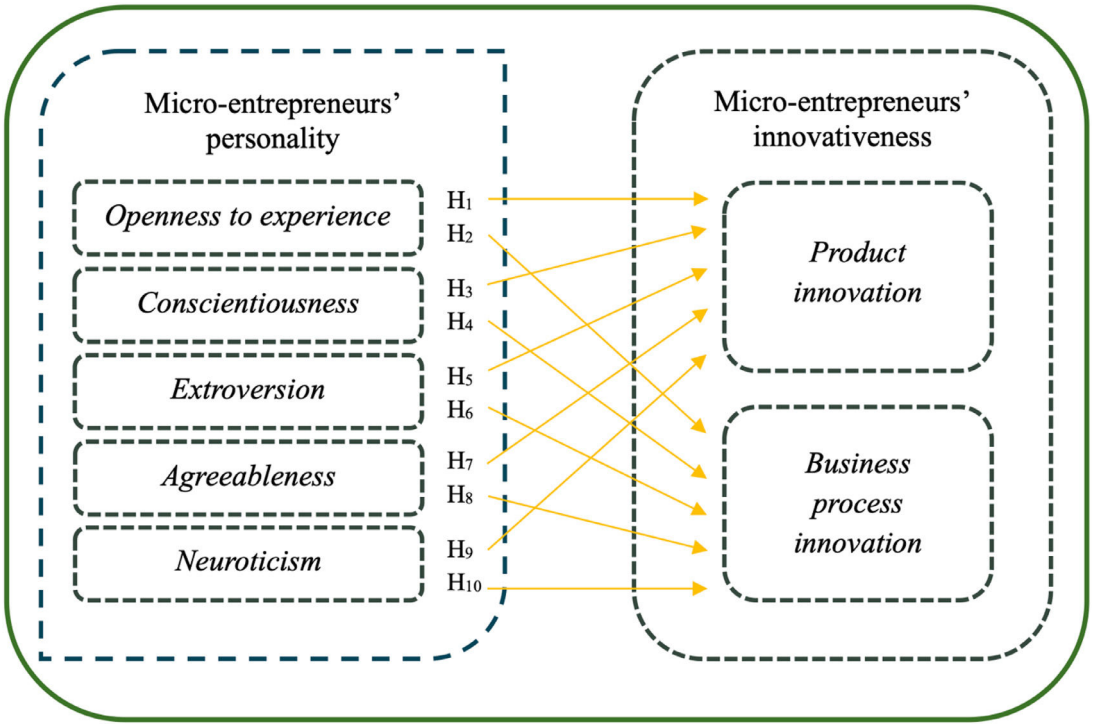

Fig. 1. Conceptual model.

to 9 people were treated as micro-enterprises. The research sample was drawn by Poland's Statistical Office from the National Official Register of Economy Entities (NOREE). The sampling frame consisted of active micro-enterprises, of which there were 4,497,099 in Poland in 2022. The sampling was carried out using a stratified sampling scheme. The following criteria distinguished the layers: activities, administrative region and legal form. The size of the primary sample – 1,850 units - was divided into sampling strata using an allocation proportional to the size in the sampling frame, with a modification to ensure that each stratum in the primary sample was represented by at least 1 unit. In addition to the primary sample, a reserve sample was drawn of the same structure and size, corresponding to 19 times the size of the primary sample. The reserve sample was drawn separately from the primary sample. The total number of randomly drawn samples - primary and reserve - was 36,994. The final data set covered 1,848 micro-enterprises, which, with a fraction size of 50% and a confidence level of 99%, makes it possible to draw conclusions with a maximum error of ± 3%.

The micro-enterprises in the study sample represented all types of economic activity (Table 1). Deviations from the NOREE register structure slightly exceeded 3% in only one case – L - activities related to real estate.

Variables

The innovativeness of micro-entrepreneurs – *the dependent variable* - was measured in accordance with the guidelines of the fourth edition of the OSLO Manual (OECD & Eurostat, 2018). According to the manual, innovations come in the following two types:

- Product innovation – which "*is a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market*" (OECD & Eurostat, 2018, p. 21),
- Business process innovation – which "*is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm*" (OECD & Eurostat, 2018, p. 21).

Consequently, micro-entrepreneurs were asked whether they had introduced a product or business process innovation in the previous three years (2019-2021). As a result, taking into account the possible categories of innovations, the nine following dummy variables were used, relating to the introduction of new or improved products or processes (OECD & Eurostat, 2018, pp. 70–74):

- Within product innovations:
  - y_1 – Goods,
  - y_2 – Services,
- Within business process innovations:
  - y_3 – Methods for producing goods or providing services (including methods for developing goods or services),
  - y_4 – Logistics, delivery or distribution methods,
  - y_5 – Methods for information processing or communication,
  - y_6 – Methods for accounting or other administrative operations,
  - y_7 – Business practices for organising procedures or external relations,
  - y_8 – Methods of organising work responsibility, decision making or human resource management,
  - y_9 – Marketing methods for promotion, packaging, pricing, product placement or after-sales services.

To examine the personality traits of micro-entrepreneurs – *as independent variables* - the Big Five Inventory developed by John and Srivastava (1999) was used. This includes 44 statements assessed on

Table 1
Structure of the sample.

Characteristics	NOREE[a] (%)	Sample (%)	Difference: NOREE – Sample (% point)
Activities (PKD)[b]			
A - agriculture, forestry, hunting and fishing	1.52	1.73	-0.21
B - mining and quarrying	0.10	1.84	-1.74
C - manufacturing	8.37	7.03	1.34
D - electricity, gas, steam, hot water and air conditioning	0.26	1.57	-1.31
E - water supply; sewage and waste management and remediation activities	0.31	2.11	-1.80
F - building construction	13.50	13.64	-0.14
G - wholesale and retail trade; repair of motor vehicles, excluding motorcycles	21.47	19.32	2.15
H - transport and storage	6.08	5.95	0.12
I - activities related to accommodation and catering services	3.22	3.08	0.14
J - information and communication	4.30	5.84	-1.54
K - finance and insurance	2.68	2.87	-0.19
L - activities related to real estate	5.95	2.71	3.24
M - professional, scientific and technical activity	10.68	11.47	-0.80
N - administration and support activities	3.37	3.46	-0.09
P - education	3.40	3.35	0.04
Q - health care and social welfare	5.84	7.31	-1.46
R - activities related to culture, entertainment and recreation	1.85	1.95	-0.10
S - Other service activities	6.82	4.76	2.06

Notes:
[a] Code list of classification of business activities in Poland.
[b] National official register of economy entities.

a five-point Likert scale. Individual personality traits were coded as follows:

- x_1 – Openness to experience,
- x_2 – Conscientiousness,
- x_3 – Extroversion,
- x_4 – Agreeableness,
- x_5 – Neuroticism.

The means of the corresponding items were used as final measurement values for the independent variables.

In line with the subject literature, control variables that may affect micro-entrepreneurs' innovativeness were also introduced into the estimated models. Here, it was decided to use enterprise age (Donate & Peña, 2016; Jia Hu et al., 2017) and size (Guan et al., 2006; Martinez-Roman & Romero, 2017). These variables were coded as follows:

- x_6 - Enterprise age – micro-enterprise age measured by the number of years since the business was founded – this variable was numerical, and a logarithm was applied to the calculations;
- x_7 - Enterprise size – micro-enterprise size measured by the number of employees (numerical).

The basic statistics describing the examined variables are presented in Table 2.

Method

Innovation is a complex process with several interdependencies. Previous research shows that introducing one type of innovation is not independent of introducing other types (Zastempowski, 2023). Therefore, assuming that this relationship also occurs in the case of micro-entrepreneurs, and drawing upon statistics literature (Ashford & Sowden, 1970), a multivariate probit model (MVP) was used to consider the correlation of error terms (Maietta, 2015; Wainaina et al., 2016). The multivariate probit model was developed to regress a set of correlated binary variables on a combination of continuous and discrete predictors (Lesaffre & Molenberghs, 1991). While this method has been applied in biological (Kesteloot et al., 1989), economic (Maietta, 2015; Wainaina et al., 2016), and psychosociological

Table 2
Description of variables.

Variable	% - yes	Cronbach's α	Mean	S.E.	M	D	S.D.	SD^2	Min.	Max.
y_1	4.654	-	0.047	0.005	0.000	0.000	0.211	0.044	0.000	1.000
y_2	8.496	-	0.085	0.006	0.000	0.000	0.279	0.078	0.000	1.000
y_3	10.335	-	0.103	0.007	0.000	0.000	0.305	0.093	0.000	1.000
y_4	5.303	-	0.053	0.005	0.000	0.000	0.224	0.050	0.000	1.000
y_5	10.335	-	0.103	0.007	0.000	0.000	0.305	0.093	0.000	1.000
y_6	8.820	-	0.088	0.007	0.000	0.000	0.284	0.080	0.000	1.000
y_7	9.416	-	0.094	0.007	0.000	0.000	0.292	0.085	0.000	1.000
y_8	9.037	-	0.090	0.007	0.000	0.000	0.287	0.082	0.000	1.000
y_9	8.063	-	0.081	0.006	0.000	0.000	0.272	0.074	0.000	1.000
x_1	-	0.806	3.538	0.014	3.500	3.500	0.616	0.379	1.400	5.000
x_2	-	0.905	3.750	0.018	4.000	4.556	0.788	0.621	1.222	4.889
x_3	-	0.856	3.555	0.019	3.625	4.250	0.804	0.647	1.250	4.750
x_4	-	0.938	3.293	0.021	3.333	2.667	0.892	0.795	1.333	5.000
x_5	-	0.875	2.682	0.021	2.625	3.000	0.888	0.789	1.000	5.000
x_6	-	-	0.969	0.008	1.000	0.602	0.354	0.125	0.000	2.021
x_7	-	-	2.692	0.068	2.000	0.000	2.937	8.628	0.000	9.000

studies (Lesaffre & Molenberghs, 1991), it has not yet gained widespread use in research on innovation (Zastempowski, 2023).

MVP examines the effect of the independent variables on each type of introduced innovation while allowing for the correlation of unobserved and unmeasured factors (error terms). As Zastempowski (2023) suggests, such correlations between the different types of introduced innovations could be the effect of their interconnectedness e.g., business process innovation leads to product innovations, and the correlations are therefore positive. On the other hand, for example due to micro-entrepreneurs limited resources (the adoption of a given type of innovation results in the abandonment of others), such correlations are negative. Hassen (2015), (Lin et al. (2005), and (Wainaina et al., (2016) suggest that in the case of such a correlation, the estimation of simple probit models may be biased and ineffective.

The suggested MVP model contains nine binary choice equations relating to the introduction of two types of product innovation and seven types of business process innovations. Consequently, there are nine dependent binary variables y_{ij} for micro-entrepreneur i and innovation j. This can be written as (Wainaina et al., 2016):

$$y^*_{ijm} = X'_{ijm}\beta_m + \varepsilon_{ijm}\ m = 1,\ 2,\ \ldots 9 \tag{1}$$

$$y_{ijm} = \begin{pmatrix} 1\ if\ y^*_{ijm} > 0 \\ 0\ otherwise \end{pmatrix}, \tag{2}$$

where y^*_{ijm} is a latent variable that captures the degree to which micro-entrepreneurs see innovation m as worth introducing. This latent variable is assumed to be a linear combination of the observed Big Five personality traits X'_{ijm}, and the unobserved characteristics captured by the stochastic error term ε_{ijm}. The vector of the parameters to be estimated is denoted by β_m. Considering the latent nature of y^*_{ijm}, the estimation is based on the observable binary y_{ijm}, indicating whether a micro-entrepreneur introduced a particular innovation in the previous three years (2019-2021).

The error terms ε_{ijm} $(m = 1,\ 2, \ldots,\ 9)$ have normal multivariate distribution, each with means of 0 and a variance-covariance matrix V, where V has 1 on the leading diagonal, and correlations $p_{jk} = p_{kj}$ as off-diagonal elements (Wainaina et al., 2016).

To quantify the marginal effects (dF/dx) of the independent variables, the probability of each innovation implementation:

$$Pr(y_{ijm} = 1) = \Phi\left(y^*_{ijm}\right),\ m = 1,\ 2,\ \ldots 9 \tag{3}$$

can be differentiated, where $\Phi(.)$ is the univariate standard normal cumulative distribution function (Lin et al., 2005).

Per Cappellari and Jenkins' (2003) recommendations, simulated maximum likelihood estimation and STATA.16.1 software were used to estimate all models.

Results

The Kendall correlation coefficients presented in Table 3 allow for the formulation of several observations. Firstly, there are correlations between particular types of innovations ($y_1 - y_9$) introduced by micro-entrepreneurs. These are positive and range from 0.239 (y_1/y_6) to 0.751 (y_2/y_3). This confirms the validity of using MVP as an estimation method. Secondly, there are statistically significant coefficients between the dependent and independent variables. However, their values for the Big Five personality traits ($x_1 - x_5$) are always below 0.27. Therefore, the interdependence is very poor. Thirdly, the coefficients among the Big Five personality variables are consistently below 0.5, and the variance inflation factors (VIF) are all below 10 (the highest observed VIF is 2.96), indicating that multicollinearity is not a concern.

Tables 4 and 5 show the MVP model estimation results. It is worth noting that the conducted likelihood ratio tests clearly indicate that the null hypothesis of zero correlation between the error terms should be rejected ($P < 0.0000$). This demonstrates that MVP is preferred over single-equation probit models.

The results also indicate that there is a strong correlation between error terms (greater than 0.7) for several types of innovations introduced by micro-entrepreneurs (Table 5). It is strongest in the case of rho41 (0.841), i.e. between innovations in logistics, delivery or distribution methods (y_4) and innovations in goods (y_1), as well as rho75 (0.820) and rho76 (0.786) - that is, between innovation in business practices for organising procedures or external relations (y_7) and methods for information processing or communication (y_5) and methods for accounting or other administrative operations (y_6). Other strong correlations are rho71, rho92, rho95, rho65, rho86, rho96 and rho83. This confirms that the various types of introduced innovations are not independent of one another (Maietta, 2015; Zastempowski, 2023) and that along with an increase/decrease in one of them, the others increase or decrease analogously.

Only two out of five micro-entrepreneurs' personality traits are statistically significant determinants explaining all categories of innovations (y_1-y_9) (Table 4). These traits are Openness to experience (x_1) and Extroversion (x_3). Conscientiousness (x_2) affects only some of the analysed innovations, i.e. two categories of product innovations (y_1 and y_2) and two of business process innovations (y_5 and y_9). The

Table 3
Correlation matrix.

Var.	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	x_1	x_2	x_3	x_4	x_5	x_6	x_7
y_1	1															
y_2	0.532**	1														
y_3	0.431**	0.751**	1													
y_4	0.429**	0.448**	0.523**	1												
y_5	0.313**	0.438**	0.550**	0.491**	1											
y_6	0.239**	0.295**	0.415**	0.412**	0.647**	1										
y_7	0.316**	0.354**	0.493**	0.420**	0.548**	0.514**	1									
y_8	0.271**	0.344**	0.470**	0.439**	0.556**	0.528**	0.687**	1								
y_9	0.454**	0.580**	0.631**	0.506**	0.526**	0.405**	0.463**	0.406**	1							
x_1	0.161**	0.178**	0.190**	0.131**	0.228**	0.177**	0.227**	0.228**	0.191**	1						
x_2	0.128**	0.136**	0.132**	0.106**	0.156**	0.108**	0.131**	0.113**	0.149**	0.316**	1					
x_3	0.153**	0.204**	0.244**	0.181**	0.263**	0.216**	0.252**	0.266**	0.211**	0.316**	0.216**	1				
x_4	0.092**	0.127**	0.157**	0.113**	0.180**	0.166**	0.174**	0.207**	0.137**	0.149**	0.003	0.438**	1			
x_5	-0.090**	-0.116**	-0.150**	-0.105**	-0.172**	-0.171**	-0.171**	-0.206**	-0.117**	-0.187**	-0.034*	-0.409**	0.427**	1		
x_{16}	0.032	0.030	0.020	0.021	-0.007	-0.003	0.003	-0.005	0.028	-0.004	0.030	-0.006	-0.027	0.014	1	
x_{17}	0.075**	-0.022	-0.024	0.097**	-0.008	0.018	0.015	0.015	0.044*	-0.036*	-0.067**	0.098**	0.157**	-0.149**	-0.031	1

* p-Value ≤ 0.05
** p-Value ≤ 0.01.

Table 4
Multivariate probit model results – Big Five personality and microentrepreneurs' innovativeness.

	Model 1 (y_1)		Model 2 (y_2)		Model 3 (y_3)		Model 4 (y_4)		Model 5 (y_5)		Model 6 (y_6)		Model 7 (y_7)		Model 8 (y_8)		Model 9 (y_9)	
	β	dF/dx	β	dF/dx	β	dF/dx	β	dF/dx	β	dF/dx	β	dF/dx	β	dF/dx	β	dF/dx	β	dF/dx
x_1	0.539**	0.027**	0.374**	0.034**	0.323**	0.035**	0.276*	0.014*	0.501**	0.051**	0.302**	0.035**	0.516**	0.051**	0.528**	0.044**	0.526**	0.039**
	(0.129)	(0.006)	(0.094)	(0.010)	(0.086)	(0.011)	(0.111)	(0.006)	(0.092)	(0.011)	(0.090)	(0.011)	(0.093)	(0.010)	(0.096)	(0.009)	(0.095)	(0.009)
x_2	0.319**	0.013**	0.239**	0.026**	0.127	0.022	0.146	0.010	0.258**	0.024**	0.154	0.015	0.149	0.013	0.032	0.003	0.267**	0.023**
	(0.106)	(0.005)	(0.078)	(0.008)	(0.069)	(0.009)	(0.093)	(0.005)	(0.076)	(0.008)	(0.072)	(0.008)	(0.074)	(0.007)	(0.075)	(0.006)	(0.081)	(0.007)
x_3	0.395**	0.019**	0.499**	0.051**	0.654**	0.076**	0.714**	0.038**	0.596**	0.065**	0.439**	0.050**	0.552**	0.059**	0.624**	0.055**	0.530**	0.049**
	(0.121)	(0.006)	(0,093)	(0.010)	(0.089)	(0.010)	(0.125)	(0.006)	(0.092)	(0.010)	(0.087)	(0.010)	(0.093)	(0.009)	(0.103)	(0.008)	(0.097)	(0.008)
x_4	-0.080	-0.005	0.077	0.005	0.044	-0.001	-0.029	-0.003	0.108	0.006	0.001	-0.003	0.021	-0.010	0.080	0.001	0.103	0.005
	(0.123)	(0.006)	(0.094)	(0.011)	(0.087)	(0.012)	(0.112)	(0.007)	(0.095)	(0.011)	(0.093)	(0.011)	(0.095)	(0.010)	(0.098)	(0.009)	(0.096)	(0.009)
x_5	-0.072	-0.002	0.017	0.000	-0.031	-0.007	0.006	0.000	0.032	-0.004	-0.163	-0.024	-0.066	-0.011	-0.161	-0.016	0.121	0.007
	(0.129)	(0.006)	(0,096)	(0.011)	(0.089)	(0.012)	(0.114)	(0.007)	(0.096)	(0.011)	(0.093)	(0.011)	(0.096)	(0.010)	(0.100)	(0.009)	(0.097)	(0.009)
x_6	0.252	0.015	0.208	0.027	0.058	0.017	0.141	0.013	-0.044	0.002	0.047	0.004	0.045	0.006	0.042	0.003	0.224	0.023
	(0.170)	(0.008)	(0.133)	(0.015)	(0.115)	(0.016)	(0.152)	(0.009)	(0.123)	(0.014)	(0.123)	(0.014)	(0.124)	(0.013)	(0.127)	(0.011)	(0.132)	(0.013)
x_7	0.048**	0.003**	-0.022	0.000	-0.025	-0.001	0.025	0.003	-0.024	0.000	-0.027	-0.001	-0.018	0.000	-0.019	0.000	0.012	0.003
	(0.017)	(0.001)	(0.015)	(0.002)	(0.014)	(0.002)	(0.016)	(0.001)	(0.014)	(0.002)	(0.014)	(0.002)	(0.014)	(0.001)	(0.014)	(0.001)	(0.014)	(0.001)
_cons	-6.499**		-6.093**		-5.543**		-6.148**		-6.816**		-4.304**		-5.861**		-5.765**		-7.393**	
	(0.948)		(0.701)		(0.638)		(0.862)		(0.704)		(0.639)		(0.683)		(0.702)		(0.735)	
Log likelihood	-2706.609																	
Wald chi^2 (63)	549.38																	
Prob > chi^2	0.0000																	

Notes: * p-Value ≤ 0.05.
** p-Value ≤ 0.01.
Standard errors in parentheses; *N* = 1848; Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho61 = rho71 = rho81 = rho91 = rho32 = rho42 = rho52 = rho62 = rho72 = rho82 = rho92 = rho43 = rho53 =
rho63 = rho73 = rho83 = rho93 = rho54 = rho64 = rho74 = rho84 = rho94 = rho65 = rho75 = rho85 = rho95 = rho76 = rho86 = rho96 = rho87 = rho97 = rho98 = 0: chi^2 (36) = 2282.68, Prob chi^2 = 0.0000.

Table 5
Multivariate probit - estimates of the correlation between the equation error terms.

rho	**rho21**	**rho31**	**rho41**	**rho51**	**rho61**	**rho71**	**rho81**	**rho91**	**rho32**	**rho42**	**rho52**	**rho62**
Coef.	0.579**	0.550**	0.841**	0.546**	0.646**	0.748**	0.404**	0.575**	0.678**	0.667**	0.303**	0.457**
Std. Err.	0.044	0.043	0.022	0.049	0.042	0.036	0.051	0.041	0.035	0.038	0.058	0.046
rho	**rho72**	**rho82**	**rho92**	**rho43**	**rho53**	**rho63**	**rho73**	**rho83**	**rho93**	**rho54**	**rho64**	**rho74**
Coef.	0.557**	0.585**	0.754**	0.361**	0.485**	0.639**	0.616**	0.700**	0.691**	0.347**	0.479**	0.631**
Std. Err.	0.044	0.042	0.027	0.051	0.045	0.037	0.042	0.032	0.034	0.054	0.043	0.035
rho	**rho84**	**rho94**	**rho65**	**rho75**	**rho85**	**rho95**	**rho76**	**rho86**	**rho96**	**rho87**	**rho97**	**rho98**
Coef.	0.615**	0.697**	0.714**	0.820**	0.466**	0.718**	0.786**	0.710**	0.701**	0.598**	0.617**	0.609**
Std. Err.	0.040	0.033	0.033	0.024	0.049	0.033	0.030	0.039	0.035	0.043	0.041	0.041

Notes: * p-Value ≤ 0.05
** p-Value ≤ 0.01.

remaining two Big Five traits, i.e. Agreeableness (x_4) and Neuroticism (x_5), have no effect.

Regarding the control variables taken into account, the size of the enterprise had a significant impact on the introduction of innovation, but only in the field of goods innovations (y_1).

Discussion

As Matz et al. (2016) indicate, "decades of psychological research suggest that individuals' behaviours and preferences are not random but driven by underlying psychological constructs: personality traits". This motivated us to pose the following research question - Does a micro-entrepreneur's personality affect their innovativeness? The results allow us to conclude that the answer is partly affirmative. Some features, namely Openness to experience (x_1), Conscientiousness (x_2) and Extroversion (x_3), have a positive impact, while some – Agreeableness (x_4) and Neuroticism (x_5) - do not, and turned out to be statistically insignificant. Therefore, it is worth looking at the results from the perspective of the two types of innovations analysed - product and business processes.

First, let us look at the results from the perspective of product innovations implemented by micro-entrepreneurs in two categories - goods (y_1) and services (y_2). Out of the Big Five personality traits (Goldberg, 1990; McCrae & Costa, 1987), three traits have a positive impact on both categories of product innovations, namely openness to experience, conscientiousness and extroversion. This means that there is no reason to reject hypotheses H_1, H_3 and H_5 ($p \leq 0.01$). In other words, looking from the point of view of marginal effects at the mean (dF/dx), micro-entrepreneurs with a higher level of openness to experience, conscientiousness and extroversion, compared to micro-entrepreneurs with a lower level of these traits, have a higher probability of introducing a product innovation (Table 4). This is the highest in the case of extraversion and implementation of service innovations (y_2) and amounts to 0.051 (dF/dx; Model 2; x_3), while the lowest is for conscientiousness and implementation of goods innovation (y_1), where it is 0.013 (dF/dx; Model 1; x_2).

In the case of business process innovations implemented by micro-entrepreneurs in the seven categories (y_3 - y_9), only two of the Big Five personality traits, namely openness to experience and extraversion, positively affect all categories of these innovations. This indicates that there is also no reason to reject hypotheses H_2 ($p \leq 0.05$) and H_6 ($p \leq 0.01$). Analysing the results from the perspective of marginal effects at the mean (dF/dx), micro-entrepreneurs with a higher level of openness to experience and extraversion have a higher probability of introducing business process innovations than micro-entrepreneurs with a lower level of these traits, (Table 4). This is the highest in two cases, namely in extraversion and implementation of

innovation from the range of methods for producing goods or providing services (y_3), where it is 0.076 (dF/dx; Model 3; x_3), and in extraversion and implementation of innovations connected with methods for information processing or communication (y_5) (dF/dx; Model 5; x_3), amounting to 0.065. The lowest value was observed for openness to experience and implementation of logistics, delivery or distribution method innovations (y_4). This amounted to 0.014 (dF/dx; Model 4; x_1).

It is also worth emphasising that conscientiousness turned out to be a significant statistical predictor of two categories of business process innovation, namely methods for information processing or communication (y_5) ($p \leq 0.01$) and marketing methods for promotion, packaging, pricing, product placement or aftersales services (y_9) ($p \leq 0.01$). In the remaining cases, the impact of conscientiousness is not statistically significant. Therefore, there are reasons to reject H_4.

The results seem to confirm previous studies indicating the positive influence of openness to experience (I. Abdullah et al., 2016; McCrae, 1987; Saatci & Ovaci, 2020; Shalley et al., 2004; Zhou & George, 2001), conscientiousness (Azami & Kaikhavani, 2017; Buchanan, 1998; Ciavarella et al., 2004; Hsieh et al., 2011) and extraversion (Ali, 2019; Azami & Kaikhavani, 2017; Eastman et al., 2001; Runst & Thomä, 2021) on various aspects of innovativeness (Ali, 2019). It is worth emphasising, however, that the conducted literature review showed that previous studies did not address the direct influence of personality traits of micro-entrepreneurs on their implementation of product or business process innovations, which is demonstrated by this study. Such studies were concerned, among others, with innovativeness measured as an element of creativity (Azami & Kaikhavani, 2017), individual innovativeness tendency (Ali, 2019), individual innovation competencies (Saatci & Ovaci, 2020), creativity (I. Abdullah et al., 2016; McCrae, 1987; Shalley et al., 2004; Zhou & George, 2001) and innovative work behaviour (H. Abdullah et al., 2019).

It is also worth adding that although previous studies have shown the existence of a relationship between agreeableness (Ali, 2019; Hsieh et al., 2011), neuroticism (Ali, 2019; Azami & Kaikhavani, 2017) and innovativeness, the presented results regarding the innovativeness of micro-entrepreneurs do not confirm such a relationship. There may be several reasons for this. Firstly, different aspects of innovation were studied (in terms of behaviours or attitudes). Our study focused on the effects of innovation processes, i.e. on specific categories of introduced innovations (products and business processes). It should be emphasised that a very wide spectrum of possible forms of innovation was taken into account based on the OSLO Manual - the foremost international source of guidelines for the collection and use of data on innovation activities in industry (OECD & Eurostat, 2018). Secondly, prior studies focused on innovativeness (in terms of attitudes) among specific groups, e.g. students (Ali, 2019) or engineers (Azami & Kaikhavani, 2017), and not, as in our study, on classic Schumpeterian innovators – micro-entrepreneurs.

It is worth considering the causes and effects of the positive impact of openness to experience, conscientiousness and extraversion on the implementation of product and business process innovations by micro-entrepreneurs.

Openness to experience – the first of the personality traits important for the innovativeness of micro-entrepreneurs - refers to an individual's willingness to embrace new ideas, explore new experiences and engage in creative thinking. A high level of this trait characterises people who are curious, imaginative and have an artistic soul (McCrae & Costa, 1990). It is considered a key determinant of an individual's adaptability and receptiveness to change. As our research shows, in the case of micro-entrepreneurs, openness to experience also has a significant and positive impact on all types of innovation they undertake (from product to business process innovations). Among the possible reasons, several issues can be pointed out.

Openness to experience fosters a curiosity-based mindset (Dyer et al., 2011), which enables micro-entrepreneurs to generate a broader range of innovative ideas. They are likely to think outside the box, be open to unconventional solutions, and seek inspiration from various sources. This ability to generate creative ideas is crucial for the success of any entrepreneurial venture (Lee et al., 2004).

It should be remembered that innovation often involves taking calculated risks (Schumpeter, 1939; Williams et al., 2020). Micro-entrepreneurs who are open to experience are generally more comfortable with uncertainty and ambiguity (Cramer et al., 2002). They are willing to take risks in implementing their innovative ideas, even if the results are uncertain. As our research shows, this propensity to take risks can lead to the development and implementation of all categories of innovations.

The business landscape is constantly changing; therefore, micro-entrepreneurs must be flexible and agile to remain competitive - they must have strong adaptability. Open micro-entrepreneurs are more flexible and adaptable in the face of changing circumstances. They are more likely to embrace new technologies, market trends and consumer preferences, enabling them to adjust their strategy and offerings accordingly.

Openness to experience is also associated with a strong learning orientation (Nasution et al., 2011). Micro-entrepreneurs with this trait will actively seek knowledge and information from various sources. They will also be more open to feedback and willing to learn from their experiences, both successes and failures. As Taleb (2012) suggests, they will become more antifragile (Taleb, 2012). It is worth emphasising that this continuous learning process increases their ability to innovate and improve business practices over time. Our research seems to confirm this.

Open individuals are often more socially outgoing and willing to engage with others (McCrae & Costa, 1990). Open micro-entrepreneurs tend to build a broader network of contacts and are more open to collaborating with others, including partners, customers, suppliers and other entrepreneurs. Research by Dyer et al. (2011) shows that networking skills are one of the critical features of disruptive innovators, and such an extensive network can provide valuable insights, resources and potential partnerships that drive innovation.

It is also worth pointing out that openness to experience may also increase the ability of micro-entrepreneurs to sense market opportunities and identify unsatisfied needs. Such entrepreneurs will be more sensitive to emerging trends and consumer requirements, which, as our research seems to indicate, allows them to develop various innovative solutions that effectively respond to these needs.

Conscientiousness - the second personality trait important for the innovativeness of micro-entrepreneurs - has a positive impact on the introduction of all categories of product innovations and two business process innovations. Conscientiousness is a feature that determines the level of organisation, perseverance and motivation at work (Stock et al., 2016). The lower the level of conscientiousness, the more disorganised a person is and the faster the onset of discouragement (Chollet et al., 2016). Its impact on implementing product innovations and some business process innovations may result from several reasons.

Conscientious individuals are characterised by strong organisation and planning skills (Chollet et al., 2016). In the context of micro-entrepreneurs, where resources are limited (Mugler, 1998; Nooteboom, 1994), the ability to manage time and resources efficiently is crucial. Conscientiousness helps micro-entrepreneurs systematically approach the innovation process, plan projects, set priorities, and execute them according to schedule.

Conscientious individuals, including micro-entrepreneurs, are also usually meticulous and pay great attention to detail (McCrae &

Terracciano, 2005). Implementing innovations requires careful testing of new products and processes so as to avoid errors and achieve high quality (Tidd & Bessant, 2018). Attention to detail allows for early detection and correction of problems, increasing the chances of success for innovative endeavours.

It is also important to note that conscientiousness is associated with perseverance in pursuing goals despite encountering difficulties (Saatci & Ovaci, 2020). Innovations often require long-term efforts and the ability to overcome many obstacles (Martínez-Román et al., 2019). Conscientious micro-entrepreneurs are more likely to continue working on innovative projects even when they face challenges, increasing the likelihood of successfully implementing novel solutions.

Innovations, especially in areas of business process innovation, often require adherence to specific standards and procedures (Plotnikova et al., 2016). Conscientiousness includes a tendency to follow rules and regulations (Abbas et al., 2018), which is essential in the context of implementing new processes and technologies within a company (Tidd & Bessant, 2018). Adhering to standards can also facilitate the certification of new products and processes, which is important for their commercialisation.

It is also worth mentioning that conscientious entrepreneurs are usually motivated to continuously improve themselves and their products or services (McCrae & Costa, 1990). This internal drive for improvement can lead to the constant search for innovative solutions and the implementation of enhancements, which is key to the long-term success of a micro-enterprise.

Finally, extroversion - the third of the personality traits important for micro-entrepreneurs' innovativeness - refers to the degree to which an individual is outgoing, sociable and seeks stimulation from the external environment (McCrae & Costa, 1990). The positive impact of this trait on all types of innovations introduced by micro-entrepreneurs may result from several phenomena.

Extroverted micro-entrepreneurs excel at networking and building relationships with others (McCrae & Costa, 1987). Unlike introverts, they feel more comfortable engaging with various stakeholders. As Dyer et al. suggest, such extensive social connections can provide them with valuable insights, market trends and potential collaborators (Dyer et al., 2011). On the other hand, by tapping into their networks, extroverted micro-entrepreneurs can also access a broader range of resources, which in turn can drive innovation in their ventures. Our results seem to confirm these observations.

As with people with a strong openness to experience, extroverts tend to be more talkative and expressive (Marcati et al., 2008), which in turn can make it easier for them to generate ideas through discussions with others. Extroverted micro-entrepreneurs will more often share their ideas, but also seek feedback from different perspectives. Such an attitude of open debate about their innovative concepts may allow extroverted micro-entrepreneurs to gather valuable insights and identify potential flaws in or improvements to their ideas before they are implemented.

Extroverted micro-entrepreneurs also seem more sensitive to social cues and customer needs. Their sociable nature allows them to interact more effectively with customers and understand their preferences, problems and desires (Zastempowski, 2024). After all, a direct relationship with customers is one of the key features of micro and small enterprises (Mugler, 1998; Nooteboom, 1994). Our research shows that the heightened market orientation of micro-entrepreneurs resulting from extroversion can lead to them developing products or services that better meet customer requirements, and thus increase the chances of successful innovation.

It is also worth noting that while innovation involves risk-taking (Schumpeter, 1939; Williams et al., 2020), it also requires resilience to bounce back from failures and setbacks. Extroverted micro-entrepreneurs are likely to be more optimistic and open-minded (McCrae & Costa, 1990), which may contribute to their ability to cope with failures and persist in their innovative pursuits. Their social support network and ability to seek help from others can also help them overcome challenges.

Conclusions

The article aimed to answer the following research question: *Does a micro-entrepreneur's personality affect their innovativeness?* Based on the Big Five theory (Goldberg, 1990; McCrae & Costa, 1987) and a broad understanding of innovations resulting from the Oslo Manual (OECD & Eurostat, 2018), the main conclusion is that in the case of micro-entrepreneurs – "a neglected part of Schumpeter's creative army" (Roper & Hewitt-Dundas, 2017, p. 559) the answer is partly affirmative. Some features, namely Openness to experience, Conscientiousness and Extroversion, have a positive impact, while some – Agreeableness and Neuroticism - turned out to be statistically insignificant. Therefore, it is worth formulating conclusions separately from the perspective of the two types of innovations analysed – product and business process.

In the case of product innovations implemented by micro-entrepreneurs, three personality traits have a positive impact. These are Openness to experience, Conscientiousness and Extroversion. In the case of business process innovations, all 7 types are positively influenced by two personality traits, namely Openness to experience and Extroversion.

The originality of the paper's contribution is manifested in the following aspects: (a) it explains the impact of micro-entrepreneurs' personality traits on specific categories of introduced innovations, (b) it covers a broad spectrum of micro-entrepreneurs' innovativeness - from product to business process innovations, and (c) it sheds new light on the innovative activity of micro-entrepreneurs, overlooked in most innovation studies.

Considering that personality traits are relatively stable (Roberts & DelVecchio, 2000), the following activities can be pointed out to micro-entrepreneurs as practical implications that may stimulate their broadly understood innovation. Since the results suggest that Openness to experience, Conscientiousness and Extroversion positively affect their product innovativeness, and Openness to experience and Extroversion impact their business process innovativeness, it is worth developing behavioural skills related to these traits. These include, among other things, questioning (e.g. provoking Question Storming or cultivating question thinking), observing (especially current or potential customers and other firms) and networking (e.g. expansion and diversity of networks, attendance at conferences, inviting outsiders). It is also worth supporting micro-entrepreneurs in terms of their education and training (workshops and courses, or mentoring programmes), and creating an appropriate work environment (e.g. implementing technologies supporting time and project management - Asana, Trello or Slack), as well as through psychological support (coaching and consulting) and personal development (e.g. reading or lifelong learning).

It should be emphasised that the research has certain limitations, which in turn indicate possible future research directions.

Firstly, it analyses the personality of micro-entrepreneurs based on the widely used Big Five theory, which is one of many methods available. Therefore, as possible avenues for further research, it is worth examining whether analyses of the personality of micro-entrepreneurs using, for example, the Myers–Briggs Type Indicator (MBTI) (Myers et al., 1985) or the HEXACO model (Ashton et al., 2014), also indicate the important role of traits related to Openness to experience, Conscientiousness and Extroversion for innovativeness. An exciting direction for further research is also to deepen the analysis of individual personality traits towards their aspects (mini-markers). As prior studies have shown (Ali, 2019;

Jirasek & Sudzina, 2020), a number of such aspects can be indicated within each trait.

Secondly, the research results are geographically limited and may only refer to micro-entrepreneurs in Poland. Therefore, it is worth extending the research scope to include other countries with different cultures and levels of economic development.

CRediT authorship contribution statement

Maciej Zastempowski: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

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