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Industry structure, entrepreneurship, and culture: An empirical analysis using historical coalfields

Michael Stuetzer^{1,2}, Martin Obschonka^{3,4*}, David B. Audretsch⁵, Michael Wyrwich⁶, Peter J. Rentfrow⁷, Mike Coombes⁸, Leigh Shaw-Taylor⁹, Max Satchell⁹

¹Baden-Württemberg Cooperative State University, Coblitzallee 1-9, D-68193 Mannheim, Germany

²Faculty of Economic Sciences and Media, Institute of Economics, Ilmenau University of Technology, Ehrenbergstr. 29, D-98684 Ilmenau, Germany

³Department of Psychology, Saarland University, Campus Building A1 3, D-66123 Saarbrücken, Germany

⁴Center for Applied Developmental Science (CADS). Friedrich Schiller University Jena, Semmelweisstr. 12, 07743 Jena, Germany

⁵ Institute of Developmental Strategies, Indiana University, 1315 East 10th Street, Bloomington, Indiana, USA

⁶ Faculty of Economics and Business Administration, Friedrich Schiller University Jena, Carl-Zeiss-Str. 3, D-07743 Jena, Germany

⁷ Department of Psychology, University of Cambridge, Downing Str., Cambridge CB2 3EB, United Kingdom

⁸ CURDS (Centre for Urban & Regional Development Studies), Newcastle University, Claremont Bridge, Newcastle-upon-Tyne NE1 7RU, United Kingdom

⁹ Cambridge Group for the History of Population and Social Structure, Faculty of History, University of Cambridge CB3 9EF, United Kingdom

*Corresponding author

E-mail: martin.obschonka@uni-saarland.de

Abstract

There is mounting evidence demonstrating that entrepreneurship is spatially clustered and that these spatial differences are quite persistent over long periods of time. However, especially the sources of that persistence are not yet well-understood, and it is largely unclear whether persistent differences in entrepreneurship are reflected in differences in entrepreneurship culture across space as it is often argued in the literature. We approach the cluster phenomenon by theorizing that a historically high regional presence of large-scale firms negatively affects entrepreneurship, due to low levels of human capital and entrepreneurial skills, fewer opportunities for entry and entrepreneurship inhibiting formal and informal institutions. These effects can become self-perpetuating over time, ultimately resulting in persistent low levels of entrepreneurship activity and entrepreneurship culture. Using data from Great Britain, we analyze this long-term imprinting effect by using the distance to coalfields as an exogenous instrument for the regional presence of large-scale industries. IV regressions show that British regions with high employment shares of large-scale industries in the 19th century, due to spatial proximity to coalfields, have lower entrepreneurship rates and weaker entrepreneurship culture today. We control for an array of competing hypotheses like agglomeration forces, the regional knowledge stock, climate, and soil quality. Our main results are robust with respect to inclusion of these control variables and various other modifications which demonstrates the credibility of our empirical identification strategy. A mediation analysis reveals that a substantial part of the impact of large-scale industries on entrepreneurship is through human capital.

Keywords: Entrepreneurship, entrepreneurship culture, Industrial Revolution, industry structure, personality

Industry structure, entrepreneurship, and culture: An empirical analysis using historical coalfields

1. Introduction

Paul Krugman (1991, p. 5) motivated the need to systematically analyze economic geography by asking, and then answering, the following question: “What is the most striking feature of the geography of economic activity? The short answer is surely *concentration*... production in many industries is remarkably concentrated in space.” The economics literature was quick to respond that there is considerably more than just production that varies significantly across geographic space. In particular, entrepreneurship activities, as measured and reflected by the start-up of new firms also tends to be much more highly concentrated in certain locations than in others (Audretsch and Fritsch, 1994; Klepper, 2010; Glaeser and Kerr, 2009; Rosenthal and Strange, 2003). Considerable efforts have been made to link the distribution of entrepreneurial activity across geographic space to variations in spatial characteristics, such as knowledge, creativity and innovations (Obschonka et al., 2015a; Stuetzer et al., 2014), income levels (Reynolds et al., 1995), agglomeration effects (e.g., Glaeser et al., 2010) and input costs (Fritsch and Falck, 2007) – to name a few.

In this paper, we focus on the regional industry structure. More precisely, we analyze the impact of the concentration of large-scale industries on entrepreneurship. We use entrepreneurship as an umbrella term comprising the actual entrepreneurial activity (measured in this paper by means of regional start-up rates and self-employment rates) and the more latent entrepreneurship culture (measured by psychological traits). Our research builds on Chinitz (1961) who tried to explain the higher prevalence of entrepreneurship in

New York compared to Pittsburgh with different processes of economic development. The large-scale physical capital driven economy of production was less conducive to entrepreneurship because the culture, attitudes and values were shaped from the work place of mass production and not decentralized and independent decision making. By contrast, the high prevalence of independent and autonomous small businesses in New York was more conducive to entrepreneurial attitudes and cultures. In particular, Chinitz (1961) argued that because of the large-scale structure of the Pittsburgh economy there were fewer independent business owners with the experience and capabilities to transfer entrepreneurial values and attitudes to the next generation of potential entrepreneurs, which in turn would lead to persisting lower levels of entrepreneurship. In recent years, the belief that economic behavior in general is imprinted from a longer-term and more fundamental cultural and institutional context has gained ground in the research community (Acemoglu and Robinson, 2012; Diamond and Robinson, 2010).

We test Chinitz's insight by hypothesizing that the historical presence of large-scale industries in regions negatively impacts regional entrepreneurship activities and the regional entrepreneurship culture jointly. While other studies have already reported negative correlations between large-scale industries and entrepreneurship, these studies employ cross-regional static settings (e.g., Armington and Acs, 2002; Davidsson, 1995; Fotopoulos and Spence, 2001; Lee et al., 2004; Reynolds et al., 1994) which is clearly not what Chinitz had in mind in his seminal paper. Furthermore, these papers almost exclusively focus on entrepreneurship activities as the dependent variable, but do not provide empirical evidence regarding the relationship with entrepreneurship culture (Davidsson, 1995 being an exception). Obviously, serious data and measurement challenges have precluded studies from exploring the long-term effects of a large-scale industry structure on both entrepreneurship

activities and entrepreneurship culture.

In order to test our hypothesis, we draw on the historical context of the Industrial Revolution in Great Britain by using the distance to coalfields as an instrument for the presence of large-scale industries in the 19th century (for example, textiles and metal). These industries dominated certain parts of Great Britain (e.g., northern and midland England, south of Wales and the central parts of Scotland) over a period of more than 100 years but have now lost their dominating role in the economy. We find that regions with a high historical employment share in large-scale industries have significantly and substantially lower entrepreneurship rates and a weak entrepreneurship culture. Beyond the direct relationship of industry structure and entrepreneurship, we also test for channels of causality about *how* the local presence of large-scale industries negatively affects entrepreneurship. We find that 13% of the effect of large-scale industries on regional start-up rates is mediated via human capital. This figure increases to 34% when looking at entrepreneurship culture as dependent variable.

Note that historical coal mines were used as an instrument for entrepreneurship in a recent paper by Glaeser et al. (2015) that investigated the causal effect of entrepreneurship on employment growth across U.S. regions. Glaeser et al. instrument regional entrepreneurship around 1980 with the presence of historical mines in close proximity of a region in 1900. Their argument is that the presence of coal mines was an important determinant for the location decision of large-scale industries. Their main finding is that regions with relatively more mines in close proximity in 1900, had less entrepreneurship in 1980 and therefore less growth in the time period between 1982 and 2002. Our approach differs from their approach as we focus on the link between entrepreneurship in an area and the distance to coalfields through a direct assessment of the historical concentration of large-

scale industries and their role in the emergence of low levels of entrepreneurship activity and entrepreneurship culture. Another related paper in the field by Fritsch and Wyrwich (2014), shows that German regions that had a high level of entrepreneurship in the 1920s had higher rates of entrepreneurship at the beginning of the 21st century despite several historical shocks. Due to the many structural breaks (World War II, socialist regime in East Germany) the 1925 entrepreneurship rate can be interpreted as an indicator for entrepreneurship culture. However, the study does not explain where these regional differences in entrepreneurial tradition come from. Our paper offers explanations of the emergence of regional differences in entrepreneurship activities and entrepreneurship culture.

Our paper makes two main contributions to the literature. First, we present causal evidence for a regional determinant of entrepreneurial activity – industry structure. While research into entrepreneurship has certainly advanced our understanding about regional differences in this phenomenon, much of these results are rather correlative in nature. Research applying causal methods such as (natural) experiments and instrumental variables (e.g., Bauernschuster et al., 2010; Wyrwich, 2013; Glaeser et al., 2015) contributes to a body of verified knowledge and thus strengthens legitimacy for a research field in adolescence.

A second main contribution is to look at the determinants of regional entrepreneurship culture. Few studies have looked at the historical roots of cultural regional characteristics (see for an overview, Nunn, 2009). For example, Guiso et al. (2008) study variations in social capital among Italian cities and find that cities that experienced self-government in the Middle Ages have higher levels of social capital. Greif (1994) analyzes cultural differences between traders from different Mediterranean regions in the Middle Ages, and finds that Genoese traders outperformed Maghribi traders because of institutions based on individualist cultural beliefs. Talhelm et al. (2014) look at the relationship between different agricultural systems (rice vs.

wheat) and personality traits. They find that individuals living in regions which have a history of rice agriculture were more holistic in their thinking and interdependent. In a paper related to this article, Obschonka et al., (2015b) investigate the effect of historical socio-economic factors on the emergence of regional personality traits. Their results suggest that, in particular, the regional presence of the heavy industries is related to factors associated with an “unhappy personality” (that predict lower well-being in the region) – higher regional levels of neuroticism and lower levels of conscientiousness. Investigating the roots of entrepreneurship culture is important because cultural characteristics can persist over an extended time and can shape the future trajectories of regions. For example, with respect to entrepreneurship, Obschonka et al., (2015a) find empirical evidence that regional knowledge predicts regional start-up rates only if the region has a strong entrepreneurship culture.

The remainder of the paper is organized as follows. Sections 2 and 3 present theory of how large-scale industries negatively affect regional entrepreneurship activities and entrepreneurship culture. Section 4 describes the data and the estimation approach. Section 5 presents and interprets the results, and Section 6 concludes the paper.

2. The effect of large-scale industries on entrepreneurship activities

2.1 Entrepreneurial activity and the nature of firms and employees in large-scale industries

The characteristics of firms in large-scale industries (such as mining) determine the scope of entrepreneurial activity for many reasons that are grounded in different strands of literature. First, there is the “classical” approach of industrial organization (IO) toward entrepreneurship (e.g., for overviews, see Siegfried and Evans, 1994; Geroski, 1995). According to the IO perspective, “market entries” depend on industry characteristics such as the level of capital

intensity, the average minimum efficient size (MES) for operating successfully in the market, and the level of irreversible investment (the sunk costs in the case of failure/exit). Large-scale industries are typically marked by a high level of capital intensity and irreversible investment and, by definition, by high MES. All three characteristics are negatively related to entry. Mining, for example, combines all above mentioned industry characteristics. It is highly capital intensive to run a mine and requires a great number of workers to operate successfully. The investment is highly specific and can hardly be recovered in the case of failure. In sum, large-scale industries provide a limited number of entrepreneurial opportunities based on their very nature. Furthermore, many large-scale industries are characterized by a routinized technological regime where entry is relatively difficult for various reasons. Such industries are in a later stage of a technological path. Operating successfully in the market presupposes great amounts of path-specific knowledge. There is a dominant technological paradigm and pronounced price competition. In the case of innovative industries, the innovative advantage is typically on the side of large firms (e.g., Nelson and Winter, 1982; Winter, 1984).

Aside from the IO tradition and the literature on technological regimes, there is another strand of literature that focuses particularly on the role of small firms for “breeding” entrepreneurs (e.g., Parker, 2009; Elfenbein et al., 2010). The literature on this small firm effect is originally also rooted in the IO tradition since average firm sizes reflect inter-industry differences in MES (e.g., Beesley and Hamilton, 1984). However, there is much more in the small firm effect (e.g., for an overview, see Parker, 2009). One aspect is that opportunity costs of starting a firm are relatively low when working in a small firm. So, the payment in small firms is relatively low as well as the job security due to the higher risk of firm failure. Furthermore, opportunities for promotion are limited in small firms. These factors reduce the opportunity costs of starting a firm and work like a push factor into self-employment. Beyond

push factors, the literature also points to a number of factors pulling people into small firms and subsequently entrepreneurship. Most importantly employees with personality traits that are conducive to entrepreneurship (e.g., low risk aversion) self-select into small firms because of the close similarities in the work environment. There is also a discussion regarding ability sorting. Although it remains unclear whether more highly-able employees or more peripheral workers self-select into small firms, it is quite likely that both the earning prospects and the prospect of being one's own boss can pull both groups into entrepreneurship (Parker, 2009).

Another mechanism behind the small firm effect is the development of entrepreneurial skills. Often, because of the low division of labor, people in small firms are exposed to more fields of activity than people working in larger firms (e.g., Wagner, 2004; Hyttinen and Maliranta, 2008; Elfenbein et al., 2010). In this respect, Lazear (2005) argues, entrepreneurial skills emanate from the ability to perform a broad spectrum of diverse tasks and challenges. Employment within the context of a large-scale industry may impede the acquisition of such entrepreneurial skills. Because firms based on large-scale production are characterized by a high division of labor, workers tend to be highly specialized and engaged in repetitive tasks. Historically, it was in textiles where the assembly line method of production was first used. When workers are only performing a handful of operations, there is no need for highly educated workers, and fewer opportunities arise to learn the diverse tasks associated with starting and running a firm (Lazear, 2005). Evidence shows that employees in smaller firms indeed have a higher balance of skills while workers in large firms have less skill balance (Stuetzer et al., 2013a; Bublitz and Noseleit, 2014; Lechmann and Schnabel, 2014).

Being exposed to many different tasks (as in small firms) may also stimulate a tendency toward entrepreneurial thinking (Stuetzer et al., 2013b) and increase the propensity to start one's own firm. This propensity might be also stimulated by direct interaction with an

entrepreneurial role model, and a small or new business may allow for that relationship to develop. Through such role models (younger) workers learn about the process of recognizing and creating entrepreneurial opportunities as well as how to act upon them. Because of the large-establishment size and the pronounced hierarchical organization of the companies in large-scale industries, there are fewer possibilities for workers to engage with the entrepreneur him/herself. Entrepreneurial human capital is often transmitted by such role models, and in an absence of entrepreneurial role models, there will be fewer people, or nascent entrepreneurs, with the necessary knowledge and capabilities to launch a new firm (e.g., Minniti, 2005; Fritsch, 2013). Summing up, there are several factors that contribute to the small firm effect, and this “seedbed” function is more or less missing in firms in large-scale industries.

The literature on the small firm effect suggests that there is a special type of employees working in small firms. Apart from that, there are additional arguments regarding individuals working in large-scale industries that suggest a low potential for entrepreneurial spin-off activities from these sectors. In this respect, it should be pointed out that people do not start a firm in just any industry, but in sectors where they have gained work experience because this experience is crucial for detecting entrepreneurial opportunities and understanding industry-specific requirements for running a firm (e.g., Sorenson and Audia, 2000; Shane, 2000; Shane and Venkatamaran, 2000). Based on this argument, people working in a large-scale industry should be more likely to start a firm in the same industry *conditioned on* that they start a firm. Thus, given that industry characteristics of large-scale industries are associated with few possibilities for entry, people working in these industries should be even less likely to launch an entrepreneurial venture in other industries. Thus, entrepreneurship among workers of large-scale industries is a “rare event” in general. This also implies a low

prevalence of peers with entrepreneurial experience in the workplace, which should again negatively affect entrepreneurial intentions (e.g., Nanda and Sørensen, 2010).

There are further arguments against large-scale industries serving a positive role in entrepreneurial spawning. These arguments aim more specifically at individual characteristics of employees working in these industries. Large-scale production, particularly from industries related to the extraction of raw materials (mining) could typically be characterized as utilizing low-skilled workers. However, general human capital is an important source for the detection and exploitation of entrepreneurial opportunities (e.g., Davidsson and Honig, 2003; Unger et al., 2011). Thus, workers in large-scale industries should have a low entrepreneurial propensity if these industries have a relatively low demand for medium and highly qualified workers. Another aspect that is relevant, especially in historical perspective, is the role of migration. Industrialized areas were characterized by a massive inflow of rural, agricultural workers that flocked to mines and steel mills in industrialized areas due to favorable employment prospects (e.g., Tipton, 1974; 1976). The entrepreneurial intentions of these migrants have presumably been fairly low because of 1) the low level of schooling and thus human capital among migrants from rural areas and 2) the lack of local support networks that are conducive for accessing and exploiting resources required for starting an entrepreneurial venture (e.g., Figueiredo et al., 2002; Michelacci and Silva, 2007; Stam, 2007).

Another mechanism through which large-scale industries might be detrimental to the likelihood of starting a firm is occupational socialization (the shaping of the workers' personality characteristics through their everyday work experiences and conditions). Research in work psychology and sociology showed that work characteristics (e.g., autonomy, complexity of work tasks) shape personality features of the workers (Frese et al., 2007; Kohn and Schooler, 1982; Roberts et al., 2003). Hence, the prevalent, non-entrepreneurial work

characteristics in large-scale industries (e.g., low autonomy, repetitive and monotonous tasks) might have contributed to a lack of entrepreneurial personality traits. Altogether, the characteristics of large-scale industries as such but also with respect to the people working in these industries imply a low level of entrepreneurial activities across such industries. The following section deals with potential “spillover” effects of this pattern on the regional level.

2.2 Regional entrepreneurial activity and large-scale industries

Large-scale industries determine the scope of entrepreneurial activity on the industry level but there are many reasons why they also affect the regional level of entrepreneurship. First, there are regional differences in the employment share of large-scale industries that accordingly affect the aggregate level of regional start-up activity. There is mounting evidence demonstrating that the regional prevalence of small firm employment is positively related to regional start-up activity and vice versa (e.g., Lee et al., 2004; Reynolds et al., 1994; Fotopoulos and Spence, 2001; Fritsch and Falck, 2007). Additionally, the absence of small firms and the presence of large-scale industries may make it attractive for firms in related industries to establish themselves in these regions, due to localization economies (e.g., Glaeser and Kerr, 2009; Jofre-Monseny et al., 2011), while industries with relatively small firm sizes remain absent. This location pattern may lead to persistence in the share of large firms (e.g., Holmes and Stevens, 2002; Barrios et al., 2006). Accordingly, the prevalence of large-scale industries may foster regional specialization in related industries with similar characteristics and, in turn, perpetuates a low level of entrepreneurship over time.

Beyond these arguments, which are grounded in spatial location theory and by applying the classical IO perspective to the region, the local prevalence of large-scale industries may have further negative effects on the regional level of entrepreneurship due to

absence of entrepreneurial role models. Role modeling was already discussed as an important mechanism for promoting entrepreneurship and entrepreneurial intentions in the context of the small firm effect. However, the entrepreneurial role model effect plays an important role in regional entrepreneurship beyond small firms. Such mechanisms also affect the family, university, neighborhood, and the regional level in general (e.g., Bosma et al., 2012; Chlosta et al., 2012; Fornahl, 2003; Kacperczyk, 2013; Minniti, 2005; Krueger et al., 2000; van Auken et al., 2006; Arenius and Minniti, 2005; Davidsson and Honig, 2003; Dunn and Holtz-Eakin, 2000; Lafuente et al., 2007; Wagner and Sternberg, 2004). Individuals can certainly observe entrepreneurs not only in the workplace, but also in their social environment and daily lives, providing opportunities to learn about entrepreneurial tasks and capabilities. Such role models demonstrate to potential entrepreneurs, for example, how to organize the resources and activities required for starting and running one's own venture more easily and increases individual self-confidence. Aside from this demonstration effect, individuals may perceive entrepreneurship as a favorable career option from observing that one of their local peers is engaged in entrepreneurship (for details, see Fornahl, 2003 as well as Wyrwich, 2015; Wyrwich et al., 2015). The demonstration and legitimation effect can together be regarded as a non-pecuniary externality (Minniti, 2005). This externality is absent in regions that were dominated by large-scale industries over a longer period of time and present in regions with a high prevalence of smaller firms and entrepreneurs as described by Chinitz (1961) in his comparison between Pittsburg and New York. If a young person's family, acquaintances and neighbors all worked in a large Pittsburgh steel mill, a textile fabric in Manchester or a coal mine in the Ruhr area, it is very unlikely that the young person would have ever been in contact with entrepreneurial values or that he or she was able to acquire entrepreneurial skills, ultimately lowering his or her chances to be an entrepreneur.

Summarizing Section 2, regions that host a high share of large-scale industries should have a lower rate of entrepreneurship due to the characteristics of firms and workers in large-scale industries and due to the low prevalence of entrepreneurial role models.

3. The effect of large-scale industries on entrepreneurship culture

3.1 What is regional entrepreneurship culture?

An entrepreneurship culture can be defined as a “positive collective programming of the mind” (Beugelsdijk 2007, p. 190) or an “aggregate psychological trait” (Freytag and Thurik 2007, p. 123) of the population oriented toward entrepreneurial values such as individualism, independence, and achievement (e.g., McClelland 1961; Hofstede and McCrae 2008). From an institutional perspective, such a culture mainly comprises informal institutions (e.g., traits, norms, values, and codes of conduct) but also formal institutions that favor entrepreneurship (Baumol 1990; North 1994). Regions with a strong entrepreneurship culture are marked by a high level of social acceptance and approval of entrepreneurship. In this respect, Kibler et al. (2014) developed the concept of regional social legitimacy, which is understood as a common perception, either positive or negative, of entrepreneurship. This concept is mainly grounded on the institutional theory of economic geography and sociology, arguing that places develop specific cultural, cognitive, normative, and regulatory characteristics that lead to variety in the perception of economic behaviors (e.g., Gertler, 2010; Rodriguez-Pose, 2013; Scott, 1995; Suchmann, 1995) such as entrepreneurial choice. In this respect, an above average regional level of start-up activity reflects a high regional social legitimacy of entrepreneurship.¹ Furthermore, since informal institutions are deeply embedded in a population, an

¹ Similarly, Westlund and Bolton (2003) developed the concept of local social capital, which can either facilitate or inhibit entrepreneurial activities.

entrepreneurship culture should manifest as a relatively high percentage of people with an entrepreneurial personality, which is characterized by a higher level in traits like extraversion, openness to experience, conscientiousness and lower levels of agreeableness and neuroticism (Obschonka et al., 2013b).

Although there are different approaches to understand and categorize the building blocks of an entrepreneurship culture across these studies², there is compelling empirical evidence that entrepreneurship culture can vary substantially across regions of a country, even though there are country-wide uniform formal rules (e.g., Andersson and Koster, 2011; Aoyama, 2009; Beugelsdijk, 2007; Davidsson, 1995; Obschonka et al., 2013b; Saxenian, 1994; Westlund and Bolton, 2003; and Westlund et al., 2014). Other researchers have studied the persistence of regional differences in entrepreneurial activities over time, which can be interpreted as indirect evidence for the presence of an entrepreneurship culture (e.g., Andersson and Koster, 2011; Fotopoulos, 2014; Fritsch and Wyrwich, 2014; Mueller et al., 2008; Acs and Mueller, 2008; van Stel and Suddle, 2008).

3.2 How do large-scale industries shape regional entrepreneurship culture?

The historical presence of large-scale industries may shape the local entrepreneurship culture of regions via the presence and emergence of distinct formal and informal institutions. Formal rules might be designed in a way to promote and protect the already existing large-scale industries which, at the same time, offsets the incentives for starting new entrepreneurial

² See Fritsch and Wyrwich (2012) for a detailed discussion. In a nutshell, the normative-cognitive layer comprises, first of all, a widespread social acceptance of self-employment. The policy layer alludes to entrepreneurship-friendly laws and regulations (e.g., conditions for entry and exit, freedom of establishment and trade, competition policy, the tax system, the social security system, low level of corruption) and the presence of a supportive infrastructure for entrepreneurship like the existence of supporting services for potential business founders (e.g., incubators).

firms. The prohibiting impact of the formal framework on the number of entrepreneurs may slowly trigger the emergence of unfavorable informal institutions in the sense of a lower acceptance of start-up activity as a business model. Regions may become “locked in” on a path of development strategies that concentrate on old established firms and industries. This pattern is vividly illustrated by the work of Grabher (1993) on the Ruhr area which has been dominated by coal mining and steel mills since the late 19th century, and has enormous difficulties in managing structural change and low entrepreneurship rates (see also, Audretsch and Fritsch, 2002).

Apart from formal institutions tuned to the needs of large-scale organizations, the low prevalence of entrepreneurial role models in large-scale industries is important to understand the informal dimension of an entrepreneurship culture. Role models enhance the perceived attractiveness of entrepreneurship as a career choice among peer groups (for details, see Fornahl, 2003; Wyrwich et al., 2015). At the same time, an increase in the number of entrepreneurs also leads to an increase of social acceptance of entrepreneurship or its “societal legitimation” (Etzioni, 1987; Kibler et al., 2014) and may trigger further entrepreneurial choices. Hence, entrepreneurship becomes self-reinforcing and strengthened over time. This matches the empirical evidence which shows that the effect of past start-up activities on entrepreneurship is stronger if the level of new firm formation was already high (Andersson and Koster, 2011; Chan et al., 2011; Fritsch and Wyrwich, 2014).

Next to the general lack of entrepreneurial role models, the low prevalence of entrepreneurial personality traits among large-scale workers (due to the occupational socialization previously mentioned) could have contributed to a lack of entrepreneurial culture via intergenerational transmission. In this respect, research in work psychology and sociology found an influence of parents’ work conditions and experiences on their upbringing

of their children (Crouter et al., 1999) through the intergenerational transmission of values that were socialized through their work experiences (Luster et al., 1989). Hence, the, non-entrepreneurial work characteristics in large-scale industries might have contributed to a non-entrepreneurial culture through the shaping of non-entrepreneurial personality traits. This channel is also indirectly mentioned by Chinitz (1961) in his comparison of Pittsburgh and New York.

The virtuous circle involving start-up activity, entrepreneurial role modeling, occupational socialization, and social acceptance of entrepreneurship might turn into a vicious cycle if there are only few entrepreneurs due to a historical specialization in large-scale industries. The focus on traditional large-scale business models may lead to a “cognitive lock-in” (Grabher, 1993), which hinders an entrepreneurial development of the respective regions. Once unfavorable conditions for entrepreneurship are established this may lead to changes in formal institutions that are in line with the informal ones, and which may further decrease the level of entrepreneurship. Taken together, large-scale industries are thus likely to affect the level of entrepreneurship culture negatively due to (1) lack of entrepreneurial role models which makes the long-term emergence of social acceptance of entrepreneurship unlikely, (2) the presence of formal institutions that prohibit entrepreneurial choice.

Summing up the above theory sections, large-scale industries are likely to negatively affect the level of entrepreneurship activity and entrepreneurship culture in regions. There are direct effects of the concentration of large-scale industries on the level of regional entrepreneurship activities due to fewer opportunities to start-up because of entrepreneurship inhibiting industry characteristics (e.g., high MES), and a weak endowment with human capital and entrepreneurial skills, the dominance of low-skill manual jobs and specialized tasks. The presence of large-scale industries can also alter the formal and informal

institutions towards inhibiting (or at least not encouraging) entrepreneurship activities. Less entrepreneurship activity is the result of these direct effects of large-scale industries. The low prevalence of entrepreneurship, in turn, contributes to an entrepreneurship deterring regional culture. As few entrepreneurship activities and a weak entrepreneurship culture mutually reinforce each other, a vicious cycle is set in motion. This vicious cycle can lead to persistently low levels of entrepreneurial activities and culture over time even when the initial impulse of the regional concentration of large-scale industries has ceased. Thus, it is possible that even decades after large-scale industries have lost their dominating role in a regional economy, a path dependency has been established that negatively shapes the future trajectory of entrepreneurship. While we cannot empirically disentangle the mutual influence of entrepreneurship culture and activity on each other by means of our data, we are able to empirically investigate the above theorized common origin of a persisting low extent of regional entrepreneurship and entrepreneurship culture: the regional concentration in large-scale industries, which we focus on in the following empirical assessment.

4. Data and estimation approach

We aim to explain current regional variation in entrepreneurial activity and culture with the historical presence of large-scale industries during the Industrial Revolution in Great Britain.

Our basic model for this investigation is

$$1) \quad E_r^{2011} = \beta \cdot Largescale_r^{1891} + Z_r + \varepsilon_r$$

where E stands for the indicators for entrepreneurship activities and culture in 2011 in region r , $Largescale$ stands for the indicator of large-scale industries in region r in 1891 and Z is a vector of regional control variables and ε is the error term. We start presenting details for our

indicators of the dependent variable, then for our main independent variable – large-scale industries and the corresponding exogenous instrument distance to coalfields, and finally we discuss the control variables.

4.1 Entrepreneurship activity and culture

We measure contemporary entrepreneurship activity in 2011 with the two commonly used indicators – the local self-employment and start-up rates (Anderson and Koster, 2011; Glaeser and Kerr 2009). Data on self-employment stems from the 2011 Census (Tables DC6602EW and DC6602SC). We focus solely on self-employment in the private sector (excluding the primary sectors and the public sector). The self-employment rate is computed by the numbers of self-employed divided by the sum of self-employed and paid employees.

The data on start-ups stems from Inter Departmental Business Register (IDBR). Start-ups are identified by comparing the active business population in two consecutive years – a business not being active in year $t-1$ but active in year t is regarded as start-up in year t . Following prior research (e.g., Audretsch and Fritsch, 1994), we compute the regional start-up rate as the number of start-ups per 1,000 employees.

Regional differences in entrepreneurship culture were measured by means of the local prevalence of an entrepreneurial personality profile. We thereby follow recent advancements in psychology where researchers quantify cultural differences between regions with individual personality traits averaged over regions (Rentfrow et al., 2008; Obschonka et al., 2013b; Obschonka et al., 2015a, 2015b). Of particular relevance to the present work, are spatial differences in the Big Five personality traits that comprise an entrepreneurial personality profile at the individual level (Obschonka, et al., 2013b). Obschonka et al., (2015a) present detailed information about the dataset and the measurement procedure, which allows us to

be brief here. We use personality data from $N = 417,217$ residents in Great Britain which was collected between 2009-2011 with a large internet-based survey designed and administered in collaboration with the British Broadcasting Corporation (BBC) (see also Jokela et al., 2015). This makes it possible, probably for the first time, to examine historical roots of regional differences in entrepreneurship culture, assessed by a personality approach.

A decade of research into entrepreneurial traits has established that an entrepreneurial constellation of the Big Five traits within the individual (high values in E, C, O; low values in A, N) predicts entrepreneurial activity and motivation at the individual level (see for an overview Obschonka et al., 2013b). Following Obschonka et al., (2015a), we capture this entrepreneurial constellation of the traits with Cronbach and Gleser's (1953) D^2 approach of quantifying the similarity between two profiles – the observed individual profile and a fixed reference profile with an entrepreneurial constellation of the Big Five traits. The fixed reference profile is defined by the outer limits of the single Big Five traits within an entrepreneurial personality structure (i.e., highest possible value in E, C, O (=4); lowest possible value in A, N (=0)). In the first step, each person's squared differences between the reference values and their personal values on each of the five scales were computed. For instance, if a person scored 3 in Neuroticism, the squared difference was 9 (because the reference value was 0). Second, the five squared differences were summed up for each person. Third, the algebraic sign of this sum was reversed (e.g., a value of 20 became -20). The resulting value served as the final variable of the entrepreneurial personality profile, whereby a higher value in this final score signals a stronger entrepreneurial personality structure. These individual scores on the profile were then aggregated to the regional level (average score based on the current residence of the respondents) to achieve the regional value for the local *entrepreneurship culture*. This index of the entrepreneurship culture of regions had a mean of

-20.83 ($SD = 0.38$) across the GB regions. Figure 1A-C visualizes the regional distribution of the entrepreneurship indicators.

*** Fig. 1A-C about here ***

4.2 Industry structure and coalfields

Our central independent variable of interest is the employment share in large-scale industries in 1891 comprising textile, metal manufacturing, coal mining, and bricks and pottery (details below). The employment data came from the British Census which was completed in 10 year intervals. The data were downloaded from the ICEM Nestar webpage and included respondents in 700+ occupations (Higgs et al., 2013). These occupations were summarized into industries applying the lookup table from (Lee, 1979). Although, the 1891 spatial structure differs considerably from today's structure, it is nevertheless possible to assign the historical registration districts in England and Wales as well as the registration counties in Scotland to contemporary counties. If a historical region is now located in multiple contemporary counties, we assigned the number employed in specific industries to the respective contemporary counties based on the historic region's share of the geographical area using GIS (see Fritsch and Wyrwich, 2014 for a similar approach).

We chose 1891 over earlier points in time because we needed additional information on average plant size in order to distinguish large from small scale industries and other industry characteristics. The first comprehensive data on industry structure stem from the 1907 Census of Production. Choosing earlier time periods would not yield very different employment shares in large-scale industries as the spatial distribution of industries remained remarkably stable in the 19th century despite rapid changes in transportation technologies and thus access to markets (Crafts and Mulatu, 2006).

While it would be interesting to simply estimate the model presented in Equation 1 above, the immediate concern of such an approach would be endogeneity. Certain industries might have established themselves in regions (and stayed there) in search of a labor force willing to follow orders, and that would be less likely to start an individual firm if they saw an opportunity (e.g., Obschonka et al., 2013a). Less entrepreneurship in a region might also contribute to the growth of incumbent firms because of missing competition. What is needed is an exogenous variation explaining the presence of large-scale industries in order to establish a causal link between industry structure and entrepreneurship.

As an exogenous instrument for large-scale industries we used the region's distance to the nearest coalfield in the context of industrializing Great Britain in the 18th and 19th century. In order to localize coalfields, we digitized a historic map of coalfields from Hatcher (1993, p. 64). The distance of a county to a coalfield was computed by GIS and refers to the distance between the borders of the nearest coalfield to the borders of the respective region. Our identification strategy of a causal effect of the presence of large-scale industries can be summarized by the first-stage specification

$$2) \text{Largescale}_r^{1891} = \gamma \cdot D_r + Z_r^{first} + \varepsilon_r^{first}$$

Where D is the distance of region r to the nearest coalfield.³

How relevant was the distance to coalfields for large-scale industries? Coal mining was itself a large-scale activity. Naturally, mines could only be successfully operated if the region was part of a coalfield. A short distance to a coalfield was also associated with low coal prices because coal was a bulky commodity with high transportation costs. This fostered growth in

³ Our approach to establish causality differs from other approaches, most notably Granger (1969). Granger's approach builds on time series data of two variables where changes in the independent variable explain and can be used to predict future changes in the dependent variable. We do not follow this approach as there are very limited data on entrepreneurship activities and large-scale industries over time and the entrepreneurship culture indicator is only available for one specific point in time.

certain industries heavily reliant on coal to power steam engines (Crafts and Mulatu, 2005; Crafts and Wolf, 2013). These “steam-intensive” industries were textiles, metal manufacturing, and bricks and pottery (see Table 1 for an overview of certain industry characteristics). Two of these industries were also large-scale in 1891 – textiles ranked 2nd out of 15 industries in average plant size and metal manufacturing ranked 4th. Note that while the information on industrial characteristics are from 1907, textiles and metal manufacturing arguably ranked even higher in the list of large-scale industries in the 18th and early 19th century. The factory system itself was first applied in the textile industry. In ironworks, Cort’s inventions of puddling and rolling around 1784 revolutionized the production process leading to large economies of scale (Mokyr, 2001). In both industries, the availability of cheap coal and the adoption of the steam engine as power source resulted in an unprecedented growth of establishment sizes and high division of labor. In 1891 the cumulated employment share in coal mining, metal manufacturing, textiles and bricks and pottery – forming our measure of large-scale industries – was on average 16.6% in British regions. This regional average masks drastic regional variation as the employment share ranged from a minimum 3.1% in Gwynedd to a maximum of 59.5% in Blackburn with Darwen. It is noteworthy that these large-scale industries are also characterized by a meager use of skilled employees. For example, textiles and metal manufacturing ranked 15th and 12th in the use of white-collar workers. This supports the relevance of low human capital endowment of regions in entrepreneurship. Figure 2A-D illustrates the similar geographical distributions of coalfields, short distances to coalfields, low coal prices and the high employment share in large scale industries.

*** Fig. 2A-D about here ***

*** Table 1 about here ***

The above discussion justifies the relevance of the instrument (distance to nearest

coalfield) for the instrumented variable (employment share in large-scale industries in 1891). However, a credible instrument must also satisfy the exclusion criterion: the instrument should not directly or via an omitted variable affect the dependent variable. Distance to a coalfield is a historical geographical feature and thus unlikely to directly affect *contemporary* entrepreneurship. It arguably had a limited effect on *past* entrepreneurial activity as the mines and firms in steam-intensive industries had to be founded in the first place. However, after these initial entrepreneurial opportunities were exhausted, the distance to a coalfield did not affect entrepreneurship other than via the scale of the firms. Indirect effects other than the presence of large-scale industries of the distance to coalfields are unlikely. Nevertheless, there might be correlations of the distance measure with other geological features such as ruggedness of a region (limited usability of land) and soil quality (affecting agricultural productivity) for which we use adequate controls.

In the 18th and 19th century the dominant use of coal was for combustion. Comparatively, the early alternative uses of coal as an input in the chemical industry were negligible in Great Britain (the employment share in the chemical industry was below 1% in 1891). Later applications of coal and its by-products, including ammonia and phenol in the chemical industry, only became relevant after 1940. Note however, that the chemical industry started to grow after the expansion of the railway system, which reduced transportation costs and shrank the regional differences in coal prices. Crafts and Mulatu (2006) find that between 1871 and 1911, the chemical industry was one of the most dispersed industries in Great Britain, providing evidence against the influence of coal on localization decisions. Other factors, such as the availability of skilled employees and market access, seem to have driven localization of chemical plants (Crafts and Mulatu, 2006).

Note also that because of the exclusion criterion we included the employment share

in coal mining into our instrumented variable – the employment share in large-scale industries – although employment in coal mining is by definition connected with the instrument distance to nearest coalfields. Coal mining shares many characteristics with the steam-intensive industries that negatively affect entrepreneurship: large-scale, manual low-skilled work, few opportunities to start-up. Leaving out employment in coal mining in the operationalization of large-scale industry presence would thus violate the exclusion criterion as employment in coal mining would constitute an omitted variable through which the distance from coalfields could affect entrepreneurship. Nevertheless the results presented below in Section 5 hold even if we exclude mining from the large-scale industries.⁴

4.3 Controls

In both stages of the above described IV estimation procedure the same set of control variables Z is included. Thereby Z includes a list of controls that might also explain the localization of large-scale industries in 1891.

Energy supply. Industrialization began earlier than the invention of the steam-engine. It is therefore possible that large-scale intensive industries might have been already located in regions rich in energy supply other than coal (Nuvolari et al., 2011). Beside horses, the most important power source in medieval times came from watermills. It was not uncommon in the beginning of the steam age for watermills to serve as the main power source, complemented by a steam engine which was only used when there was a drought. The number of watermills in British regions around 1800 is taken from Kanefsky (1979) and serves as control variable in the regressions (as log).

⁴ For the sake of brevity these additional regressions are not reported in the paper but are available from the authors on request.

Market potential. New Economic Geography predicts that industries locate in regions with greater access to markets and customers (Crafts and Mulatu, 2006). Thus, large-scale industries might have located in regions with a spatial proximity to regions with a large customer base. To account for these spatial dependencies we include a Harris-type market potential function which is computed as distance-weighted sum of the employment levels of all other regions (see for a similar approach, Redding and Sturm 2008).

Locational features. Large-scale industries might have located in regions with values opposed to entrepreneurship. As entrepreneurship is a city phenomenon (Glaeser et al., 2010), we control for the regional presence of larger cities in the Middle Ages. The respective dummy variable takes the value of 1 if a city with at least 10,000 inhabitants was located in a region around 1290. Applying the same reasoning, we also include a dummy variable indicating the presence of important harbors in the Middle Ages (around 1290). Additionally, we include a dummy variable indicating whether a university (founded before 1500) was located in the region. Data regarding medieval cities and harbors are taken from Campbell (2008) and data on early universities in Great Britain stem from Rashdall (1895).

Geology and climate. Above we have argued that large-scale industries are located in or close to coalfields. However, the possibility remains that they were located in less prosperous regions and that this lack of prosperity persists until today ultimately determining the contemporary regional distribution of entrepreneurship activity and culture. Thus we include a series of controls intended to capture pre-industrialization wealth. First, in pre-industrialization society wealth was determined to a large degree by agrarian productivity which depended on soil quality and climate (Combes et al., 2010). A region's soil quality is measured with a dummy variable indicating any limits to agricultural use (e.g., gravelly, lithic, or sodic soil; see for a similar approach Falck et al., 2012). An additional variable measures the

soil depth to rocks. The data are taken from the European Soil Project (Panagos et al., 2012; 1km by 1km raster data) and the data generation procedure is described in great detail by Combes et al. (2010). For climate, we use the mean July temperature in the 1960-1990 reference period. Higher temperatures prolong the growing season which should contribute to richer harvests and higher regional wealth. The temperature data are from the Met UK Office (5km grid files). A second source of wealth in a pre-industrialization society was trade (Greif, 1994). Trade routes connected economic centers but probably avoided difficult terrain. As a basic indicator for terrain difficulty we use the ruggedness of a region which is measured by the distance of the maximum and minimum elevation (Falck et al., 2011). Data on terrain differences also stem from the European Soil Project. Note that we do not use other geographic features such as distance to the coast as we already included the presence of harbors as a control.

Employment level and population density. The number of employees of a region is used as a control because a larger population indicates high demand for products and services, which might jointly drive localization decisions of firms and entrepreneurial activity. Population density can be regarded as a catch-all variable as it is correlated with many structural characteristics such as land prices, size of the labor market, and availability of infrastructure (e.g., Fritsch and Wyrwich, 2014).

Table 2 provides summary statistics of the above described variables and correlations among the variables.

*** Table 2 about here ***

5. Results

5.1 IV-results

We employed the Huber-White procedure in all IV-regressions to account for

heteroskedasticity. Note that the variables regarding entrepreneurship activities, the employment share in large-scale industries, the distance to coalfields, and number of watermills are log transformed for the analysis in order to assist interpretation of the regression coefficients.⁵ The results of the first stage estimation are displayed in Table 3 in Model 1-2. In Model 1 we include only the variable distance to coalfields into the regression without any further controls. The distance to a coalfield is statistically significant at the 1% level. This shows that a larger distance to a coalfield reduces the employment in large-scale industries (10% increase in distance reduces the employment share by 2.7%). As other factors might also influence the localization of large-scale industries we include the control variables in Model 2. Regions with larger market potential had a higher share of large-scale industries. Early supply of energy is interestingly negatively related to localization of large-scale industries. Interpreted conservatively, the historic energy supply did not pull large-scale industries into the region. There is also a negative correlation with the presence of medieval cities. One potential explanation for this negative correlation might be that medieval cities had strong guilds which resisted the development of industrialization. Note that the first-stage F statistics are well above 15 in Model 1 and 2 indicating the appropriateness of our instrument.

*** Table 3 about here***

The results of the second-stage regressions on three contemporary entrepreneurship indicators are displayed in Models 3-5. Recall that we use in this stage of the regression only the employment share in large-scale industries which can be explained by spatial proximity to coalfields. The historical coal-related employment share in large-scale industries negatively

⁵ More precisely we take the natural logarithm of the variables +1 as some counties have coalfields and thus a distance of 0 to a coalfield. Adding unity to the variables before log transformation was done for all variables that were logged.

predicts contemporary regional self-employment rates (Model 3), regional start-up rates (Model 4) and the regional entrepreneurship culture (Model 5). As the main variables are entered in logs into the regressions, we can conclude that a 10% increase in the employment share in large-scale industries in 1891 that can be directly related to distance to coalfields leads to a 1.5% decrease in the self-employment rate and a 1.7% decrease in start-up rates in 2011.⁶

Note that the size of the coefficient for employment in large-scale industries in 1891 estimated with the instrumental variable approach does not differ much from those of simple OLS-estimates (the IV coefficient is about the same in the self-employment regression, slightly lower in the start-up rate regression and slightly higher in the entrepreneurship culture regression). This suggests that there is no upward bias in the estimates induced by employing the IV-approach.

5.2 Robustness checks

One main drawback of the above models is that we used only control variables related to the 1891 time period. It is clear, however, that contemporary developments can also explain regional variation in entrepreneurship and entrepreneurship culture. In a robustness check we rely on the growth of Gross Value Added per head (henceforth per capita GVA) and the change in the unemployment rate between 2001 and 2011 as additional controls (Audretsch and Fritsch, 1994; Ritsilä and Tervo, 2002).⁷ These data stem from the 2001 and 2011 Census. We further include the average number of patents over the regional workforce

⁶ The results of the reduced-form equation show – as expected – a positive and significant relationship between distance from a coalfield and the entrepreneurship indicators.

⁷ Note that we rather use changes in the GVA and unemployment instead of levels of GVA and unemployment. This is because levels of regional characteristics are strongly correlated over time and thus with the 1891 employment share in large-scale industries and can be thus regarded as a channel of how past industry structure affects contemporary entrepreneurship.

(age group 16-64 in millions) between 2005 and 2011 (logged). This variable intends to capture the effect of skill-biased technological change on entrepreneurship (Acemoglu, 2002; Berman et al., 1998). Technological change and innovation have a regional dimension which can explain regional variation in entrepreneurship. It is quite possible that the old industrial regions are more affected by this skill-biased technological change. The data on granted patents were kindly provided by the UK Intellectual Property Office. We also substitute the 1891 population density with the population density in 2011. The results of the robustness check (displayed in Table 4) reveal that the coal related employment share in large-scale industries still predicts the entrepreneurship indicators.

*** Table 4 about here ***

A second robustness check tries to capture contemporary migration pattern to the south-eastern parts of England (Champion, 2005) due to economic distress in the old industrialized regions that might have shaped regional variation in entrepreneurship culture and subsequently entrepreneurship activities. In order to rule out that this selective migration drives our results, we reran the analysis using a modified indicator of entrepreneurship culture based on the residence of the respondents in their youth instead of the current residence (which we used in the main analysis). As teenagers do not consciously choose their residence, using youth residence instead provides an indicator of entrepreneurial culture before any occupational and trait-related migration decisions are made. The results of this additional robustness check are presented in Table 5. The coal-related employment share in large-scale industries still predicts the modified entrepreneurship culture measure although the size of the coefficient is reduced.⁸

⁸ Unfortunately, we cannot control for migration decisions of the respondents' parents and grandparents which potentially could also shape today's regional differences in personality and well-being.

** Table 5 about here **

Another drawback of the models presented above is that we use the 1891 employment share in large-scale industries instead of the share from earlier years. In 1891, the British railway system spanned the whole country and might have fostered the relocation of large-scale industries to regions with larger markets (Crafts and Mulatu, 2006; Krugman, 1991). In order to rule out this potentially confounding effect, we turn to another source of employment data which stems from the research project “*The Occupational Structure of Britain c.1379-1911*” (Kitson et al., 2013). One central part of this project is a data set covering the occupation of male inhabitants in England and Wales in the time period 1813-1820 (see for details of the construction procedure, Kitson et al., 2013). Using these employment data we re-computed the male employment share in large-scale industries for the 1813-1820 time period.⁹ The results of the IV-regression are displayed in Table 6 and replicate our earlier findings. Thus, our results are robust across modifications.

*** Table 6 about here ***

5.3 Testing for channels of causality: human capital

While the above discussed results shed light on the effect of industry structure on different aspects of entrepreneurship, they are silent in regards to the actual mechanisms by which the effect is transmitted. We had theorized that the large-scale industries 1) provide a limited number of new entrepreneurial opportunities, 2) impede the acquisition of human capital and entrepreneurial skills, and 3) lead to entrepreneurship inhibiting formal and

⁹ Note that this data set covers England and Wales but not Scotland which reduces the number of counties from 143 to 111. We substitute the 1891 population density with the 1811 population density which stems from the 1811 Census. Note that the 1811 Census does unfortunately not include the number of employees in a region but rather the number of families employed. Thus we substitute in the regressions the regional number of employees with the regional population size and also compute the market potential variable of a region based on the population size of all other regions.

informal institutions. Although we cannot directly test channels 1 and 3, data are available to test the second transmission channel with respect to general human capital.

Based on the literature on human capital and entrepreneurship presented in Section 2, we test the hypothesis that the presence of large-scale industries is associated with lower regional human capital which in turn is related to lower levels of contemporary entrepreneurship. We again rely on the 1820 employment share in large-scale industries as independent variable and the regional start-up rate as dependent variable. Our measure of regional human capital is the regional school attendance rate in 1851. School attendance is measured as the percentage of the children aged 5-14 attending school, which was not compulsory in Great Britain in 1851. The data stem originally from the 1851 Education Census, were initially published in the original Census of Population report and digitized as part of the Great Britain Historical GIS project.¹⁰

We conduct a mediation analysis with the indicators of contemporary entrepreneurship activity and entrepreneurship culture as dependent variable, voluntary school attendance rate as mediator and the coal-related employment share in large-scale industries as independent variable. The latter variable is computed by an auxiliary regression of the 1813-1820 employment share in large-scale industries on the distance from coalfields. Based on this regression we calculated the linear prediction, which results in the regional employment share in large-scale industries that can be attributed to spatial proximity to coalfields. To test for the mediating effect of human capital, we follow the two-step procedure

¹⁰ As noted by Humphrey Southall (2013), the data are not unproblematic as they combine two different sources: data on school attendance from the Census of Education and data on children aged 5-14 from the Census of Population. As a result, the school attendance rate in very small scale regions can exceed 100% (as in the case of the Isle of Scilly). As we use larger regional units in the analysis, we are confident that random variations in the number of pupils and children cancel out. The results should nevertheless be interpreted with some caution. Note that data for the county Rhondda were missing and were imputed by taking the average from neighboring regions.

outlined by Zhao et al. (2010). First, we use bootstrapping to determine the presence of a mediation effect (Preacher and Hayes, 2008). Second, Zhao et al. (2010) suggest using the Baron and Kenny (1986) procedure to illuminate the nature of the mediation (partial or full). The regressions are controlled for the historical presence of cities, harbors and universities, the 1811 market potential of the regions, 1811 population size and 1811 population density.

The results displayed in Table 7 provide some support for the mediation hypothesis. Starting with the indirect effect, both the lower and upper limit of the 95% bias-corrected confidence interval are below zero for regional human capital in the regressions on regional start-up rates and regional entrepreneurship culture but not regional self-employment rates. This shows that there is a negative effect of large-scale industries in 1820 on regional start-up rates and entrepreneurship culture but not self-employment rates running through the human capital transmission channel. The right part of Table 7 shows that after accounting for human capital there is still a significant and negative direct effect of large-scale industries on regional entrepreneurship. This suggests partial mediation of human capital in the relationship between large-scale industries and entrepreneurship. The estimation result suggests that approximately 13% of the effect of large-scale industries on start-up rates is mediated via human capital. This proportion is higher for the entrepreneurship culture where 34% of the effect of large-scale industries is mediated via human capital.

*** Table 7 about here ***

6. Conclusion

This article adds to the growing literature on the regional determinants of entrepreneurial activity and also sheds light on the still dormant domain of the origins of entrepreneurship culture. Generally the existing literature on determinants of the regional variation in

entrepreneurship has focused on cross-sectional empirical evidence, thus impeding causal analysis. Following others, we try to make a contribution by applying a causal method (IV regressions) – which is why this study looks back in history and makes use of an exogenous variation (the regional distribution of coalfields).

We have shown that the presence of large-scale industries in British regions in the 19th century negatively affects entrepreneurial activities and entrepreneurship culture in recent times. Thereby, the distance to coalfields served as an instrument for the presence of large-scale industries because the availability of cheap coal attracted the industries relying on steam power such as metal manufacturing, textiles, and bricks and pottery. The presence of these large-scale industries negatively affects entrepreneurship via several transmission channels. Large-scale industries offer fewer opportunities to start-up and are in historical perspective characterized by low-skill jobs, thereby reducing the necessity for schooling and the accumulation of entrepreneurial skills. Above and beyond these industry-related effects there are also negative effects of large-scale industries on entrepreneurship culture. The lack of entrepreneurial role models can contribute to the development of informal institutions opposed to entrepreneurship. Theoretical approaches to entrepreneurship argue that these forces mutually reinforce each other and can lead to a vicious cycle of low entrepreneurship and weak entrepreneurship culture. Thus, the presence of large-scale industries during the Industrial Revolution in Great Britain seem to have left a long-term imprint that negatively affects different aspects of entrepreneurship, entrepreneurship culture and the actual entrepreneurial activities, even after the large-scale industries have lost their dominating role in the regional economy.

Appendix

Data on coal prices

BPP, 1843. An Account of the Prices at Poor Law Unions, vol. XLV. London: H.M.S.O.

BPP, 1844. Report of the Poor Law Commissioners for Scotland. London: H.M.S.O.

Scottish data are taken from Levitt, I., Scottish Poor Law Commission Statistics, 1844

[computer file]. Colchester, Essex: UK Data Archive [distributor], 1977. SN: 1132,

<http://dx.doi.org/10.5255/UKDASN-1132-1>.

Missing data for some counties (Hartlepool, Kingston upon Hull, Isle of Wight, Isle of Anglesey, Methyr Tyfdill) were imputed by taking the averages from values of neighboring counties.

Coalfield map

We digitized the map on coalfields before 1700 from Hatcher, J., 1993. The History of the British Coal Industry: Volume 1 Before 1700: Towards the Age of Coal. Oxford, Clarendon Press, (p.64).

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Table 1

Industry structure in 1891 with industry characteristics from 1907

Industry	Average employment share in British regions in 1891	Steam-use	Average plant-size	White-collar use
<i>Coal mining</i>	5.1	n.a.	n.a.	n.a.
Food, drink & tobacco	5.8	0.94	15.0	13.4
Chemicals	0.7	2.44	35.9	13.8
<i>Metal manufacturers</i>	3.8	7.10	67.6	5.7
Mechanical engineering	2.4	2.50	50.3	8.5
Instrument engineering	0.2	2.50	23.0	12.2
Electrical engineering	0.1	2.50	64.8	8.5
Shipbuilding	1.0	1.96	164.4	5.0
Vehicles	0.6	1.51	62.4	5.2
Metal goods	0.9	1.57	32.6	7.8
<i>Textiles</i>	6.4	5.74	155.3	3.4
Leather	0.5	0.69	28.9	11.6
Clothing & footwear	8.0	0.45	72.0	10.3
<i>Bricks & pottery</i>	1.2	8.02	39.7	6.1
Timber & furniture	1.6	2.54	22.8	10.1
Paper & publishing	1.4	2.99	21.9	11.8

Notes:

Industries in Italics are summarized as main variable – large-scale industries.

Steam use (steam horsepower per 1000 Pound of gross output).

Average plant size: Average # employees per plant.

White-collar use: percentage share of employees classified as administrative, technical and clerical

Data on steam-use, average plant size and white-collar use are taken from Crafts and Mulatu (2006, p. 591), data on average employment shares are own computations based on 1891 Census data.

Table 2

Descriptive statistics and correlation matrix

Variable	Mean	SD	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) Distance to coalfield	36.61	58.08	0	372	1.00														
(2) Employment share in large-scale industries 1891	16.57	13.92	3.1	59.5	-0.47	1.00													
(3) Self-employment rate 2011	14.68	3.40	8.07	23.3	0.18	-0.47	1.00												
(4) Start-up rate 2011	9.47	2.51	5.5	19.9	0.28	-0.44	0.50	1.00											
(5) Entrepreneurship culture	-20.83	0.38	-22.3	-19.5	0.25	-0.48	0.50	0.58	1.00										
(6) Watermills around 1800	74.16	92.96	1	500	0.07	0.02	0.25	-0.01	0.06	1.00									
(7) Market potential 1891	72924.92	23808.33	15355	134388	-0.17	0.09	-0.02	0.35	-0.00	-0.23	1.00								
(8) Cities around 1290	0.03	0.18	0	1	0.05	-0.15	0.06	0.17	0.10	-0.06	-0.02	1.00							
(9) Universities before 1500	0.03	0.18	0	1	0.00	-0.01	-0.12	0.05	0.00	0.02	-0.10	-0.04	1.00						
(10) Harbors around 1290	0.19	0.39	0	1	0.09	-0.08	-0.01	0.02	0.02	0.06	-0.38	0.30	0.10	1.00					
(11) Limits to agricultural use	0.07	0.26	0	1	0.25	-0.08	-0.05	-0.18	0.05	0.08	-0.32	-0.05	-0.05	-0.06	1.00				
(12) Depth to rock	2.43	1.00	1	4	0.06	-0.16	-0.05	0.28	0.17	-0.06	0.21	0.07	-0.04	0.13	-0.06	1.00			
(13) Mean July temperature	15.15	0.91	12.3	17.0	0.23	-0.13	-0.03	0.15	0.17	-0.12	0.05	0.11	0.08	0.08	-0.04	0.14	1.00		
(14) Ruggedness	457.24	277.21	120	1215	-0.22	0.17	0.16	-0.09	-0.06	0.27	-0.07	-0.07	-0.01	-0.03	0.02	-0.19	-0.74	1.00	
(15) Employment 1891	84364.73	192504.22	17031947583		-0.01	0.08	0.10	0.30	0.13	0.15	0.03	0.38	-0.03	0.15	-0.08	0.12	0.09	0.05	1.00
(16) Population density 1891	363.70	571.62	8.4	3425	0.02	0.10	-0.23	0.13	0.00	-0.27	0.19	0.19	-0.07	0.03	-0.02	0.13	0.21	-0.20	0.50

Notes

Correlations above .16 are significant at the 5% level.

Table 3

Instrumental variable regressions

	first-stage		second-stage		
	1	2 DV: Employment share in large- scale industries 1891	3 DV: Self- employment rate 2011	4 DV: Start- up rate 2011	5 DV: Entrepreneurship culture 2009-2011
Distance to coalfield	-0.274*** (0.020)	-0.297*** (0.025)	---	---	---
Employment share in large-scale industries 1891	---	---	-0.154*** (0.026)	-0.169*** (0.024)	-0.188*** (0.062)
Watermills around 1800	---	-0.116** (0.053)	0.047*** (0.014)	-0.0005 3.24e- 06***	0.019 (0.029)
Market potential 1891	---	-1.88e-06 (2.19e-06)	6.12e-07 (7.24e-07)	(7.24e-07)	-5.05e-08 (1.50e-06)
Cities around 1290	---	-0.646*** (0.206)	-0.029 (0.044)	-0.078 (0.063)	-0.029 (0.134)
Universities prior 1500	---	-0.031 (0.167)	-0.209*** (0.044)	0.095 (0.098)	-0.022 (0.097)
Harbors around 1290	---	0.164 (0.136)	-0.038 (0.042)	0.024 (0.041)	-0.052 (0.077)
Limits to agricultural use	---	-0.091 (0.224)	-0.092 (0.079)	-0.099 (0.074)	0.065 (0.134)
Depth to rock	---	-0.039 (0.056)	-0.019 (0.016)	0.027* (0.015)	0.044 (0.028)
Mean July temperature	---	-0.011 (0.069)	0.039*** (0.015)	0.018 (0.019)	0.085* (0.047)
Ruggedness	---	-0.0002 (0.0002)	0.0001* (6.99e-05)	6.06e-05 (7.00e-05)	0.0002 (0.0002)
Employment 1891	---	5.81e-07* (3.37e-07)	1.55e-07** (6.43e-08)	3.60e- 07***	2.78e-07** (1.37e-07)
Population density 1891	---	-3.08e-05 (0.0001)	-5.85e-05* (3.19e-05)	-3.22e-05 (3.42e-05)	-2.72e-05 (5.65e-05)
Constant	3.125*** (0.071)	4.013*** (1.093)	2.339*** (0.267)	2.143*** (0.332)	-21.88*** (0.824)
Observations	143	143	143	143	143
F-statistic of instrument in first stage	182.8	139.5	---	---	---
F-values	182.8	17.49	10.65	13.7	4.01
R-squared	0.498	0.556	0.504	0.517	0.297

Notes:

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 4

Robustness check with contemporary controls

	first-stage 1	2	second-stage 3	4
	DV: Employment share in large-scale industries 1891	DV: Self- employment rate 2011	DV: Start-up rate 2011	DV: Entrepreneurship culture 2009- 2011
Distance to coalfield	-0.281*** (0.025)	---	---	---
Employment share in large-scale industries 1891	---	-0.159*** (0.026)	-0.160*** (0.024)	-0.177** (0.070)
Watermills around 1800	-0.157** (0.066)	0.038** (0.018)	-0.001 (0.015)	0.037 (0.043)
Market potential 1891	3.85e-06 (2.41e-06)	9.88e-07 (8.02e-07)	2.24e-06** (9.31e-07)	-1.54e-06 (1.64e-06)
Cities around 1290	-0.639*** (0.164)	-0.057 (0.046)	-0.090 (0.055)	-0.022 (0.122)
Universities prior 1500	0.193 (0.168)	-0.226*** (0.053)	0.034 (0.096)	-0.092 (0.108)
Harbors around 1290	0.208 (0.127)	-0.044 (0.041)	0.011 (0.039)	-0.071 (0.075)
Limits to agricultural use	-0.142 (0.216)	-0.115 (0.073)	-0.099 (0.074)	0.071 (0.142)
Depth to rock	0.002 (0.057)	-0.011 (0.015)	0.026* (0.015)	0.035 (0.030)
Mean July temperature	0.055 (0.061)	0.033** (0.016)	0.002 (0.021)	0.064 (0.053)
Ruggedness	-1.27e-05 (0.0002)	0.0001 (0.00001)	0.00002 (0.0001)	0.0001 (0.0002)
Employment 1891	7.79e-07** (2.79e-07)	1.08e-07* (6.04e-08)	3.07e-07*** (6.46e-08)	1.66e-07 (1.32e-07)
Change unemployment rate 2001-2011	-0.008** (0.003)	-0.003*** (0.001)	-0.0002 (0.001)	0.001 (0.002)
Change GVA per head 2001-2011	-0.008 (0.005)	-0.003** (0.002)	0.0004 (0.001)	0.002 (0.003)
Average number of granted patents per 1 million inhabitants 2005-2011	-0.129 (0.086)	0.055*** 0.021	0.064*** 0.021	0.050 0.069
Population density 2011	(9.77e-05)* (5.56e-05)	-0.00003 (0.00002)	-1.74e-06 (0.00002)	0.00003 (0.00004)
Constant	3.554*** (1.002)	2.458*** (0.280)	2.215*** (0.347)	-21.809*** (0.863)
Observations	143	143	143	143
F-statistic of instrument in first stage	121.84	---	---	---
F-values	20.44	---	---	---
R-squared	0.612	0.540	0.549	0.309

Notes:

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 5

Robustness check with entrepreneurship culture based on youth residence

	first-stage	second-stage
	1	2
	DV: Employment share in large-scale industries 1891	DV: Entrepreneurship culture 2009-2011
Distance to coalfield	-0.297*** (0.025)	---
Employment share in large- scale industries 1891	---	-0.095** (0.045)
Watermills around 1800	-0.116** (0.053)	-0.001 (0.022)
Market potential 1891	-1.88e-06 (2.19e-06)	1.05e-06 (1.07e-06)
Cities around 1290	-0.646*** (0.206)	0.060 (0.112)
Universities prior 1500	-0.031 (0.167)	-0.0047 (0.092)
Harbors around 1290	0.164 (0.136)	0.0002 (0.073)
Limits to agricultural use	-0.091 (0.224)	0.098 (0.110)
Depth to rock	-0.039 (0.056)	0.0087 (0.025)
Mean July temperature	-0.011 (0.069)	-0.012 (0.033)
Ruggedness	-0.0002 (0.0002)	-2.08e-05 (0.0001)
Employment 1891	5.81e-07* (3.37e-07)	2.51e-07*** (9.51e-08)
Population density 1891	-3.08e-05 (0.0001)	-3.48e-05 (4.45e-05)
Constant	4.013*** (1.093)	-20.46*** (0.575)
Observations	143	143
F-statistic of instrument in first stage	139.5	---
F-values	17.49	5.39
R-squared	0.556	0.168

Notes:

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 6

Robustness check using 1813-1820 male employment data

	first stage 1 DV: Employment share in large- scale industries 1813-1820	2 DV: Self- employment rate 2011	second stage 3 DV: Start-up rate 2011	4 DV: Entrepreneurship culture 2009- 2011
Distance to coalfield	-0.445*** (0.031)	---	---	---
Employment share in large-scale industries 1813-1820	---	-0.126*** (0.016)	-0.124*** (0.017)	-0.160*** (0.040)
Watermills around 1800	-0.205*** (0.073)	0.054*** (0.013)	0.001 (0.014)	0.058* (0.030)
Market potential 1811	5.11e-06 (4.07e-06)	-6.18e-07 (1.01e-06)	6.52e-06*** (1.00e-06)	4.02e-06* (2.17e-06)
Cities around 1290	-0.171 (0.331)	0.008 (0.059)	-0.023 (0.062)	0.023 (0.129)
Universities prior 1500	0.194 (0.210)	-0.140** (0.069)	-0.090** (0.035)	-0.011 (0.107)
Harbors around 1290	0.225* (0.130)	-0.027 (0.049)	0.0020 (0.038)	-0.026 (0.087)
Limits to agricultural use	-0.760*** (0.283)	0.224*** (0.067)	0.216** (0.084)	0.284** (0.120)
Depth to rock	-0.065 (0.062)	-0.0002 (0.016)	0.023 (0.016)	0.0121 (0.027)
Mean July temperature	-0.205** (0.103)	0.018 (0.020)	-0.017 (0.020)	0.018 (0.042)
Ruggedness	-0.0003 (0.0003)	0.0002** (8.55e-05)	3.01e-05 (7.93e-05)	-9.25e-05 (0.0002)
Population 1811	1.81e-06** (7.32e-07)	2.43e-07*** (7.50e-08)	7.00e-07*** (1.07e-07)	4.55e-07*** (1.66e-07)
Population density 1811	0.0002 (0.0003)	-4.02e-05 (7.50e-05)	-1.54e-05 (8.07e-05)	0.0002 (0.0002)
Constant	6.157*** (1.590)	2.476*** (0.357)	2.173*** (0.346)	-21.38*** (0.720)
Observations	111	111	111	111
F-statistic of instrument in first stage	202.2	---	---	---
F-values	20.85	11.83	23.01	7.03
R-squared	0.682	0.531	0.557	0.327

Notes:

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 7

Mediation analysis

	Indirect effect			Direct effect		
	Observed coefficient	LLCI	ULCI	Observed coefficient	LLCI	ULCI
Human capital on start-up rate	-.026** (.013)	-.055	-.007	-.200*** (.042)	-.026	-.095
Human capital on self-employment rate	.002 (.018)	-.034	.038	-.208*** (.053)	-.308	-.104
Human capital on entrepreneurship culture	-.006** (.003)	-.014	-.002	-.013* (.007)	-.027	.001

Notes

Bootstrapping using 5000 replications using case resampling; N=111 English and Welsh regions; Unstandardized coefficients of direct and indirect effects are reported; standard errors in parentheses; 95% bias-corrected confidence interval; LLCI=Lower Limit Confidence Interval; ULCI=Upper Limit Confidence Interval; *** p<0.01, ** p<0.05, * p<0.1

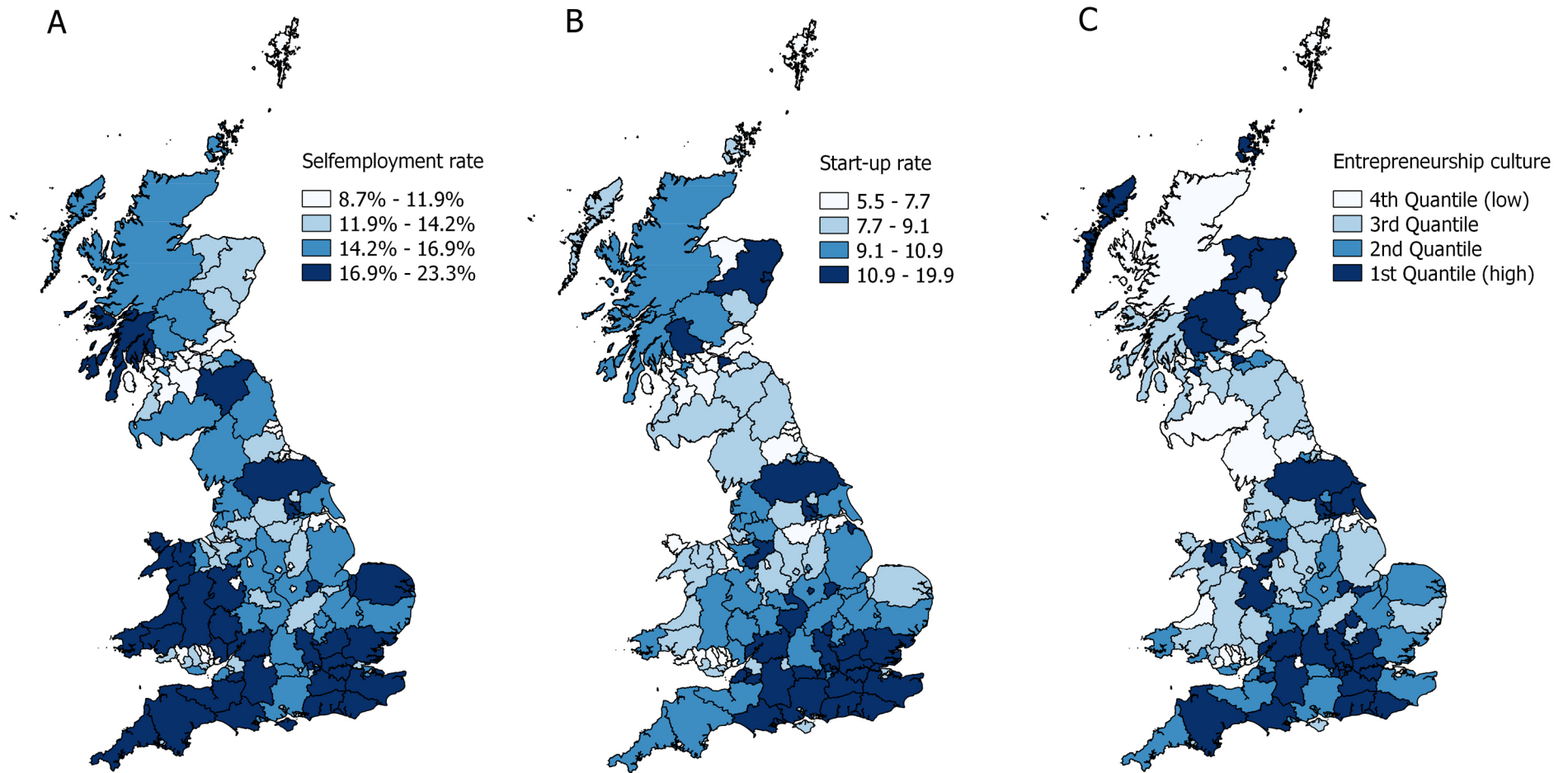


Fig 1. Entrepreneurship indicators: A – Self-employment rate in 2011; B – Start-up rate in 2011; C – Entrepreneurship culture 2009-2011

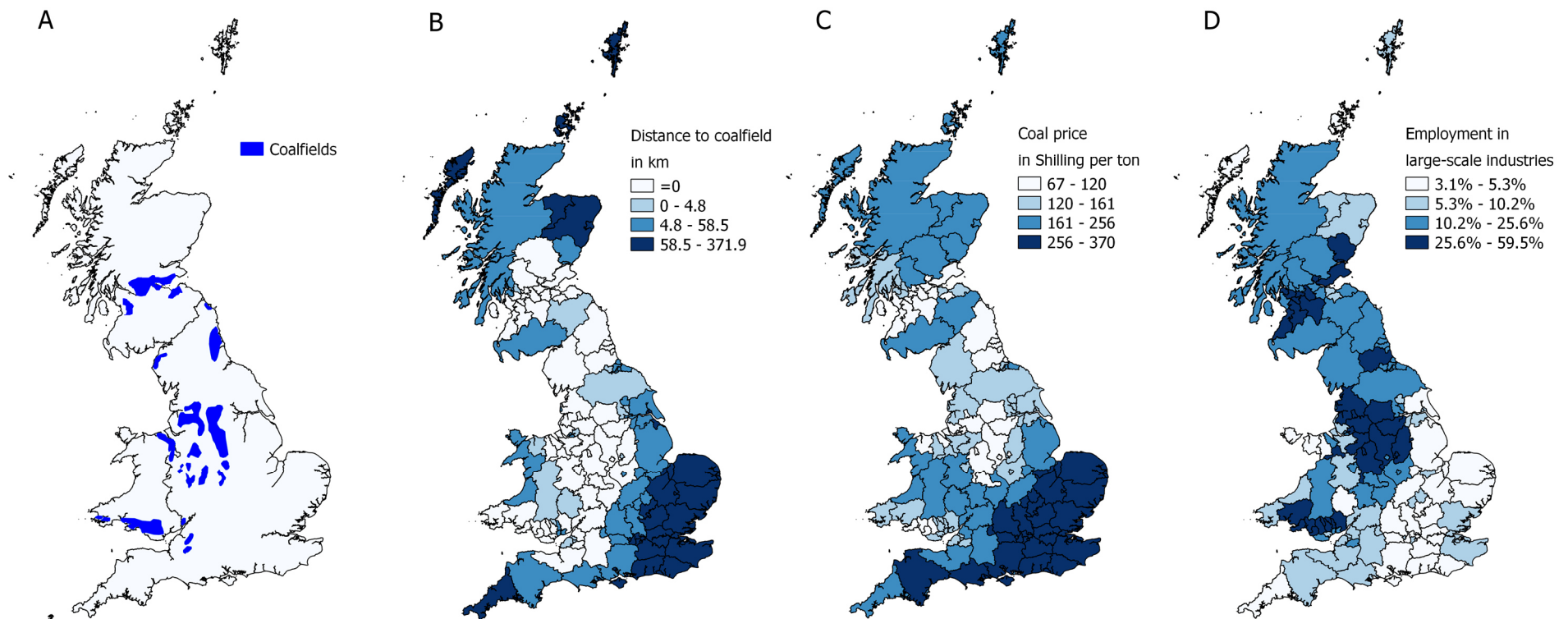


Fig. 2. Coal and employment in large-scale industries: A – Coalfields before 1700; B – Distance to nearest coalfield in km; C – Coal price around 1840 in Shilling per ton; D – Employment share in large-scale industries in 1891

Notes:

See Appendix for data sources on coalfields and coal prices.

The distance of a county to a coalfield was computed by GIS and refers to the distance between the borders of the nearest coalfield to the borders of the respective region.