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Do the regional population traits drive innovation activity?

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Abstract
The study provides unique insights into the role of prevailing personality traits in shaping regional innovation activity. It covers the period of 2017–2022 and includes fourteen Czech NUTS III regions. The multivariate regression analysis tests the relationship between selected population traits obtained from the 16Personalities survey, specifically Extraverted over Introverted (Extraversion), and Feeling over Thinking (Agreeableness), and regional innovation activity measured through patent applications and granted patents. The results, also controlled for other previously identified determinants of innovation, show that in the regions with more Introverted and Thinking individuals, the innovation activity, measured by both indicators, is higher. This finding extends the observations from the individual-level studies, showing that these traits are more likely associated with innovation behaviour. The study expands the existing research on the role of innovation culture by using 16Personalities survey data at the regional level and arguing their statistical significance in shaping innovation activity.

Keywords: innovation, patents, patent applications, traits, 16Personalities, introvert, thinking, Czech Republic
JEL Classification Codes: O18, O3

1. Introduction

The current research on regional innovation ecosystems and innovation activity seeks to further explore the role of population characteristics, psychological profiles, and other human characteristics in shaping regional innovation performance (Lee, 2017; Obschonka et al., 2023; Mewes et al., 2023; Reher et al., 2024). Obschonka et al. (2023) and Mewes et al. (2023) report the findings from the United States context on the baseline of the Big Five Personality traits model, i.e., Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. The

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authors aggregated the survey data at the level of cities and used data from the years 2000-2015. The main takeaway from their studies is that cities, where respondents scored higher in openness, tend to report a small but positive correlation with patenting activity. By connecting individual-level psychological research with spatial and regional sciences, the authors claim to provide a multidisciplinary approach towards understanding innovation performance, assuming that the local populations differ in psychological traits, yet more research in this direction is needed.

For instance, Reher et al. (2024) responded to this emerging call by offering insights from the German Socio-Economic Panel data and the Big Five Project. The main results from the county-level analysis again support the relevance of Big Five personality traits as an additional proxy measure of innovation culture, despite only extraversion being statistically significant, thereby expanding on the pioneering study of Lee (2017), which examined the United Kingdom. Reher et al. (2024) argue that extraversion increases connectivity, networking, and collaboration, which can boost innovation performance, i.e., patent applications and granted patents.

Nevertheless, as can be seen from the above-mentioned studies, the empirical results on the role of local personality traits of the population are diverse and far from being conclusive, limited mostly to the data of the Big Five Project and the context of the United States, United Kingdom, Sweden and Germany, representing only a small group of researchers, calling for further evidence from the countries and continents that were not explored yet.

At the same time, there is a lack of theoretical framing for this research. Overall, current researchers assume that personality traits vary across regions, enabling the identification of cold and hot spots and the formulation of policy and research recommendations (Rentfrow and Jokela, 2016; Obschonka et al., 2025). Yet, some available concepts from the innovation and behavioural economics literature, such as regional innovation culture, regional innovation systems theory (Fernandes et al., 2021) and cognitive diversity (Nguyen et al., 2022), might be used to explain these variations and help explain the findings from personality maps, persistence in population traits, and overall psychological mapping.

In this way, we contribute to this scholarly discussion by providing empirical evidence from the Czech Republic, a country that underwent economic transition and is now classified as a small Central European open economy, a member state of the European Union (Dvouletý, 2019; Dvouletý and MacGregor Pelikánová, 2025). This research study provides unique insights into the role of population-level prevailing personality traits in shaping regional innovation activity from the small open economy context. The analysis covers the period 2017–2022 and includes all 14 Czech NUTS III regions, representing the whole country's geographical area. The multivariate regression analysis quantifies the relationship between selected population traits obtained from the 16Personalities survey, specifically Extraverted over Introverted (Extraversion), and Feeling over Thinking (Agreeableness), and regional innovation activity measured through patent applications and granted patents.

Our central contribution is to propose that these population-level personality traits are

closely linked to innovation culture and social capital. Specifically, we argue that higher average levels of Extraversion and Agreeableness function as proxies for more active networking, more frequent social interactions, and stronger engagement within regional populations, which, in turn, increase the likelihood of innovation outcomes. This assumption links two key dimensions of interactive processes: the quantity of interactions (Extraversion) and their relational quality (Agreeableness), manifested in open communication, idea exchange, trust, and joint problem-solving.

Compared to the existing studies, this research utilises different sources of data concerning personality traits compared to the previously published studies, and it also captures the country's institutional and economic context, which has not been empirically described yet in the previous literature. The article also addresses the issue of individual patent records extraction, encoding and adoption for regional innovation research (de Rassenfosse and Seliger, 2021), as they had to be created for the purpose of this research study.

2. Data and empirical methodology

The study aims to better understand the role of populational prevailing personality traits in shaping regional innovation activity in the Czech Republic at the fourteen NUTS III-level regions. Therefore, the first objective is to obtain regional innovation data. We work with the two commonly used proxy measures of innovation activity at the regional level: patent applications and granted patents (Katila, 2000; Paula and Silva, 2021). However, the Czech Republic does not currently have any official regional patenting data available for extraction (Picman, 2006; Mana et al., 2007), so we had to create the regional time series from the individual-level patent records.

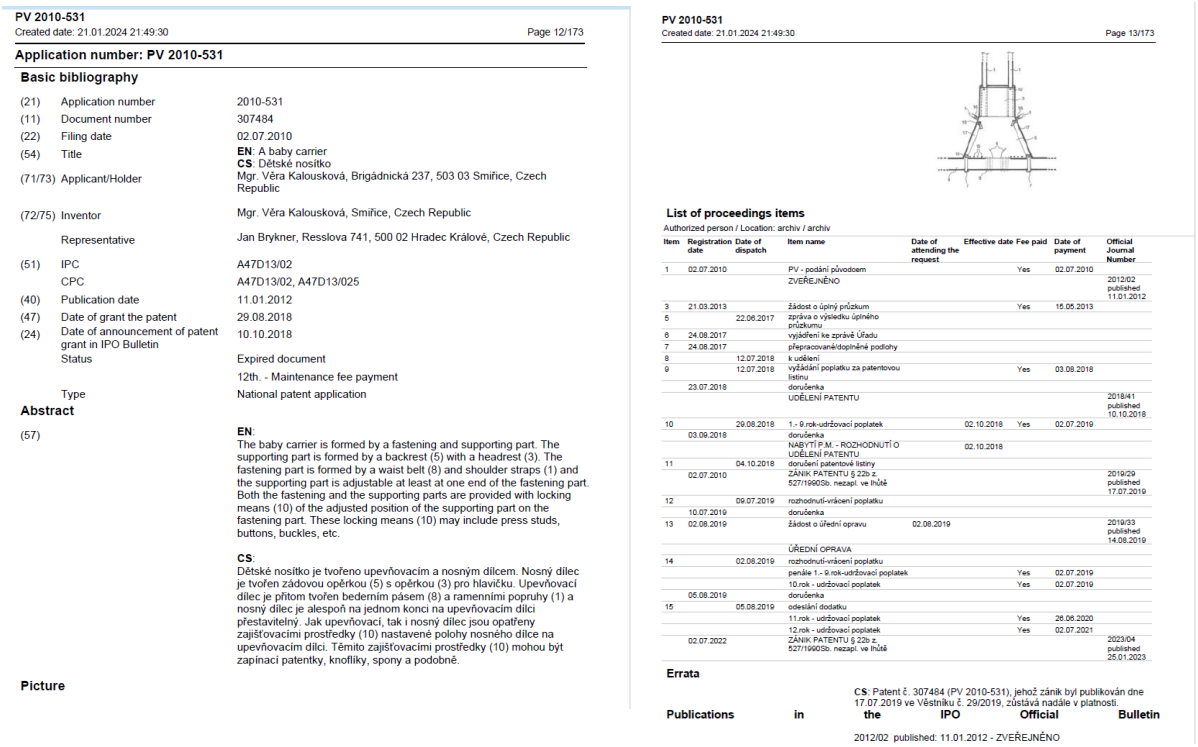
The process started in early 2024 by collecting data from the Czech Industrial Property Office (2024) online database, and the initial extraction included 32,005 individual patent records covering the years 1993-2023. Figure 1 shows a sample picture of a PDF downloaded in Figure 1 to demonstrate the available geodata and how we had to work with it further. For several months, the research team strived to scrape the data, encode it, and program the language inaccuracies and word inconsistencies to distinguish between granted patents to the Czech inventors and those from abroad. With the help of the address of the inventor placed behind individual's name (see Figure 1 again, row 72/75), we could match the administrative structure of the Czech Republic data (Czech Statistical Office, 2024a), adding to the data ZIP code and then, based on the ZIP code, we assigned the nomenclature of territorial units for statistics (NUTS) III resulting in the regional affiliation of the patent, and out of that we constructed the regional time series of the patents. When the inventor team consisted of multiple persons, we followed the first inventor's address to ensure that each patent was assigned to a region only once. The foreign inventors, i.e., those with addresses different from the Czech Republic, were excluded from the analysis. The average share of the Czech-nationality inventors is, for the available data, 46.1% on an annual basis; in absolute numbers, it is 10,958 patents out of the whole sample. In hundreds of cases, due to typos and errors, the

research team manually checked the address to mitigate situations when the patent would be assigned to the wrong region. Yet, the process is not flawless and could still contain some errors that the research team could not see/correct/fix. Similarly, with the help of an employee of the Czech Statistical Office (2024b), the research team obtained regional patent applications and additional regional control variables, including the number of inhabitants in each region, which was used as a common denominator, ensuring comparability of the variables in the regression analysis.

Inspired by the prior individual-level research on the drivers of innovation behaviour (Chatterjee, 2014; Ali, 2019; Mauroner and Zschau, 2021) and the lack of conclusive research on regional innovation culture and population traits (Petrakos et al., 2011; Georgios et al., 2021; Zemanova et al., 2022; Reher et al., 2024) served as a motivation for gaining access to regional data from the 16Personalities Personality survey (16Personalities, 2025) that reports on the website over 3 million taken tests in the Czech Republic with the regional data available from 2017 to 2024. The two key variables used from the 16Personalities Personality survey are displayed across the fourteen regions and the study period in Figure 2. Surprisingly, the data do not seem to show persistence or constant development over time, but rather a relatively similar trend across all regions. When considering the availability of other variables, our final data covers the years 2017-2022. To illustrate the survey responses coverage, the regional data for the Personality survey (16Personalities, 2025) included a total of 74,040 respondents in 2022 (highest from the capital Praha, N=22,680 and lowest from Karlovarský region, N=1,984) and a total of 131,268 respondents in 2017 (highest from the capital Praha, N=36,955 and lowest from Karlovarský region, N=2,731), which makes the regional data quite a solid source of populational traits, despite its limitations, especially the fact that the respondents fill in the survey voluntarily, so the population representativity is not ensured. For the purpose of our analysis, we explored two trait-related variables from the available survey data that are most closely related to innovation outcomes. The first captures the regional population's attitudes to be either extraverted or introverted (Extraversion). The second operationalises the average attitudes of the population responding to the survey from the specific region toward being of either a feeling or a thinking nature (Agreeableness).

Table 1 reports summary statistics for the collected variables. The control variables were collected from the Czech Statistical Office. (2024b) and their selection reflects upon the previous literature on the determinants of regional innovation performance (Oughton et al., 2002; Fritsch and Storey, 2014; Fritsch and Wyrwich, 2018; Vokoun and Dvouletý, 2025). Specifically, we include the gross domestic product (GDP) per capita in millions of the Czech Crowns (CZK) to reflect upon the economic performance of the region, which we converted to the 2015 stable prices using the GDP deflator obtained from the Czech National Bank (2024) database. The regional entrepreneurial activity is approximated through the proportion of small and medium-sized enterprises (SMEs) per economically active (15-64 years) population, and we also control for the regional innovation infrastructure by including the number of universities in the region.

Figure 1. Example of a patent PDF file extracted from the patent database



PV 2010-531
Created date: 21.01.2024 21:49:30 Page 12/173

Application number: PV 2010-531

Basic bibliography

(21)	Application number	2010-531
(11)	Document number	307484
(22)	Filing date	02.07.2010
(54)	Title	**EN**: A baby carrier **CS**: Dětské nosítko
(71/73)	Applicant/Holder	Mgr. Věra Kalousková, Brigádnická 237, 503 03 Smiřice, Czech Republic
(72/75)	Inventor	Mgr. Věra Kalousková, Smiřice, Czech Republic
	Representative	Jan Brykner, Resslova 741, 500 02 Hradec Králové, Czech Republic
(51)	IPC	A47D13/02
	CPC	A47D13/02, A47D13/025
(40)	Publication date	11.01.2012
(47)	Date of grant the patent	29.08.2018
(24)	Date of announcement of patent grant in IPO Bulletin	10.10.2018
	Status	Expired document 12th. - Maintenance fee payment
	Type	National patent application

Abstract

(57)

EN:
The baby carrier is formed by a fastening and supporting part. The supporting part is formed by a backrest (5) with a headrest (3). The fastening part is formed by a waist belt (8) and shoulder straps (1) and the supporting part is adjustable at least at one end of the fastening part. Both the fastening and the supporting parts are provided with locking means (10) of the adjusted position of the supporting part on the fastening part. These locking means (10) may include press studs, buttons, buckles, etc.

CS:
Dětské nosítko je tvořeno upevňovacím a nosným dílcem. Nosný dílec je tvořen zádovou opěrkou (5) s opěrkou (3) pro hlavičku. Upevňovací dílec je přitom tvořen bederním pásem (8) a ramenními popruhy (1) a nosný dílec je alespoň na jednom konci na upevňovacím dílci přestavitelný. Jak upevňovací, tak i nosný dílec jsou opatřeny zajišťovacími prostředky (10) nastavené polohy nosného dílce na upevňovacím dílci. Těmito zajišťovacími prostředky (10) mohou být zapínací patentky, knoflíky, spony a podobně.

Picture

PV 2010-531
Created date: 21.01.2024 21:49:30 Page 13/173

List of proceedings items

Authorized person / Location: archiv / archiv

Item	Registration date	Date of dispatch	Item name	Date of attending the request	Effective date	Fee paid	Date of payment	Official Journal Number
1	02.07.2010		PV - podání původcem			Yes	02.07.2010	
			ZVEŘEJNĚNO					2012/02 published 11.01.2012
3	21.03.2013		žádost o úplný průzkum			Yes	15.05.2013	
5		22.06.2017	zpráva o výsledku úplného průzkumu					
6	24.08.2017		vyjádření ke zprávě Úřadu					
7	24.08.2017		přepracované/doplněné podklady					
8		12.07.2018	k udělení					
9		12.07.2018	vyžádání poplatku za patentovou listinu			Yes	03.08.2018	
	23.07.2018		doručenka					
			UDĚLENÍ PATENTU					2018/41 published 10.10.2018
10		29.08.2018	1.- 9.rok-udržovací poplatek		02.10.2018	Yes	02.07.2019	
	03.09.2018		doručenka					
			NABYTÍ P.M. - ROZHODNUTÍ O UDĚLENÍ PATENTU		02.10.2018			
11		04.10.2018	doručení patentové listiny					
	02.07.2010		ZÁNIK PATENTU § 22b z. 527/1990Sb. nezapl. ve lhůtě					2019/29 published 17.07.2019
12		09.07.2019	rozhodnutí-vrácení poplatku					
	10.07.2019		doručenka					
13	02.08.2019		žádost o úřední opravu	02.08.2019				2019/33 published 14.08.2019
			ÚŘEDNÍ OPRAVA					
14		02.08.2019	rozhodnutí-vrácení poplatku					
			penále 1.- 9.rok-udržovací poplatek			Yes	02.07.2019	
			10.rok - udržovací poplatek			Yes	02.07.2019	
	05.08.2019		doručenka					
15		05.08.2019	odeslání dodatku					
			11.rok - udržovací poplatek			Yes	26.06.2020	
			12.rok - udržovací poplatek			Yes	02.07.2021	
	02.07.2022		ZÁNIK PATENTU § 22b z. 527/1990Sb. nezapl. ve lhůtě					2023/04 published 25.01.2023

Errata

CS: Patent č. 307484 (PV 2010-531), jehož zánik byl publikován dne 17.07.2019 ve Věstníku č. 29/2019, zůstává nadále v platnosti.

Publications in the IPO Official Bulletin

2012/02 published: 11.01.2012 - ZVEŘEJNĚNO

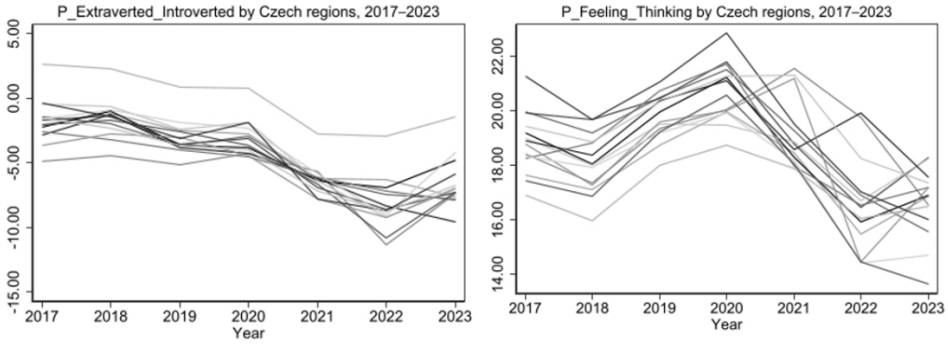
Notes: This figure is extracted from the Czech Industrial Property Office (2024) Database.

Table 1. Descriptive statistics of collected variables

Variable/indicator	Mean	Standard deviation	Minimum	Maximum	Number of Observations
Patent Applications per ths. inhabitants	0.05	0.04	0.00	0.18	84
Patents per ths. inhabitants	0.04	0.02	0.00	0.10	84
16P_Extraverted_Introverted	-3.98	2.89	-11.36	2.61	84
16P_Feeling_Thinking	18.86	1.77	14.40	22.85	84
Real GDP per capita	440,087.40	183,786.40	287,852.60	1,137,899.00	84
SMEs per population 15-64 years	0.04	0.01	0.03	0.09	84
Number of Universities	4.30	7.34	0.00	31.00	84

Notes: Own calculations in STATA 14 software..

Figure 2. 16Personalities survey traits plotted across the Czech regions and over time



Notes: Own calculations in STATA 14 software..

3. Analysis and results

The main objective of the empirical analysis is to explore the role of population-level prevailing personality traits in shaping regional innovation activity. We do so by conducting a quantitative regression analysis of the collected panel dataset, a standard approach in regional economics and innovation literature (Fagerberg et al., 2010; Zhang et al., 2016; Hunady et al., 2017; Kadlec et al., 2023; Georgescu and Kinnunen, 2024). The dataset is fully balanced; it covers fourteen Czech NUTS III regions for the years 2017-2022. We work with the two dependent variables measuring innovation activity at the regional level, i.e., patent applications and granted patents, expressed per thousand inhabitants. The main variables of interest are two survey-aggregated measures of population traits, testing whether more extroverted or introverted and more feeling or thinking inhabitants drive the Czech regional innovation activities. In addition, we include in our multivariate analysis economic performance measured via real GDP per capita, a proxy of entrepreneurial activity expressed as SMEs per economically active population, the number of universities and a set of zero-one variables for each of the regions, capturing the remaining potential sources of regional heterogeneity.

Regression analysis results are reported in Table 2, which includes four estimated models, precisely two for each dependent variable. All four estimated models are statistically significant, as shown by the results of the Chi-square tests of model significance. The most important finding from the econometric analysis is that the more extroverted the population of the region, on average, the more patent applications (Model 1) and granted national patents (Model 3) the region produces. We also find that the more thinking over feeling the regional population is on average (more agreeable), the more patent applications (Model 2) and more granted national patents (Model 4) the region has. This supports the stated assumptions of individual-level studies that individual traits can be important drivers of innovation performance, also at the regional (aggregated) levels, and another proxy for innovation culture, active networking and regional social capital accumulation (Petrakos et al., 2011; Georgios et al., 2021; Zemanova et al., 2022; Reher et al., 2024).

The estimated coefficients for the remaining variables also expand the regional knowledge of the innovation ecosystem in Central and Eastern Europe (Kostić and Květoň, 2022; Marešová et al., 2022). Specifically, we emphasise the role of universities in positively affecting regional innovation performance, serving thus as knowledge brokers and research and development workspaces, fostering innovation in the Czech regions. While we find a statistically significant impact of the GDP per capita on patenting activity, we must acknowledge that the direction of the impact observed over the studied period was negative for both patent applications and granted patents. This could possibly be explained by a relatively short time period of analysis or alternatively, double-sided causality between the regional economic development and patenting, arguing that there needs to be some time (1-5 years) to see the economic benefits of productive technological innovation advancement, transferred into the higher economic performance of the region or that innovation activity is boosted in the developing regions, offering more favourable conditions for boost of the regional innovation activity (Ćudić, 2021; Domazet et al., 2022; Liu et al., 2024). In line with the previous research conducted by Vokoun and Dvouletý (2025), we also find the importance of SMEs in shaping innovation activity. However, while we observe positive effects of SME activity in the region on the granted patents (expected and in line with Vokoun and Dvouletý, 2025), we report a negative effect on patent applications. We can only speculate on the reasons for this negative association. Still, one available justification is that SMEs, on average, face relatively high costs for applying for patent protection, so they might apply less compared to the larger companies. Also, not all SMEs are bearers of innovation, and in many regions, enterprises do not conduct research and development activities (Ehrenberger et al., 2015; Wadhwa et al., 2017; Civelek et al., 2021). Yet these potential reasons are yet to be further explored by future research, as this was not the main aim of this study.

4. Conclusion

A better understanding of regional innovation culture as a set of population mindsets, traits, attitudes, values, and norms is an ongoing research stream requiring additional insights (Fritsch and Wyrwich, 2018; Kraus et al., 2021; Ponta et al., 2021; Costantini et al., 2023). Several scholars have recently turned their attention toward populational traits (Lee, 2017; Obschonka et al., 2023; Mewes et al., 2023; Reher et al., 2024; Obschonka et al., 2025) by studying especially the Big Five Personality Traits model in shaping the regional innovation performance, measured through the patent applications and patents granted within a specific context. The above-mentioned literature argues that the personality traits within the particular region can drive spillovers of innovation.

The analysis conducted in the Czech context, covering the period 2017–2022, offers another perspective on this debate by finding that, on average, in regions with more Extroverted and Thinking (Agreeable) individuals, innovation activity, measured by patent applications and granted patents, is higher. We used these two traits as proxies for active networking (social capital) and innovation culture, and the findings could be aligned with the some of the

individual-level research, ongoingly debating about the role of Big Five personality traits on the creativity and innovation performance (Jirásek and Sudzina, 2020; Kao and Chiou, 2020; Wolniak, 2022; Arun Kumar and Lavanya, 2024). Specifically, we assume that more frequent interactions foster the establishment of new connections (Extraversion), promote open and trustworthy communication (Agreeableness), and lead to idea exchange, joint problem-solving, and the creation of new ideas and inventions. Additionally our findings could be linked with the literature arguing that innovation requires, in the Czech context, more deep thinking, effective processing of the relevant information, its critical evaluation and active networking (Dyer et al., 2019), considering innovation more as an outcome of the extensive learning process and active communication (Beckman and Barry, 2007; Durham, 2024; Almeida et al., 2026).

However, this would require a more extensive analysis of regional conditions and additional control variables, preferably at even lower administrative levels, such as cities and districts, which was not currently possible due to the lack of data. For example, Reher et al. (2024) controlled their analysis for the local research and development spending across the private and public sectors, while our own analysis covered only the presence of universities. This is certainly a limitation of this research, recommending future studies to control the presence of innovation infrastructure, especially local incubators, innovation centres, innovation hubs, science parks and accelerators (Dvouletý et al., 2018; 2023). More insights concerning the interaction between the type of prevailing industry and the specific region (Weidner et al., 2023) would better clarify the intersections between innovation performance and entrepreneurial activity, which was controlled in this analysis by SMEs, without considering their economic activity. This would be particularly interesting to study in relation to the regional smart specialisation strategy implementation (RIS3), which is being implemented in the country to foster regional competitiveness and innovation performance (Stejskal et al., 2018; Prokop et al., 2021; Hájek et al., 2021; But et al., 2025). Additional variables worth further investigation, discussed in the pioneering work of Lee et al. (2017), include the operationalisation of regional ethnicity and religiosity operationalisation. Lastly, we propose including control variables reflecting the physical infrastructure, such as high-speed internet and logistics availability, and the structure of regional transport, i.e., the density of roads and railways (Acheampong et al., 2022).

Lastly, we would like to remind our readers that working with the 16Personalities Personality survey data offers novel insights but also raises several issues regarding the data's representativeness across the populations of the Czech regions. Due to the lack of demographic weights and survey data on respondents' basic characteristics (such as age and gender), the research team could not provide weighted (and corrected) findings that better reflect population-level personality traits and yield more balanced results. A longitudinal perspective with more years of data and additional variables would ensure more stable findings and offer the use of additional panel-data tailored analytical approaches, such as panel vector autoregressive models (PVAR) that would allow modelling of the dynamic responses to the

changes of aggregated population traits in the Czech regions.

Table 2. Regression analysis results

Model number	**(1)**	**(2)**	**(3)**	**(4)**
Independent/dependent variable	***Patent Applications per ths. inhabitants***	***Patent Applications per ths. inhabitants***	***Patents per ths. inhabitants***	***Patents per ths. inhabitants***
16P_Extraverted_Introverted	2.192**		0.00141***	
	(0.790)		(0.000301)	
16P_Feeling_Thinking		1.343*		0.00179*
		(0.549)		(0.000751)
Real GDP per capita	-0.000273***	-0.000237***	-0.000000299***	-0.000000242**
	(0.0000154)	(0.0000587)	(2.86e-09)	(7.47e-08)
SMEs per population 15-64 years	-1477.7***	-2614.3***	5.817**	4.555***
	(211.8)	(739.8)	(1.944)	(0.189)
Number of Universities	1.715***	5.855***	0.00328*	0.00616***
	(0.382)	(0.994)	(0.00137)	(0.000523)
Jihočeský region	73.27***	62.59***	-0.0315	-0.0358***
	(0.554)	(1.593)	(0.0271)	(0.000464)
Karlovarský region	-40.04***	-28.21***	-0.0109	-0.00106
	(1.756)	(2.397)	(0.0121)	(0.00482)
Královéhradecký region	27.44**	37.76***	0.0446***	0.0504***
	(8.583)	(2.924)	(0.000318)	(0.00522)
Liberecký region	2.560***	13.89***	0.0576***	0.0656***
	(0.548)	(0.573)	(0.0106)	(0.00191)
Moravskoslezský region	34.86***	34.84***	0.0243**	0.0242***
	(5.981)	(1.875)	(0.00866)	(0.00218)
Olomoucký region	0.955	3.675	0.00863***	0.0106***
	(4.348)	(4.042)	(0.000873)	(0.00159)
Pardubický region	8.389	18.08***	0.0333*	0.0396***
	(8.260)	(3.173)	(0.0140)	(0.00421)
Plzeňský region	13.74	20.82***	0.0484***	0.0518***
	(10.16)	(4.517)	(0.0121)	(0.000650)
Praha region	388.2***	328.6***	-0.128	-0.166***
	(16.55)	(25.23)	(0.133)	(0.0352)
Středočeský region	62.17***	66.51**	0.0630***	0.0637***
	(0.232)	(20.37)	(0.00839)	(0.00594)
Vysočina region	-23.56***	-19.63***	0.0246	0.0274***
	(1.595)	(2.230)	(0.0150)	(0.00321)
Zlínský region	-14.09***	-8.071	0.0444***	0.0462***
	(2.132)	(6.753)	(0.0132)	(0.000794)
Ústecký region	18.66***	28.94***	0.0276***	0.0346***
	(3.518)	(1.675)	(0.00110)	(0.00204)
Constant	185.6***	161.1***	-0.0787	-0.107***
	(4.934)	(7.117)	(0.0751)	(0.00710)
Observations	84	84	84	84
Prob > chi2	0.00	0.00	0.00	0.00
R-Squared (R2) within	0.3195	0.2080	0.4155	0.3622
R-Squared (R2) overall	0.9422	0.9327	0.8697	0.8578

Notes: Own calculations in STATA 14 software.

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