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Historical Roots of Entrepreneurial Culture and Innovation Activity—An Analysis for German Regions

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Abstract

There is a research gap with respect to understanding the role of entrepreneurial culture and tradition for actual start-up behaviour. We combine historical self-employment data (entrepreneurial tradition) with a psychological measure for entrepreneurial attitudes (entrepreneurial culture). The results reveal a positive relationship between the historical level of self-employment in a region and the presence of people with an entrepreneurial personality structure today. Our measure for a regional culture of entrepreneurship is positively related not only to the level of new business formation but also the amount of innovation activity.

JEL-classification: L26, N94, O11, O30, R11

Keywords: Entrepreneurship, self-employment, new business formation, personality traits, culture, innovation

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1. Introduction

Several recent empirical studies have found pronounced persistence of regional levels of entrepreneurial activity over longer periods of time.[1] In the case of Germany, Fritsch & Wyrwich (2014; 2017) find that regions with higher levels of self-employment before WWII have higher levels of new business formation today. The multiple disruptive shocks that impacted Germany in the period of analysis clearly exclude an explanation that builds on persistence of the regional determinants of self-employment and new business formation. The authors presume that the prevalence of a regional culture of entrepreneurship is an alternative explanation of the effect of historical self-employment on current rates of new firm formation.

We extend the work of Fritsch & Wyrwich (2014; 2017) in two ways. First, we introduce a psychological measure of cultural attitudes in favour of entrepreneurship—which is the entrepreneurial personality fit of the local population today—and investigate its link to current levels of new business formation. Second, we analyse the relationship between historical entrepreneurship, the entrepreneurial personality fit of the local population, and innovation activity today.

We find a significant positive relationship between the levels of historical self-employment in a region and the entrepreneurial personality fit of the local population. This indicates that areas with an entrepreneurial tradition are marked by cultural attitudes in favour of entrepreneurship today. Based on this observation, we show that variation in the average entrepreneurial personality fit across regions that is due to historical differences in self-employment has a positive effect on current entrepreneurship rates. Moreover, our analyses reveal a similar two-stage link for innovation activity.

The paper first gives an overview on the relationship between historical roots of entrepreneurship and entrepreneurial culture (Section 2).

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[1] Andersson & Koster (2011) for Sweden; Fritsch et al. (2018a) for the region of Kaliningrad; Fotopoulos (2014) and Fotopoulos & Storey (2017) for the UK; Glaeser, Kerr & Kerr (2015) for US cities.

The empirical strategy is introduced in Section 3. Results are reported in Section 4. The final section (Section 5) discusses limitations, offers conclusions and suggests avenues for further research.

2. Conceptual framework

2.1 The self-perpetuation of regional entrepreneurship and its implications for the emergence of an entrepreneurial culture

One important aspect of entrepreneurship culture is social legitimacy of entrepreneurs and their activities (Etzioni, 1987). Empirical research has revealed pronounced regional differences of this kind of social (Kibler, Kautonen & Fink, 2014), as well as of the local public attitude to entrepreneurship (Westlund, Larsson & Olsson, 2014). This social acceptance also implies a low stigma of failure and lower psychological costs (fear of failure) of starting a firm (e.g. Wyrwich, Stuetzer & Sternberg, 2016; 2018). Variation in social acceptance of entrepreneurship is also the narrative for explaining differences in regional entrepreneurship in case-study based research (e.g., Chinitz, 1961; Saxenian, 1994).

The acceptance of entrepreneurship within a society can be regarded as part of the informal institutions of a community, which is defined as codes of conduct as well as norms and values (North, 1994). Informal institutions in favour of entrepreneurship are the building blocks of 'culture'. According to Williamson (2000), culture belongs to the level of social structure that is deeply embedded in a population and that tends to change very slowly over long periods of time.[2]

According to a widespread belief, there is a pronounced effect of the number of entrepreneurial role models in a region on the level of acceptance or legitimacy of entrepreneurship (Andersson & Koster, 2011; Arenius & Minniti, 2005; Minniti, 2005). The main idea behind this hypothesis is that an individual's perception of entrepreneurship, his or her cognitive representation, is shaped by observing entrepreneurial role models in

[2] Another element of such a culture is social capital such as the presence of entrepreneurship-facilitating network relationships (Westlund et al., 2014).

his or her social environment. This supposedly enhances the social acceptance of entrepreneurial lifestyles, boosts entrepreneurial self-efficacy beliefs, and increases the propensity of adopting entrepreneurial behaviour. Furthermore, entrepreneurs in the local environment provide opportunities to observe and learn about entrepreneurial tasks (e.g. Minniti, 2005; Nanda & Sørenson, 2010; Bosma et al., 2012). Observing successful entrepreneurs provides potential entrepreneurs with examples of how to organise resources and activities and can lead to increased self-confidence in the sense of 'if they can do it, I can, too' (Sorenson & Audia, 2000, 443).

In this way, factual entrepreneurship, i.e. visible entrepreneurial activity in a region, creates a perceptual non-pecuniary externality that spurs additional start-up activity and makes entrepreneurship self-reinforcing. Furthermore, individuals who observe successful entrepreneurs among their peers may perceive entrepreneurship as a favourable career option (for a detailed exposition of this argument, see Fornahl, 2003). Hence, people in regions characterised by a widespread positive attitude towards entrepreneurial activities may be more likely to perceive entrepreneurship as a viable career option and to start their own business. A self-perpetuating effect of high levels of new business formation in a region stems from the fact that most new ventures remain rather small (Schindele & Weyh, 2011). Hence, high levels of start-ups in a region lead to large shares of small business employment and a high density of entrepreneurial role models. Since small firms have been found to be a fertile seedbed for future entrepreneurs, large shares of small business employment due to high levels of new business formation today may lead to correspondingly high levels of entrepreneurship in the future (Parker 2009; Elfenbein, Hamilton, & Zenger 2010).

A further self-perpetuating effect of high levels of new business formation in a region can emerge if the newcomers create additional entrepreneurial opportunities that induce further start-ups. Empirical evidence suggests that persistence of start-up rates is stronger in high-entrepreneurship areas (Andersson & Koster, 2011; Fritsch & Wyrwich,

2014). This suggests that new business formation and entrepreneurial role models accelerate future entrepreneurship, particularly in areas with high levels of entrepreneurship due to the aforementioned mechanisms of self-perpetuation.

Minniti (2005) provides a theoretical model that, based on the above-mentioned regional role-model effects, explains why regions with initially similar characteristics may end up with different levels of entrepreneurial activity. In this model, chance events at the outset of such a process may induce entrepreneurial choice among individuals that leads to different levels of regional entrepreneurship. The presence of entrepreneurial role models in the social environment reduces ambiguity for potential entrepreneurs and may help them acquire necessary information and entrepreneurial skills. In Minniti's model, this self-reinforcing effect of entrepreneurship depends critically on the ability of individuals "to observe someone else's behaviour and the consequences of it" (Minniti, 2005, 5).[3] Another mechanism contributing to self-perpetuation of regional levels of new business formation and self-employment is intergenerational transmission of entrepreneurial values (e.g. Niittykangas & Tervo, 2005; Laspita et al., 2012).

Based on the mechanisms described in this section, past entrepreneurship fosters the self-perpetuation of entrepreneurship. This implies an accumulation of resources conducive for entrepreneurship and it also triggers the emergence of an entrepreneurial culture. A regional *culture* of entrepreneurship is characterised by societal legitimacy of entrepreneurial behaviour that emerges from past entrepreneurship and past entrepreneurial role models that imply the emergence of networks and peer effects.[4] This understanding of an entrepreneurship culture has also a psychological foundation which is outlined in the following section.

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[3] In historical terms, one could also think of certain natural conditions and institutional shocks that influence the emergence of entrepreneurship (Sorenson, 2017).

[4] Regions with an entrepreneurial culture are likely to have an infrastructure of supporting services, particularly the availability of competent consulting as well as appropriate financial institutions, may also be important elements.

2.2 Entrepreneurship culture: a psychological perspective

An entrepreneurship culture can be understood 'as a positive collective programming of the mind' in favour of entrepreneurship within a certain population (Beugelsdijk, 2007, 190) or as an aggregate psychological trait (Freytag & Thurik, 2007).[5] This conceptualisation of an entrepreneurship culture follows the logic of a trait psychology approach to culture (McCrae, 2001; Hofstede & McCrae, 2004). This approach has delivered promising and replicated results in entrepreneurship research concerned with the origin and effects of regional differences in entrepreneurship (Obschonka et al., 2013; 2015; 2016; Stuetzer et al., 2016, 2017).

At the individual level, research often reveals that entrepreneurs score relatively high on the Big Five personality traits 'extraversion', 'conscientiousness', and 'openness' but score relatively low on 'agreeableness' and 'neuroticism' (Caliendo, Fossen, & Kritikos, 2014; John, Naumann, & Soto, 2008; Zhao & Seibert, 2006). Combining these five traits into an entrepreneurial profile index leads to an intraindividual entrepreneurial Big Five profile (entrepreneurial constellation of Big Five traits within the individual) that indeed predicts entrepreneurial skill growth, motivation, self-identity, intention, and behaviour at the individual level (Obschonka & Stuetzer, 2017; Schmitt-Rodermund, 2004).

One measure for the prevalence of an entrepreneurship culture that is conceptualised this way is to assess the share of people with an entrepreneurship-prone personality profile in the regional population or the deviation of the population's average personality profile from an ideal entrepreneurial personality structure. According to Rentfrow et al.'s (2008) theory on the emergence, persistence, and expression of regional personality profiles, regional differences in the share of people with an entrepreneurial mindset today may be explained by social influence within the region as people respond, adapt to, or become socialised according to regional norms, attitudes, and beliefs. Furthermore, people with an entrepreneurial mindset may tend to migrate to places where the local population has

[5] See also, Davidsson (1995) and Davidsson & Wiklund (1997).

similar personality characteristics or where they find better framework conditions and opportunities for entrepreneurial endeavours (see also Obschonka et al., 2013; 2015).

Entrepreneurship research on the conceptualisation and effects of culture has mainly focussed on broad cultural values and dimensions with mixed and often disappointingly inconsistent results (Hayton & Cacciotti, 2013). The personality approach to entrepreneurship culture based on aggregate regional values in the entrepreneurial personality profile has several advantages. It builds on an entrepreneurship-specific concept of culture—the established trait psychology approach (Hofstede & McCrae, 2004; McCrae, 2001). This approach finds considerable empirical support by individual-level research regarding the effect of such personality profiles, as well as by results at an aggregate regional level, that have indicated regional variations of personality differences in general (Bleidorn et al., 2016; Rentfrow, Gosling, & Potter, 2008; Talhelm et al., 2014).

A personality-based approach to entrepreneurship can help solve (or at least investigate) some of the most pressing questions in regional entrepreneurship research and practice such as the reasons for the persistence of regional variation in entrepreneurial activity (Obschonka et al., 2013) or different regions' reactions during and after major economic crises (Obschonka et al., 2016). At the regional level of aggregate values of individual personality scores, research found a similarly robust link between regional variation in this entrepreneurial personality profile and regional variation in regional entrepreneurial activity (Obschonka et al., 2013; 2015; 2016).

2.3 Concluding hypotheses

We argued that past entrepreneurship fosters the self-perpetuation of entrepreneurship and triggers the emergence of an entrepreneurial culture. Furthermore, the prevalence of such a culture should be reflected by local attitudes in favour of entrepreneurship that is indicated by a high share of people with an entrepreneurship-prone personality profile. Taken together, historical self-employment rates should be positively related to the preva-

lence of people with such a personality structure today. In a second step, the presence of such a people should be positively related to entrepreneurial activity today. If this two-stage relationship holds, this indicates that the presence of an entrepreneurial culture is behind the well-established empirical regularity that past entrepreneurship has a positive long-run effect on current entrepreneurial rates.

Finally, entrepreneurship in its very core includes behaviours such as creativity, recognition of opportunities, taking initiative, readiness to assume risk, and introducing new ideas, products, and services to the market. These behavioural elements are not only conducive to setting up one's own business but should also be particularly relevant for innovation activity—the process of transforming new ideas and knowledge into concrete products and services that are accepted in the marketplace. Thus, the relationship between historical self-employment and the regional share of people with an entrepreneurship-prone personality file should also positively affect innovation activity.

3. Data and measurement

3.1 Historical and current levels of entrepreneurship

The indicator for the historical level of entrepreneurship is the number of self-employed persons in the private sector divided by the total regional labour force. We use two definitions of the start-up rate in 1925. Per the first definition, we exclude self-employment in agriculture as well as homeworkers (*Heimgewerbetreibende*). Homeworkers are omitted in this first definition because homework can be regarded as a rather marginal form of self-employment, one that is often characterised by strong economic dependence on a single customer.

Self-employment in agriculture is excluded because it constitutes a rather special case that is hardly comparable to other industries. In particular, agriculture follows a traditional and well-established business model that requires qualifications and abilities that differ considerably from entrepreneurship in other sectors. One special feature of self-employment in

agriculture in the early 19th century in Germany was that farms in most German regions consisted almost entirely of family businesses that were passed on by customs of inheritance.[6] Hence, hardly any farm owner had to experience the risky process of founding and establishing his or her business. Moreover, since growth of farms was limited by available acreage, the business strategies of farmers were dominated by attempts to preserve their farms; expansion played a rather minor role, if any. In contrast, self-employment in non-agricultural parts of the economy is much more heavily related to industrialisation and economic development. Therefore, it should more positively reflect perceived role models and should be more closely associated with the generation of additional entrepreneurial opportunities than self-employment in agriculture. The second definition of the self-employment rate in 1925 only comprises these two types of self-employment—homeworkers and self-employed in agriculture. Due to the reasons mentioned above, we consider it unlikely that this group of self-employed people represents the "nucleus" that drives the self-perpetuation of entrepreneurship over time.

We also include a measure for the science-based historical self-employment rate. This is the number of self-employed in certain industries that may be regarded as being reliant on academic knowledge[7] divided by the workforce. The rationale behind this strategy is to have an indicator that disentangles high-quality entrepreneurship which could be a particularly important source for the self-perpetuation of entrepreneurship in line with our arguments presented in section 2.

The historical data are derived from a full-sample census conducted in 1925 (Statistik des Deutschen Reichs, 1927). These historical data include detailed information on the number of employees broken down by gender, industry (26 industries), and 'social status' at the level of counties (*kleinere Verwaltungsbezirke*). The variable social status distinguishes

[6] One exception is the area of northeastern Germany marked by large-scale farming businesses, which were typically run by aristocratic landowners.

[7] We classified machine, apparatus, and vehicle construction, electrical engineering, precision mechanics, optics, chemicals, as well as rubber and asbestos as science-based.

between blue-collar workers, white-collar employees, self-employed people, homeworkers, and helping family members.

Although the definition of administrative districts at that time was considerably different from what is defined as an administrative district today, it is nevertheless possible to assign the historical districts to current planning regions. The spatial framework of our analysis is comprised of the 92 planning regions of Germany,[8] which represent functionally integrated spatial units comparable to labour-market areas in the United States. If a historical district falls within two or more current planning regions, we assign employment to the respective planning regions based on each region's share of the geographical area.

The information on current levels of new business formation are from the Enterprise Panel of the Center for European Economic Research (ZEW-Mannheim). These data are based on information from the largest German credit-rating agency (Creditreform). As in the case of many other data sources on start-ups, these data may not have complete coverage of solo entrepreneurs. However, once a firm is registered, hires employees, requests a bank loan, or conducts reasonable economic activities, even as a solo entrepreneur, it is included, and its information is gathered starting from the date the firm was established. Hence, many solo entrepreneurs are captured along with the business founding date. This information is limited to the set-up of a firm's headquarters and does not include the foundation of branches. Based on these criteria, solo entrepreneurs who are not covered are likely to be of low economic significance or set up primarily out of necessity and therefore not suitable for our analysis since it is unlikely that necessity-driven entrepreneurship is promoted by the long-term self-perpetuation mechanisms described in section 2. In our empirical

[8] There are 96 German planning regions. The cities of Hamburg and Bremen are defined as planning regions even though they are not functional economic units. To avoid distortions, we merged these cities with adjacent planning regions. Further, we exclude the "Saarland" since most of its area was not under German administration in 1925. The small sample size is a limitation of the analysis.

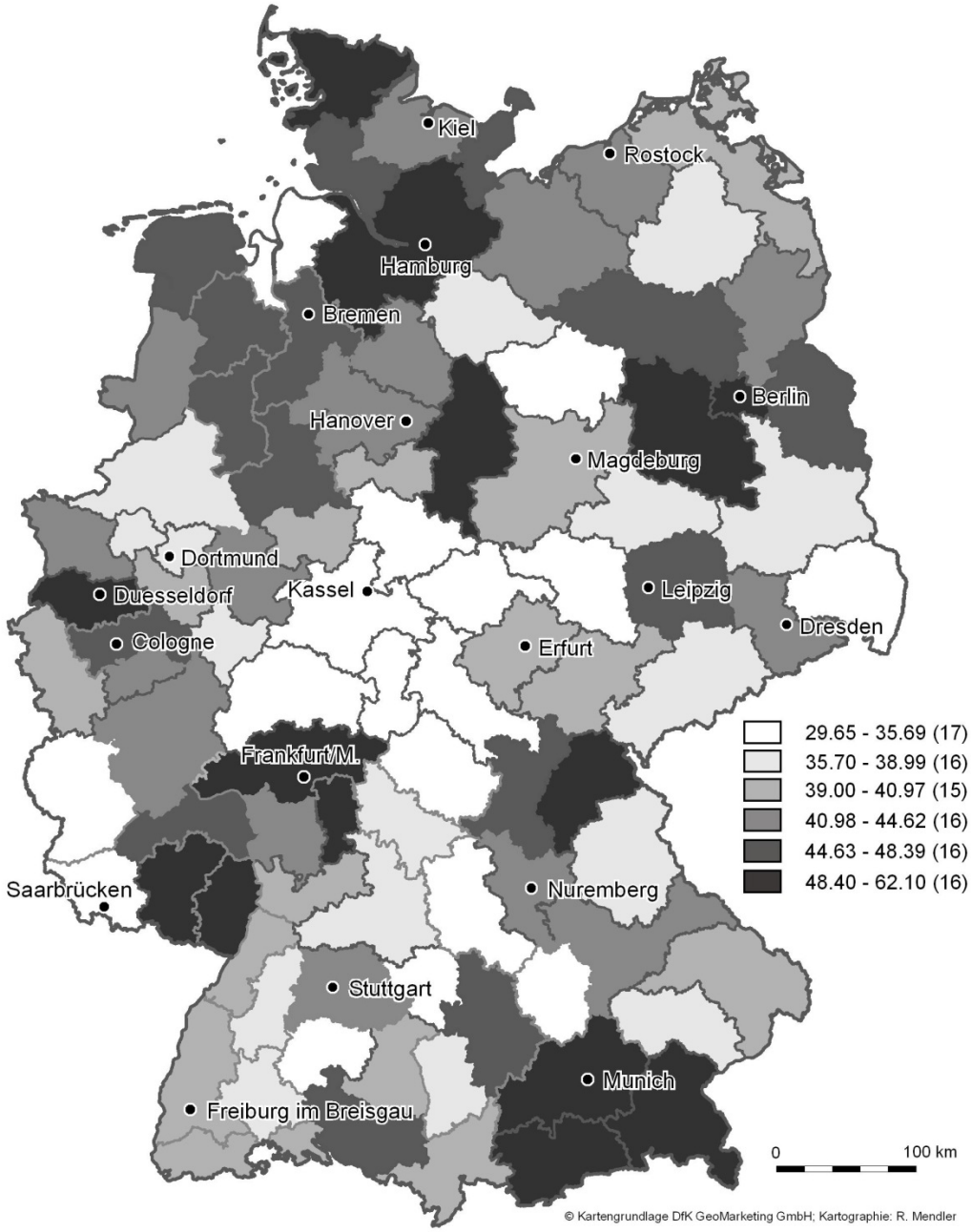

Figure 1: Average start-up rates in German regions for 2000-2016

analysis, we use the average annual number of start-ups formed between the year 2000 and the year 2016 per population in working age (in 10,000) as the main outcome variable.

On average, the ZEW data record approximately 214 thousand new businesses per year over the 2000-2013 period. 82 percent of start-ups are in the service sector while only 5 percent are in manufacturing (Bersch

et al., 2014). Figure 1 shows the average annual start-up rates in German planning regions for the period 2000-2016. We find pronounced regional differences with relatively high rates in those regions with larger cities such as Berlin, Duesseldorf, Frankfurt, Hamburg, and Munich. One reason for the relatively high start-up rates in larger cities may be that these regions have rather high shares of small-scale service firms and a high share of the new businesses (about 82%) is a service firm.[9] There is also a 'cluster' of regions with relatively low start-up rates in the centre of the country, which consists primarily of rural areas.

The self-employment rate in 1925 measures the share of entrepreneurial role models within the total regional labour force, thereby reflecting how widespread self-employment was at the time. In line with our conceptualisation in section 2, we do not regard the historical self-employment rate as such to be a measure of entrepreneurial culture. We rather argue that any effect of the historical self-employment rate on current entrepreneurship indicates the prevalence of a regional culture of entrepreneurship. The reason behind this train of thought is that Germany faced severe historical shocks over the course of the 20th century. We argue that these numerous disruptive shocks largely rule out that persistence of entrepreneurship is driven by persistence of structural determinants of entrepreneurship. Thus, only the alternative channel behind persistence, namely the local prevalence of an entrepreneurial culture, remains as a plausible explanatory factor of persistence (for details, see Fritsch & Wyrwich, 2017). A measure indicating an entrepreneurial culture that we employ in the dataset is the entrepreneurial personality profile. In the following section, we describe how we measure this profile empirically.

3.2 The entrepreneurial personality profile

In line with earlier research on the entrepreneurial personality profile, we construct an overall indicator for an entrepreneurial personality fit based on the Big Five personality traits measured at the individual level (Ob-

[9] Only about 5% of start-ups are part of the manufacturing sector.

schonka & Stuetzer, 2017). We utilise German data from the global Gosling–Potter Internet project, which collects personality data in a number of countries (http://www.outofservice.com; see Rentfrow et al., 2008, for details). Respondents indicated the extent to which they agreed or disagreed with 44 statements using a five-point Likert-style rating scale. The database for Germany consists of 73,756 respondents between 2003 and 2015. This sample can be regarded as representative for the German population (for details, see Obschonka et al., 2017; Fritsch et al. 2018b). Individual respondents were allocated to a planning region based on their current residence, specifically using their ZIP code.

Our indicator measures the deviation from the statistical reference profile of an entrepreneurial personality structure (highest scores on extraversion, conscientiousness, and openness; lowest scores on agreeableness and neuroticism). This fixed reference profile is determined by the outer limits of the single Big Five traits within an entrepreneurial personality structure (see Obschonka & Stuetzer, 2017). The individual-level entrepreneurial personality fit is the sum of the squared deviations of the individual Big Five scores from this reference profile (Cronbach & Gleser's, 1953, D^2 measure). The individual values on the profile are then aggregated to the regional level (average score based on respondents' current residence) to achieve the regional value for the local entrepreneurial culture. This index of the regional culture of entrepreneurship has a mean of 19.39 (standard deviation: 0.563) across German planning regions.

Figure 1 shows that there are quite considerable differences in the population's entrepreneurial personality profile across the German planning regions (see Fritsch et al., 2018, for a more detailed presentation). There are particularly high values for the regions of Baden-Wuerttemberg located in the south-west of the country, confirming a common prejudice regarding the area. Relatively high values can also be found for Duesseldorf, Cologne, Hamburg, Frankfurt, and Munich. Many of the regions with a low entrepreneurial personality profile of the local population have, for

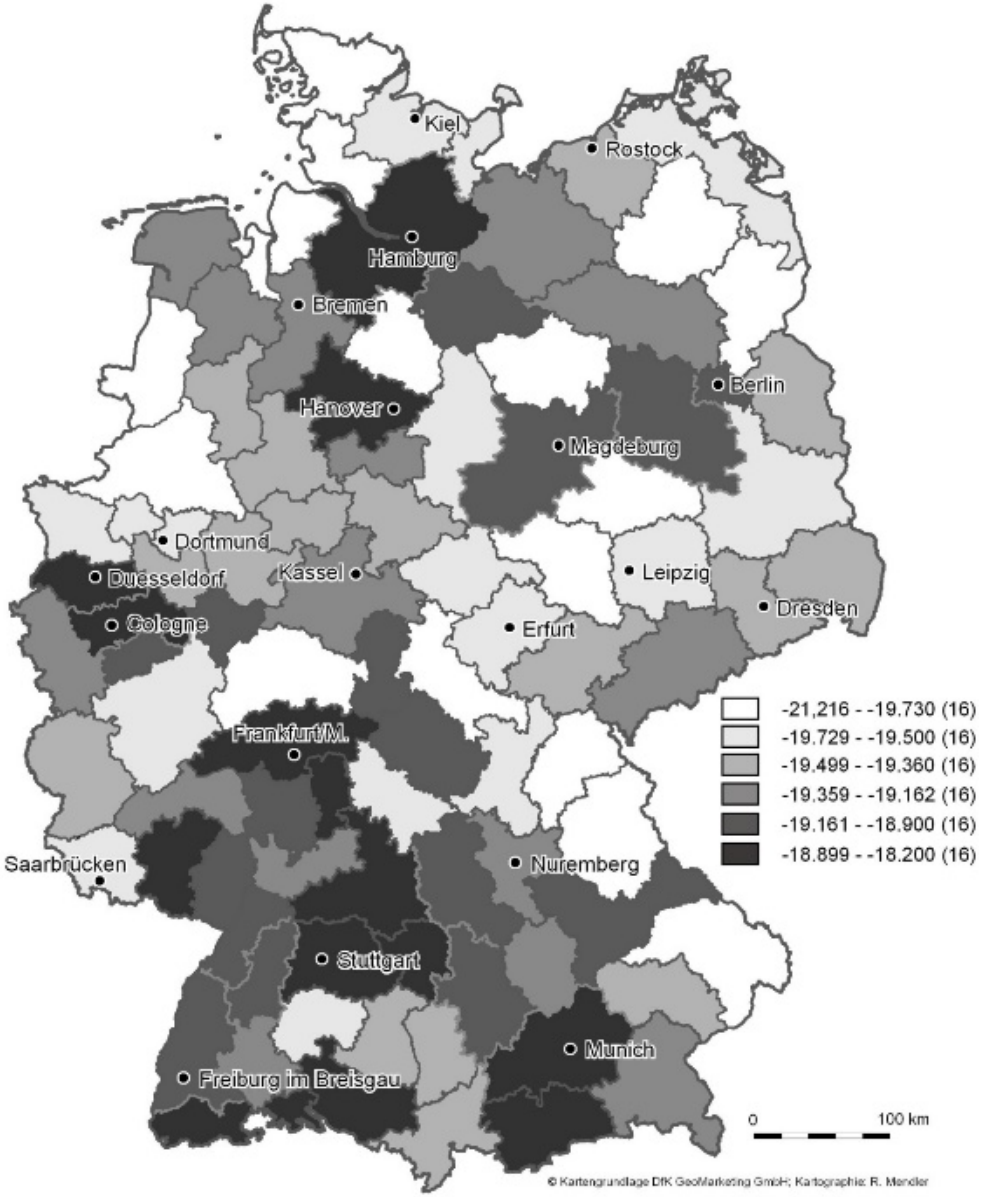

Figure 2: Regional distribution of the entrepreneurial personality profile in Germany

longer time periods, been characterised by large-scale heavy industries, such as mining and steel, confirming results for Great Britain (Stuetzer et al., 2016) and the US (Stuetzer et al., 2017). Low-level entrepreneurial personality profiles are also found in larger areas north of Berlin, south of Magdeburg and in regions east of Nuremberg.

3.3 Measures of innovation activity

We use two measures for current regional innovation activity in our analyses: the number of patents per population in working age (in 10,000) and the share of R&D employees. Patents are taken from the regional patent database (REGPAT) and are assigned to the region in which the inventor claims his or her residence. We have access to information for the years 2000 to 2012. If a patent has more than one inventor, the count is divided by the number of inventors, and each inventor is assigned his or her share of the patent. Data on the share of R&D employees are from German Employment Statistics, which covers all employees subject to compulsory social insurance contributions (Spengler, 2008). R&D employees are defined as those with tertiary degrees working as engineers or natural scientists. We have access to information for the years 2000 to 2014.

Further information is from different sources; of note are the 1925 Census and other publications from the Statistical Offices. Our indicator for the historical regional knowledge base is the presence of higher education institutions that existed already in the 19th century. We distinguish between 'classical' universities, technical universities, and higher commercial schools (*Hoehere Gewerbeschulen*).[10] We form three distance-based measures indicating the minimum distance to a region hosting a classical university or technical university. We also consider higher commercial schools. The indicator is set to zero if the region hosted a respective higher education institution. Classical universities, technical universities, and higher commercial schools represent the regional knowledge base, which, according to the knowledge-spillover theory of entrepreneurship (Acs et al., 2009), may stimulate regional new business formation. Since knowledge is typically regionally bounded, distance to these historical knowledge centres should matter.

[10] For details on the role of different types of higher education institutions for (persistent) entrepreneurship and innovation, see Fritsch & Wyrwich (2018).

3.4 Controls

Because German Federal States are an important level of policymaking, we include dummy variables for Federal States in all models to control for their influence. Population density, in turn, is supposed to account for a variety of factors such as agglomeration economies, wages, and land prices, which are closely correlated with population density.

The employment share of manufacturing controls for the sectoral structure of the regional economy. For these variables, we use the values for the year 1925 in the main models and not a more current period in order to minimise concerns that these controls could directly influence the level of new business formation in the years 2000-2016. However, we also provide robustness checks with current controls. It should, however, be noted that most of the historical control variables show high correlations with current values (see Fritsch & Wyrwich, 2018). Table A1 in the Appendix summarises the definition of variables, Table A2 provides descriptive statistics, and Table A3 shows correlations between variables.

4. Results

4.1 Historical self-employment, entrepreneurial personality profile, and new business formation today

Comparing the historical self-employment rate without including agriculture and homework to the regional level of new business formation in the 2000-2016 period reveals a pronounced positive relationship (Table 1, columns I and II).[11] The self-employment rate in science-based industries is also positively related to the overall level of new business formation today (Table 1, column III).

[11] The correlation coefficient between these two variables is 0.36 and is statistically significant at the 5% level (see Table A3 in the Appendix).

Table 1: Relationship between self-employment 1925, entrepreneurial personality fit of today's population, and current new firm formation (OLS regression)

	Start-up rate						Entrepreneurial personality fit						Start-up rate	
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
SER 1925, excl. agriculture & homeworkers	0.366***	0.379***					1.110***	1.225**						
	(0.114)	(0.106)					(0.384)	(0.484)						
SER 1925, science-based industries			0.261***	0.215***					0.769***	0.829***				
			(0.067)	(0.068)					(0.184)	(0.209)				
SER 1925, homeworkers & farmers					-0.091***	-0.040					-0.095	0.116		
					(0.033)	(0.061)					(0.090)	(0.189)		
Entrepreneurial personality fit													0.108***	0.078**
													(0.035)	(0.033)
Controls	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
R^2	0.414	0.549	0.492	0.564	0.438	0.502	0.356	0.421	0.419	0.465	0.312	0.372	0.438	0.537

Notes: N=92. OLS regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **statistically significant at the 5% level; *: statistically significant at the 10% level. All continuous variables are log transformed (except for entrepreneurial personality fit, which assumes negative values). All models include dummies indicating the Federal State the planning region is locates in. Constants are not shown for brevity

The relationship between current levels of new business formation and the share of homeworkers and self-employed people in agriculture in the year 1925 is, however, negative (Table 1, columns V and VI). These different results for the two versions of the self-employment rate clearly indicates that homeworkers and self-employed in agriculture are not relevant for the self-perpetuation of entrepreneurship. The reason for the non-significance of homeworkers could be that most of them were more or less dependent on a single main customer and did not perform many of the tasks, such as marketing, management etc., that characterise entrepreneurship. The non-significance of historical self-employment in agriculture confirms the preconceived notion that farm owners make up a rather special case with regard to their business model, as well as their qualifications and abilities, that differs considerably from entrepreneurship in other sectors.

In line with findings documented in previous research (Fritsch & Wyrwich, 2014; 2017), we find that the positive relationship between the narrowly defined self-employment rates and current levels of new business formation is rather robust if a number of controls are included (columns II and IV in Table 1). In contrast, the historical self-employment rate for farmers and homeworkers is negatively related to new business formation (model VI in Table 1).

Comparing the self-employment rate that excludes agriculture and homeworkers in the year 1925 with the entrepreneurial personality fit of today's population, we find a significantly positive relationship even when a set of control variables is included. A similar pattern is found for the self-employment rate in science-based industries. There is no statistically significant relationship between the historical level of homeworking and self-employment in agriculture and the entrepreneurial personality fit (Table 1, columns VII to XII). This result clearly indicates that the historical level of self-employment excluding agriculture and homework is a source of the emergence of a regional entrepreneurial culture in the sense of an aggregate psychological trait of today's population. There is no robust relation-

ship between the control variables, new business formation and the entrepreneurial personality fit. Finally, we also find that the entrepreneurial personality fit of the local population is positively related to the start-up rate (Table 1, columns XIII and XIV). The results for our main variables of interest are not affected by including historical controls. Thus, any potential multicollinearity between historical levels of self-employment and the historical controls is no issue.[12]

4.2 Historical self-employment, entrepreneurial personality profile and innovation activity today

We use the share of R&D employees in the regional workforce and number of patents per member of the working population as outcome variables reflecting regional innovation activity today. We regress these measures on historical self-employment rates and on the entrepreneurial personality structure that we regard as an indicator for the presence of a regional culture of entrepreneurship today.

The results of Table 2 show a clear statistically significant relationship between the historical self-employment rate and our two measures of regional innovation activity when no regional controls are considered (columns I, III, V, VII). This relationship becomes, however, insignificant for R&D employment when regional controls are included (columns II and IV) and it is only weakly significant for patenting when the general historical self-employment rate is employed (column VI). There is still significant effect with regional controls when instrumenting the personality fit with the historical science-based self-employment rate.[13]

[12] The mean variance inflation factor (VIF) is only about 1.52 in the full specification. The coefficient estimates for control variables are shown in the Appendix (Tables A4 and A5).

[13] Including the employment share in manufacturing in 1925 leads to the insignificance of historical self-employment and the entrepreneurial personality fit. The mean VIF with the manufacturing control of 1.52 clearly indicates that multicollinearity is no issue here.

Table 2: Relationship between self-employment 1925, entrepreneurial personality fit, and innovation activity today (OLS regressions)

	Employment share of R&D employees				Patent rate				Employment share of R&D employees		Patent rate	
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
SER 1925, excl. farmers & homeworkers	0.753**	0.192			1.831***	0.863*						
	(0.299)	(0.253)			(0.494)	(0.464)						
SER 1925, science-based industries			0.660***	0.154			1.661***	1.012***				
			(0.158)	(0.117)			(0.252)	(0.222)				
Entrepreneurial personality fit									0.179**	0.040	0.611***	0.459***
									(0.072)	(0.054)	(0.163)	(0.148)
Controls	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
R^2	0.319	0.705	0.424	0.708	0.660	0.786	0.755	0.815	0.687	0.812	0.315	0.704

Notes: N=92. OLS regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **statistically significant at the 5% level; *: statistically significant at the 10% level. All continuous variables are log transformed (except for entrepreneurial personality fit, which assumes negative values). All models include dummies indicating the Federal State the planning region is locates in. Constants are not shown for brevity

Taking the entrepreneurial personality fit as an indicator of a regional culture of entrepreneurship, we also find a positive and statistically significant relationship with current innovation activities. In the case of the share of R&D employment, regional differences in the entrepreneurial personality structure do not remain statistically significant when the controls for regional conditions are added (Table 2, columns IX to XII).

We find a negative of relationship between geographic distance to a technical university that existed already before 1900 and today's innovation activity. Distance to a classical university has a somewhat weaker negative effect on R&D employment. It also has a less pronounced negative relationship with patenting. These results suggest that there is also persistence in the regional presence of relatively high levels of innovation activity. Historical population density is positively related to R&D employment today and there is a positive relationship between the employment share in manufacturing in 1925 with both measures of current innovation activities (Tables A6 and A7).

4.3 Instrumental variable approach

Based on the findings of Tables 1 and 2 as well as the two-stage relationship proposed in Section 2, we transform the analysis into a two stage least square instrumental variable approach (2SLS IV) where the historical self-employment rate is taken as an instrument for the share of people with an entrepreneurship-prone personality profile. In the second stage, the variation in the local personality structure that is due to historical differences in entrepreneurship is used to explain regional differences in new business formation today (Table III, columns I to IV, for a similar application see Fritsch & Wyrwich, 2017).[14] Since historical self-employment in

[14] In their approach historical entrepreneurship is used as an instrument for current new business formation. Regional employment growth was the dependent variable in the second stage.

Table 3: Relationship between self-employment 1925, the entrepreneurial personality fit of today's population, and start-up rates/ innovation activities today: 2-SLS IV regressions (Second stage)[15]

Dependent variable:	Start-up rate				Employment share of R&D employees		Patent rate	
Instrument:	SER 1925, excl. farmers & homeworkers		SER 1925, science-based industries		SER 1925, science-based industries			
	I	II	III	IV	V	VI	VII	VIII
Entrepreneurial personality fit	0.329***	0.309***	0.339***	0.259***	0.858***	0.186	2.159***	1.221***
	(0.109)	(0.117)	(0.091)	(0.086)	(0.236)	(0.119)	(0.486)	(0.282)
Controls	N	Y	N	Y	N	Y	N	Y
First Stage F-Statistics	8.34***	6.40**	17.58***	15.77***	17.58***	15.77***	17.58***	15.77***
R^2	0.086	0.189	0.055	0.324	0.315	0.681	0.283	0.723

Notes: IV regression second stage. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **statistically significant at the 5% level; *: statistically significant at the 10% level. All continuous variables are log transformed (except for entrepreneurial personality fit, which assumes negative values). ll models include dummies indicating the Federal State the planning region is locates in. Constants are not shown for brevity. The coefficient estimates for the first stage regressions are the same for the respective OLS regressions presented in Table 1. The standard errors are only slightly different.

[15] Full tables with coefficient estimates for control variables are provided in the Appendix (Table A8 and A9).

agriculture and homework is also never statistically significant in our further analyses, we do not present the results for this group.

The estimates of the 2SLS IV approach confirm the OLS analysis. In a nutshell, the entrepreneurial personality profile of a region that is due to historical differences in entrepreneurship is positively related to current-levels of new business formation. Assessing the first stage F-Statistics reveals that the relationship is more pronounced for science-based historical entrepreneurship.[16]

As for new firm formation, we transform the analysis into a 2SLS IV estimation approach (Table 3, column V to VIII). The only difference is that our measures for innovation activities are the dependent variables in the second stage of the estimation. We also restrict the analysis to models with historical science-based entrepreneurship as an instrument for the entrepreneurial personality fit because we showed in the previous section that the first-stage F-Statistics for the relevance of non-science-based self-employment as an instrument are much weaker.

Applying our two-stage estimation procedure reveals that there is a positive effect of the entrepreneurship-prone personality profile on patenting activity but no significant relationship with the share of R&D employment. We cautiously interpret this finding as evidence that the relationship between entrepreneurship culture and innovation activity is more robust for innovation output (patents) than for innovation input (share of R&D employees).[17]

We conducted several robustness checks and falsification tests. First, we used the employment share of science-based industries as an

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[16] A plausible interpretation of this pattern is that science-based entrepreneurship is a cleaner measure for the self-perpetuation of entrepreneurship and the according emergence of an entrepreneurship culture. This may also explain the higher coefficient estimates in the second stage of the IV analysis. The general private-sector self-employment rate certainly includes also the necessity self-employed, which is unlikely to induce entrepreneurship-facilitating mechanisms as described in the conceptual part.

[17] There is also a higher coefficient estimate for the entrepreneurial personality fit as compared to the OLS models of Table 2. Thus, regional differences in personality structure that are rooted in historical tradition are particularly important for regional innovation activity.

instrument to test whether it is the general presence of such industries rather than science-based entrepreneurship that is behind the two-stage relationship that we revealed in the main analysis. The analysis shows that there is no meaningful relationship for entrepreneurship today when using the employment share in science-based industries. Thus, it is entrepreneurship in non-science-based industries in general that matter. For innovation activity, there is also a significant first-stage relationship for the employment share in science-based industries which is however, much smaller than for science-based entrepreneurship in the case of patenting activity. We also employed lagged historical controls for industry structure and population density from a full census conducted in 1907 (Statistik des Deutschen Reichs, 1909). Finally, instead of historical regional conditions, we considered controls for current population density, industry structure, and the regional knowledge base which is captured by the employment share of R&D employees. Our two-stage relationship is not affected by this model adjustment (see Table A10, for robustness checks).

5. Discussion and conclusions

Our investigation of histories of regional entrepreneurship, entrepreneurship culture, and innovation has led to several interesting results. First of all, self-employment in agriculture as well as marginal forms of self-employment such as homework do not have a lasting effect on entrepreneurship and on our measure for a regional culture of entrepreneurship. Second, the higher the level of historical self-employment in a region, the more pronounced the entrepreneurial personality fit of today's population is. Third, regions with higher levels of historical self-employment and a more pronounced entrepreneurial personality fit of the population have higher levels of innovation activity that may be an important driver of future growth. The second and third findings are more pronounced for past science-based entrepreneurship.

A main conclusion that can be drawn from these results is that regional entrepreneurship culture, new business formation, and innovative activities today have distinct historical roots. The transmission mecha-

nisms of an entrepreneurship culture, however, remain unknown and warrant exploration in future research. The intergenerational transmission of entrepreneurial role models among the local population might be a relevant explanation, but it is unclear to what extent such a transmission has been impaired by disruptive external shocks, such as the devastating World War II, and 40 years of a socialist regime in East Germany. One factor that needs further analysis in this regard is geographic mobility of people. Do people with an entrepreneurial mindset show a tendency to migrate to regions with a pronounced culture of entrepreneurship? Moreover, future researchers should, of course, investigate the sources of historical self-employment rates. Learning about the factors that engendered the emergence of entrepreneurship and entrepreneurial culture may be particularly helpful when it comes to developing policies for regions in which such a culture is absent.

References

Acs Z.J., Braunerhjelm, P., Audretsch, D.B., & Carlsson, B. (2009). The knowledge spillover theory of entrepreneurship. *Small Business Economics*, 32, 15–30.

Andersson, M., & Koster, S. (2011). Sources of persistence in regional start-up rates—Evidence from Sweden. *Journal of Economic Geography*, 11, 179–201.

Arenius, P., & Minniti, M. (2005). Perceptual Variables and Nascent Entrepreneurship. *Small Business Economics*, *24*, 233–247.

Bersch, J., Gottschalk, S., Müller, B., & Niefert, M. (2014). The Mannheim Enterprise Panel (MUP) and firm statistics for Germany. *ZEW Discussion Paper No. 14–104*. Mannheim: ZEW.

Beugelsdijk, S. (2007). Entrepreneurship culture, regional innovativeness and economic growth. *Journal of Evolutionary Economics*, 17, 187–210.

Bleidorn, W., Schönbrodt, F., Gebauer, J. E., Rentfrow, P. J., Potter, J., & Gosling, S. D. (2016). To live among like-minded others: Exploring the links between person-city personality fit and self-esteem. *Psychological Science*, *27*(3), 419-427.

Bosma, N., Hessels, J., Schutjens, V., van Praag, M., & Verheul, I. (2012). Entrepreneurship and role models. *Journal of Economic Psychology*, *33*, 410–424.

Caliendo, M., Fossen, F., & Kritikos, A. (2014). Personality characteristics and the decision to become and stay self-employed. *Small Business Economics*, *42*, 787–814.

Chinitz, B. (1961), Contrasts in Agglomeration: Pittsburgh and New York City, *American Economic Review*, 51, 279-289.

Cronbach, L. J., & Gleser, G. C. (1953). Assessing the similarity between profiles. *Psychological Bulletin, 50*, 456–473. doi:10.1037/h0057173

Davidsson, P. (1995). Culture, structure and regional levels of entrepreneurship. *Entrepreneurship and Regional Development*, 7, 41–62.

Davidsson, P., & Wiklund, J. (1997). Values, beliefs and regional variations in new firm formation rates. *Journal of Economic Psychology*, 18, 179–199.

Elfenbein, D.W., Hamilton, B.H., & Zenger, T.R. (2010): The Small Firm Effect and the Entrepreneurial Spawning of Scientists and Engineers. *Management Science*, 56, 659–681.

Etzioni, A. (1987). Entrepreneurship, adaptation and legitimation. *Journal of Economic Behavior and Organization*, 8, 175–199.

Fornahl, D. (2003). Entrepreneurial activities in a regional context. In: D. Fornahl and T. Brenner (Ed). *Cooperation, networks, and institutions in regional innovation systems (*pp. 38–57). Northampton, Mass.: Edward Elgar.

Fotopoulos, G. (2014). On the spatial stickiness of UK new firm formation rates. *Journal of Economic Geography*, *14*, 651–679.

Fotopoulos, G., & Storey, D. J. (2017). Persistence and Change in Interregional Differences in Entrepreneurship: England and Wales, 1921-2011. *Environment and Planning A*, 49, 670-702. DOI: 10.1177/0308518X16674336

Freytag, A., & Thurik, R. (2007). Entrepreneurship and its determinants in a cross-country setting. *Journal of Evolutionary Economic*s, 17, 117–131.

Fritsch, M., & Wyrwich, M. (2014). The Long Persistence of Regional Levels of Entrepreneurship: Germany 1925 to 2005. *Regional Studies*, *48*, 955-973.

Fritsch, M., & Wyrwich, M. (2017). The Effect of Entrepreneurship for Economic Development—An empirical analysis using regional entrepreneurship culture. *Journal of Economic Geography*, *17*, 157-189. DOI:10.1093/jeg/lbv049

Fritsch, M., & Wyrwich, M. (2018). Regional Knowledge, Entrepreneurship culture and Innovative Start-ups over Time and Space—An Empirical Investigation. *Small Business Economics*. https://doi.org/10.1007/s11187-018-0016-6

Fritsch, M., Sorgner, A., Wyrwich, M., & Zazdravnykh, E. (2018a). Historical Shocks and Persistence of Economic Activity: Evidence from a Unique Natural Experiment, *Regional Studies* (forthcoming).

Fritsch, M., Obschonka, M., Wyrwich, M., Gosling, S.D., Rentfrow, P.J. & Potter, J. (2018b). Regionale Unterschiede der Verteilung von Personen mit unternehmerischem Persönlichkeitsprofil in Deutschland – Ein Überblick (Regional differences of people with an entrepreneurial personality structure in Germany—An overview). *Raumforschung und Raumordnung/Spatial Research and Planning,* 76, 65-81. doi: 10.1007/s13147-018-0519-2

Glaeser, E., Kerr, S.K., & Kerr, W.R. (2015), Entrepreneurship and Urban Growth: an Empirical Assessment with Historical Mines. *Review of Economics and Statistics*, 97, 498-520. doi:10.1162/REST_a_00456Hayton, J. C., & Cacciotti, G. (2013). Is there an entrepreneurship culture? A review of empirical research. *Entrepreneurship & Regional Development*, *25*(9-10), 708-731.

Hofstede, G., & McCrae, R. R. (2004). Personality and culture revisited: Linking traits and dimensions of culture. *Cross-Cultural Research*, *38*(1), 52-88.

John, O.P., Naumann. L.P., & Soto, C. J. (2008). Paradigm shift to the integrative Big Five trait taxonomy: History, measurement, and conceptual issues. In: O.P. John, R.W. Robins & L.A. Pervin (Eds.), *Handbook of personality: Theory and research* (3rd ed., pp. 114–158). New York, NY: Guilford Press.

Kibler, E., Kautonen, T., & Fink, M. (2014). Regional social legitimacy of entrepreneurship: Implications for entrepreneurial intention and start-up behaviour. *Regional Studies*, 48, 995–1015.

Laspita, S., Breugst, N., Heblich, S., & Patzelt, H. (2012), Intergenerational transmission of entrepreneurial intentions, Journal of Business Venturing, 27, 414–435.

McCrae, R. R. (2001). Trait psychology and culture: Exploring intercultural comparisons. *Journal of Personality*, *69*(6), 819-846.

Minniti, M. (2005). Entrepreneurship and network externalities. *Journal of Economic Behavior & Organization*, *57*, 1–27.

Nanda, R., & Sørenson, J. B. (2010). Workplace Peers and Entrepreneurship. *Management Science*, *56*, 1116-1126. DOI: 10.1287/mnsc.1100.1179.

Niittykangas, H., & Tervo, H. (2005). Spatial variations in intergenerational transmission of self-employment, *Regional Studies*, 39, 319-332.

North, D. C. (1994). Economic performance through time. *American Economic Review*, 84, 359–368.

Obschonka, M., Schmitt-Rodermund, E., Silbereisen, R. K., Gosling, S. D., & Potter, J. (2013). The regional distribution and correlates of an entrepreneurship-prone personality profile in the United States, Germany, and the United Kingdom: A socioecological perspective. *Journal of Personality and Social Psychology, 105*(1), 104–122.

Obschonka, M., Stuetzer, M., Gosling, S. D., Rentfrow, P. J., Lamb, M. E., Potter, J., & Audretsch, D. B. (2015). Entrepreneurial regions: Do macro-psychological cultural characteristics of regions help solve the “knowledge paradox” of economics? *PLOS ONE, 10*(6), e012933. DOI: 10.1371/journal.pone.0129332

Obschonka, M., Stuetzer, M., Audretsch, D. B., Rentfrow, P. J., Potter, J., & Gosling, S.D. (2016). Macro-psychological factors predict regional economic resilience during a major economic crisis. *Social Psychological and Personality Science, 7*(2), 95-104.

Obschonka, M., Stuetzer, M., Rentfrow, P. J., Potter, J., & Gosling, S. D. (2017). Did Strategic Bombing in the Second World War Lead to ‘German Angst’? A Large-scale Empirical Test Across 89 German Cities. *European Journal of Personality, 31*(3), 234-257.

Obschonka, M., & Stuetzer, M. (2017). Integrating Psychological Approaches to Entrepreneurship: The Entrepreneurial Personality System (EPS). *Small Business Economics*. DOI: 10.1007/s11187-016-9821-y

Parker, S. (2009). Why do small firms produce the entrepreneurs? *Journal of Socio-Economics*, 38, 484-494.

Rentfrow, P. J., Gosling, S. D., & Potter, J. (2008). A theory of the emergence, persistence, and expression of geographic variation in psychological characteristics. *Perspectives on Psychological Science,*

3(5), 339–369.

Saxenian, A. (1994), Regional Advantage. Culture and Competition in Silicon Valley and Route 128, Cambridge: Harvard University Press.

Schindele, Y., & Weyh, A. (2011). The direct employment effects of new businesses in Germany revisited: an empirical investigation for 1976–2004. *Small Business Economics*, 36, 353-363. DOI 10.1007/s11187-009-9218-2

Schmitt-Rodermund, E. (2004). Pathways to successful entrepreneurship: Parenting, personality, early entrepreneurial competence, and interests. *Journal of Vocational Behavior*, *65*(3), 498-518.

Sorenson, O., & P. G. Audia (2000). The Social Structure of Entrepreneurial Activity: Geographic Concentration of Footwear Production in the United States, 1940–1989. *American Journal of Sociology*, 106, 424-462.

Sorenson, O. (2017). Regional ecologies of entrepreneurship. *Journal of Economic Geography*, forthcoming. DOI:10.1093/jeg/lbx031

Spengler, A. (2008). The Establishment History Panel. *Schmollers Jahrbuch/Journal of Applied Social Science Studies*, *128,* 501–509

Statistik des Deutschen Reichs (1909). *Gewerbestatistik, Vol. 209.* Berlin: Puttkammer & Mühlbrecht.

Statistik des Deutschen Reichs (1927). *Volks-, Berufs- und Betriebszaehlung vom 16 Juni 1925: Die berufliche und soziale Gliederung der Bevoelkerung in den Laendern und Landesteilen, Vol. 403–405.* Berlin: Reimar Hobbing.

Stuetzer, M., Obschonka, M., Audretsch, D. B., Wyrwich, M., Rentfrow, P. J., Coombes, M., & Satchell, M. (2016). Industry structure, entrepreneurship, and culture: An empirical analysis using historical coalfields. *European Economic Review, 86*, 52-72. DOI: org/10.1016/j.euroecorev.2015.08.012

Stuetzer, M., Audretsch, D. B., Obschonka, M., Gosling, S. D., Rentfrow, P. J., & Potter, J. (2017). Entrepreneurship culture, knowledge spillovers and the growth of regions. *Regional Studies*. DOI: 10.1080/00343404.2017.1294251

Talhelm, T., Zhang, X., Oishi, S., Shimin, C., Duan, D., Lan, X., & Kitayama, S. (2014). Large-scale psychological differences within China explained by rice versus wheat agriculture. *Science*, *344*(6184), 603-608.

Westlund, H., Larsson, J. P., & Olsson, A. R. (2014): Start-ups and Local Entrepreneurial Social Capital in the Municipalities of Sweden*. Regional Studies*, 48, 974-994.

Williamson, O. (2000). The new institutional economics: Taking stock, looking ahead. *Journal of Economic Literature*, 38, 595–613.

Wyrwich, M., Stuetzer, M., & Sternberg, R. (2016). Entrepreneurial role models, fear of failure, and institutional approval of entrepreneur-

ship: a tale of two regions. *Small Business Economics*, *46*, 467–492. DOI 10.1007/s11187-015-9695-4

Wyrwich, M., Stuetzer, M., & Sternberg, R. (2018). Failing Role Models and the Formation of Fear of Entrepreneurial Failure: A Study of Regional Peer Effects in German Regions. *Journal of Economic Geography*, forthcoming, https://doi.org/10.1093/jeg/lby023

Zhao, H., & Seibert, S. E. (2006). The big-five personality dimensions and entrepreneurial status: A meta-analytical review. *Journal of Applied Psychology*, 91, 259–271.

Appendix

Table A1: Definition of variables

Variable	*Definition*
Self-employment rate 1925, excluding farmers and homeworkers [18]	Number of self-employed persons in non-agricultural private sector industries over workforce (excl. helping family members).
Rate of homeworkers and self-employed farmers in 1925	Number of self-employed persons in agriculture and homeworkers (*Heimgewerbetreibende*) over all workforce (excl. helping family members).
Rate of self-employed in science-based industries in 1925	Number of self-employed in industries that may be regarded as being reliant on academic knowledge divided by the workforce (excl. helping family members). We classified machine, apparatus, and vehicle construction, electrical engineering, precision mechanics, optics, chemicals, as well as rubber and asbestos as science-based.
Entrepreneurial personality fit	Weighted Score based on the Big Five personality characteristics that are measured on a 5-point Likert scale: Formula: entr_persfit=-1*((4-(ext-1))*(4-(ext-1))+(4-(cns-1))*(4-(cns-1))+(4-(opn-1))*(4-(opn-1))+(agr-1)*(agr-1)+(neu-1)*(neu-1)).
Start-up rate	Number of start-ups in all private sector industries (excluding agriculture) over population aged between 18 and 64 years old.
Patent rate	Number of patents over population aged between 18 and 64 years old.
Share of R&D employees	Number of employees working as natural scientists and engineers over the total regional employment.
Population density in 1925	Population over distance in sqkm.
Distance to a classical university in 1900	Distance to a classical university (*Universitaet*) that already existed in the year 1900 in km.
Distance to a technical university in 1900	Distance to a technical university (*Technische Hochschule*) that already existed in the year 1900 in km.
Distance to a higher commercial school in 1900	Distance to a higher commercial school (*Hoehere Gewerbeschule*) that already existed in the year 1900 in km.
Minimum distance to a coalfield	Minimum distance to a coalfield in km.
Employment share of manufacturing in 1925	Number of employees in manufacturing industries over all employees (excluding helping family members).

[18] Freelance professions are not considered because they are included in the “state” sector and cannot be disentangled.

Table A2: Descriptive statistics

	Mean	Standard Deviation	Minimum	Maximum
Start-up rate	0.004	0.001	0.003	0.006
Patent rate	4.097	4.467	0.166	28.74
Share of R&D employees	0.019	0.008	0.007	0.045
Self-employment rate 1925, excluding famers and homeworkers	0.108	0.013	0.06	0.139
Rate of self-employed in science-based industries in 1925	0.004	0.001	0.002	0.007
Rate of homeworkers and self-employed farmers in 1925	0.131	0.073	0.013	0.306
Entrepreneurial personality fit	-19.316	0.501	-20.79	-18.258
Population density in 1925	4.841	0.773	3.668	8.363
Distance to a classical university in 1900	61.979	39.595	0	163.577
Distance to a technical university in 1900	96.986	53.465	0	253.005
Distance to a higher commercial school in 1900	155.135	91.59	0	397.858
Minimum distance to a coal field	102.421	89.096	0	357.198
Employment share of manufacturing in 1925	0.262	0.096	0.117	0.547

Table A3: Correlations between variables

		1	2	3	4	5	6	7	8	9	10	11	12
1	Start-up rate	1											
2	Patent rate	0.382***	1										
3	Share of R&D employees	0.308***	0.687***	1									
4	Self-employment rate 1925, excluding famers and homeworkers	0.358***	0.296***	0.175*	1								
5	Rate of self-employed in science-based industries in 1925	0.319***	0.500***	0.545***	0.482***	1							
6	Rate of homeworkers and self-employed farmers in 1925	-0.227**	0.096	-0.268**	0.312***	-0.119	1						
7	Entrepreneurial personality fit	0.357***	0.578***	0.391***	0.244**	0.442***	0.022	1					
8	Population density in 1925	0.314***	0.299***	0.431***	-0.091	0.308***	-0.726***	0.218**	1				
9	Distance to a classical university in 1900	-0.006	-0.148	-0.27***	-0.139	-0.236**	0.208**	-0.025	-0.237**	1			
10	Distance to a technical university in 1900	-0.266**	-0.358***	-0.604***	-0.154	-0.397***	0.191*	-0.293***	-0.37***	0.013	1		
11	Distance to a higher commercial school in 1900	-0.097	-0.129	-0.255**	-0.126	-0.337***	0.173	-0.087	-0.35***	0.412***	0.203*	1	
12	Minimum distance to a coal field	-0.022	-0.016	-0.037	0.271***	0.14	0.416***	-0.018	-0.421***	-0.057	0.064	-0.173***	1
13	Employment share of manufacturing in 1925	0.166	0.334***	0.494***	0.055	0.493***	-0.453***	0.149	0.639***	-0.198*	-0.31***	-0.358***	-0.25**

Notes: ***: statistically significant at the 1% level; **: statistically significant at the 5% level *: statistically significant at the 10% level.

Table A4: The relationship between self-employment in 1925 and new business formation today (full table)

	Start-up rate					
	I	II	III	IV	V	VI
Self-employment rate in 1925 excluding agriculture and homeworkers	0.366***	0.379***				
	(0.114)	(0.106)				
Rate of self-employed in science-based industries in 1925			0.261***	0.215***		
			(0.067)	(0.068)		
Rate of homeworkers and self-employed farmers in 1925					-0.091***	-0.040
					(0.033)	(0.061)
Population density in 1925		0.086**		0.056*		0.020
		(0.033)		(0.028)		(0.065)
Distance to a technical university in 1900		-0.008		-0.006		-0.015
		(0.013)		(0.012)		(0.012)
Distance to a classical university in 1900		0.006		0.005		0.002
		(0.010)		(0.009)		(0.010)
Distance to a higher commercial school in 1900		0.007		0.007		0.003
		(0.015)		(0.015)		(0.017)
Minimum distance to nearest coal field		-0.020*		-0.026**		-0.020
		(0.012)		(0.012)		(0.013)
Employment share of manufacturing in 1925		0.042		0.019		0.080
		(0.051)		(0.066)		(0.058)
Federal State dummies	***	***	***	***	***	***
Constant	-4.690***	-4.894***	-3.947***	-4.325***	-5.672***	-5.347***
	(0.239)	(0.207)	(0.389)	(0.341)	(0.101)	(0.291)
R^2	0.414	0.549	0.492	0.564	0.438	0.502

Notes: N=92. OLS regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **statistically significant at the 5% level; *: statistically significant at the 10% level. All continuous variables are log transformed. Including both self-employment rates in one regression leads to nearly identical results.

Table A5: Relationship between self-employment 1925, entrepreneurial personality fit of today's population, and current new firm formation (full table)

	Entrepreneurial personality fit						Start-up rate	
	I	II	III	IV	V	VI	VII	VIII
Self-employment rate in 1925 excluding agriculture and homeworkers	1.110***	1.225**						
	(0.384)	(0.484)						
Rate of self-employed in science-based industries in 1925			0.769***	0.829***				
			(0.184)	(0.209)				
Rate of homeworkers and self-employed farmers in 1925					-0.095	0.116		
					(0.090)	(0.189)		
Entrepreneurial personality fit							0.108***	0.078**
							(0.035)	(0.033)
Population density in 1925		0.204*		0.110		0.202		0.046
		(0.121)		(0.099)		(0.216)		(0.029)
Distance to a technical university in 1900		-0.042		-0.032		-0.072**		-0.011
		(0.032)		(0.026)		(0.033)		(0.012)
Distance to a classical university in 1900		0.008		0.007		-0.005		0.002
		(0.034)		(0.031)		(0.036)		(0.009)
Distance to a higher commercial school in 1900		0.054		0.059		0.029		-0.002
		(0.042)		(0.039)		(0.044)		(0.016)
Minimum distance to nearest coal field		-0.051		-0.072		-0.044		-0.015
		(0.057)		(0.052)		(0.056)		(0.012)
Employment share of manufacturing in 1925		-0.107		-0.217		-0.001		0.077
		(0.192)		(0.168)		(0.197)		(0.056)
Federal State dummies	***	***	***	***	***	***	***	***
Constant	-17.491***	-18.192***	-15.365***	-15.678***	-20.030***	-19.965***	-3.307***	-3.844***
	(0.908)	(0.890)	(1.054)	(1.224)	(0.380)	(1.016)	(0.687)	(0.653)
R^2	0.356	0.421	0.419	0.465	0.312	0.372	0.438	0.537

Notes: OLS regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **statistically significant at the 5% level; *: statistically significant at the 10% level. All continuous variables are log transformed (except for entrepreneurial personality fit, which assumes negative values).

Table A6: Relationship between self-employment in 1925 and innovation activity today (full table)

	Employment share of R&D employees				Patent rate			
	I	II	III	IV	V	VI	VII	VIII
Self-employment rate in 1925, excluding farmers and homeworkers	0.753**	0.192			1.831***	0.863*		
	(0.299)	(0.253)			(0.494)	(0.464)		
Rate of self-employed in science-based industries in 1925			0.660***	0.154			1.661***	1.012***
			(0.158)	(0.117)			(0.252)	(0.222)
Population density in 1925		0.120***		0.105**		0.037		-0.026
		(0.045)		(0.041)		(0.117)		(0.108)
Distance to a technical university in 1900		-0.132***		-0.129***		-0.143***		-0.116**
		(0.017)		(0.016)		(0.054)		(0.046)
Distance to a classical university in 1900		-0.044***		-0.044***		-0.063*		-0.059*
		(0.014)		(0.013)		(0.036)		(0.032)
Distance to a higher commercial school in 1900		-0.026		-0.025		0.027		0.043
		(0.030)		(0.029)		(0.052)		(0.057)
Minimum distance to nearest coal-field		0.038*		0.034		0.050		0.022
		(0.020)		(0.022)		(0.075)		(0.072)
Employment share of manufacturing in 1925		0.227*		0.203		0.896***		0.704***
		(0.117)		(0.126)		(0.219)		(0.222)
Federal State dummies	***	***	***	***	***	***	***	***
Constant	-2.827***	-3.377***	-0.589	-2.864***	3.969***	3.788***	9.734***	7.697***
	(0.634)	(0.466)	(0.927)	(0.634)	(1.090)	(0.975)	(1.465)	(1.308)
R^2	0.319	0.705	0.424	0.708	0.660	0.786	0.755	0.815

Notes: OLS regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; ***: statistically significant at the 5% level; *: statistically significant at the 10% level. All continuous variables are log transformed.

Table A7: Relationship between entrepreneurial personality fit and innovation activity today: (full table)

	Employment share of R&D employees		Patent rate	
	I	II	III	IV
Entrepreneurial personality fit	0.179**	0.040	0.611***	0.459***
	(0.072)	(0.054)	(0.163)	(0.148)
Population density in 1925		0.100**		-0.082
		(0.039)		(0.102)
Distance to a technical university in 1900		-0.133***		-0.130***
		(0.016)		(0.048)
Distance to a classical university in 1900		-0.046***		-0.070**
		(0.013)		(0.031)
Distance to a higher commercial school in 1900		-0.031		-0.003
		(0.029)		(0.051)
Minimum distance to nearest coalfield		0.041*		0.075
		(0.021)		(0.072)
Employment share of manufacturing in 1925		0.245**		0.974***
		(0.113)		(0.210)
Federal State dummies	***	***	***	***
Constant	12.270***	11.740***	-0.857	-2.832**
	(3.253)	(2.962)	(1.470)	(1.087)
R^2	0.687	0.812	0.315	0.704

Notes: OLS regressions. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *statistically significant at the 10% level. All continuous variables are log transformed (except for entrepreneurial personality fit, which assumes negative values).

Table A8: Relationship between self-employment 1925, the entrepreneurial personality fit of today's population, and start-up rates today: 2-SLS IV regressions (Second stage, full table)

Dependent variable:	Start-up rate			
Instrument:	Self-employment rate in 1925, excluding farmers and homeworkers		Rate of self-employed in science-based industries in 1925	
	I	II	III	IV
Entrepreneurial personality fit	0.329***	0.309***	0.339***	0.259***
	(0.109)	(0.117)	(0.091)	(0.086)
Population density in 1925		0.023		0.028
		(0.029)		(0.029)
Distance to a technical university in 1900		0.006		0.002
		(0.012)		(0.009)
Distance to a classical university in 1900		0.003		0.003
		(0.010)		(0.009)
Distance to a higher commercial school in 1900		-0.010		-0.008
		(0.017)		(0.016)
Minimum distance to nearest coalfield		-0.005		-0.007
		(0.015)		(0.013)
Employment share of manufacturing in 1925		0.075		0.075
		(0.069)		(0.063)
Federal State dummies	***	***	***	***
Constant	1.073	0.735	1.261	-0.269
	(2.158)	(2.249)	(1.787)	(1.672)
First Stage F-Statistics	8.34***	6.40**	17.58***	15.77***
R^2	0.086	0.189	0.055	0.324

Notes: Robust standard errors in parentheses. ***: statistically significant at the 1% level; *: statistically significant at the 10% level. All continuous variables are log transformed (except for entrepreneurial personality fit, which assumes negative values). The coefficient estimates for the first stage regressions are the same for the respective OLS regressions presented in Table 1. The standard errors are only slightly different.

Table A9: Relationship between self-employment 1925, the entrepreneurial personality fit of today's population, and start-up rates today: 2-SLS IV regressions (Second stage, full table)

Dependent variable:	Employment share of R&D employees		Patent rate	
Instrument:	Rate of self-employed in science-based industries in 1925			
	I	II	III	IV
Entrepreneurial personality fit	0.858***	0.186	2.159***	1.221***
	(0.236)	(0.119)	(0.486)	(0.282)
Population density in 1925		0.085**		-0.160
		(0.042)		(0.135)
Distance to a technical university in 1900		-0.123***		-0.077**
		(0.017)		(0.039)
Distance to a classical university in 1900		-0.045***		-0.067*
		(0.012)		(0.034)
Distance to a higher commercial school in 1900		-0.036		-0.030
		(0.026)		(0.057)
Minimum distance to nearest coalfield		0.048**		0.110
		(0.023)		(0.076)
Employment share of manufacturing in 1925		0.243**		0.968***
		(0.100)		(0.238)
Federal State dummies	***	***	***	***
First Stage F-Statistics	17.58***	15.77***	17.58***	15.77***
Constant	12.596***	0.046	42.902***	26.836***
	(4.628)	(2.347)	(9.593)	(5.627)
R^2	0.315	0.681	0.283	0.723

Notes: Robust standard errors in parentheses. ***: statistically significant at the 1% level; ***: statistically significant at the 5% level. All continuous variables are log transformed (except for entrepreneurial personality fit, which assumes negative values). The coefficient estimates for the first stage regressions are the same for the respective OLS regressions presented in Table 1. The standard errors are only slightly different.

Table A10: Robustness checks I: Instrumenting entrepreneurship and innovation activity by the employment share in science-based industries 1925 and considering historical controls from 1907 instead of 1925

Dependent variable:	Start-up rate			Employment share of R&D employees			Patent Rate		
Instrument:	Employment share science-based industries 1925	Rate of self-employed in science-based industries in 1925		Employment share science-based industries 1925	Rate of self-employed in science-based industries in 1925		Employment share science-based industries 1925	Rate of self-employed in science-based industries in 1925	
	I	II	III	IV	V	VI	VII	VIII	IX
Entrepreneurial personality fit	-0.017	0.294***	0.233***	0.583**	0.298**	0.219	1.405***	1.688***	1.619***
	(0.128)	(0.081)	(0.078)	(0.270)	(0.124)	(0.134)	(0.514)	(0.390)	(0.438)
Distance to a technical university in 1900	-0.017	0.003	0.019*	-0.095***	-0.120***	-0.118***	-0.064	-0.062	-0.073**
	(0.015)	(0.009)	(0.010)	(0.028)	(0.018)	(0.018)	(0.050)	(0.045)	(0.035)
Distance to a classical university in 1900	0.002	0.003	0.014	-0.043**	-0.046***	-0.050***	-0.066*	-0.069	-0.109**
	(0.009)	(0.009)	(0.009)	(0.019)	(0.013)	(0.012)	(0.038)	(0.043)	(0.042)
Distance to a higher commercial school in 1900	0.002	-0.011	-0.004	-0.050	-0.046*	-0.045*	-0.036	-0.071	-0.077
	(0.015)	(0.016)	(0.014)	(0.032)	(0.026)	(0.027)	(0.064)	(0.068)	(0.066)
Minimum distance to nearest coalfield	-0.020	-0.008	-0.019*	0.066	0.045*	0.049**	0.119	0.103	0.135*
	(0.013)	(0.015)	(0.011)	(0.043)	(0.026)	(0.023)	(0.086)	(0.093)	(0.080)
Population density in 1925	0.056*			0.044			-0.178		
	(0.031)			(0.077)			(0.155)		
Employment share of manufacturing in 1925	0.077			0.241*			0.967***		
	(0.049)			(0.132)			(0.260)		

Population density 1907		-0.033			-0.015			-0.445*	
		(0.052)			(0.076)			(0.263)	
Employment share of manufacturing in 1907		0.189*			0.386**			1.273***	
		(0.108)			(0.182)			(0.460)	
Population density 2000			0.018			0.230***			0.271
			(0.038)			(0.075)			(0.247)
Employment share of manufacturing in 2000			-0.122*			0.263**			1.279***
			(0.070)			(0.124)			(0.443)
Employment share of R&D employees in 2000			0.129**			-			-
			(0.059)			-			-
Federal State dummies	***	***	***	***	***	***	***	***	***
Constant	-5.732**	0.788	-0.578	7.917	2.810	0.018	30.496***	37.356***	33.540***
	(2.510)	(1.697)	(1.582)	(5.241)	(2.582)	(2.866)	(10.181)	(8.253)	(9.172)
First Stage F-Statistics	5.57**	15.45***	13.69***	5.47**	15.45***	12.48***	5.47**	15.45***	12.48***
R^2	0.478	0.255	0.421	0.385	0.633	0.674	0.675	0.570	0.604

Notes: IV regression second stage. Robust standard errors in parentheses. ***: statistically significant at the 1% level; **: statistically significant at the 5% level; *: statistically significant at the 10% level. All continuous variables are log transformed (except for entrepreneurial personality fit, which assumes negative values).