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# Shacklean Uncertainty and Cultural Embeddedness as Innovation Constraints in the UK

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## Abstract

We focus on both individual and local uncertainty to explain the innovation potential of entrepreneurs in the NUTS1 UK regions in 2005 and 2009. The ‘potential surprise function’ (Shackle, 1949) clarifying why sometimes promising business choices are truncated is taken as a determinant of an entrepreneur’s innovation decision. GEM (Global Entrepreneurship Monitor) data and data on psychological types are used in the empirical analysis. The econometric estimation strategy addresses both the issue of selection bias (due to uncertainty) and that of zero-inflated data (i.e., presence of only a few highly innovative actors in comparison to the majority in our sample). Findings suggest that local uncertainty is the predominant determinant of individual entrepreneurial choice. The regional effect appears to amount to about 4% of the innovation differences across NUTS1 UK regions, while almost one third of it is determined by the local level of uncertainty bias. Thus, the novelty of the present study is that it shows how differences in local cultural tolerance to uncertainty may explain differences in the quantity of truncated innovative ideas among localities.

**Keywords:** potential surprise function; entrepreneurship; innovation; knowledge; epistemic uncertainty; cultural embeddedness; Culture Based Development, quality ladder.

**JEL classification:** Z10, D81, R11

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# 1 Introduction

Are non-entrepreneurs in general non-creative people? Or can they be sub-divided into two types: people with no ideas at all and people with very innovative ideas who are however not encouraged to venture into entrepreneurship by the local environment or by past dependence? By sticking to the presumed certainty of knowledge derived from past experiences, do we constrain the growth of new knowledge itself? Why is the evidence regarding the impact of knowledge on local economic growth still somewhat patchy<sup>1</sup>? And more in particular, why is there no well-substantiated explanation for local disparities in entrepreneurial success<sup>2</sup>?

In order to address such questions, one major strand of contemporary research, initiated by Aghion and Howitt (1992), has argued that the new enterprise is an engine of economic growth, whenever it is able to generate innovation and to grow big<sup>3</sup> – the Steve Jobs type of success, which starts small, grows fast, and becomes so large to be soon included in the *Fortune 500*. This entrepreneurial success is clearly different from a neighborhood hairdresser shop opened by a technical school graduate and closed down at her/his retirement age. Yet, this barber shop may also be regarded as a success in terms of job creation<sup>4</sup>. Such heterogeneity in the nature of entrepreneurial outcomes confronts economists clearly with a difficult measurement problem (Fischer and Nijkamp 2009; Fritsch and Storey, 2014). However, whatever further development a new business undergoes, it always starts off by taking a decision about venturing into an activity facing actual uncertainty on the choice regarding ideas on which little is known from previous experiences.

A seminal contribution to understanding the mechanism differentiating between the operation of risk and uncertainty in making a choice on innovative ideas was proposed by G.L.S. Shackle (1949), in the form of what he calls a ‘potential surprise function’. Trivial ideas for which enough past examples are

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<sup>1</sup> Cf. also Romer, 1994; Mulhern, 1995. The main findings from the entrepreneurship literature are reported by Baumol, 1990; Griliches, 1998; Audretsch and Fritsch, 2002; Keller, 2002; Carree and Thurik, 2003; Audretsch and Lehman, 2005; Yusuf 2012; Piergiovanni et al., 2012.

<sup>2</sup> Frenz and Ietto-Gillies, 2009; Phelps, 2013; Mokyr, 2014; Tubadji et al., 2016.

<sup>3</sup> Schumpeter, 1934; Romer, 1994; Santarelli and Vivarelli, 2007; Åstebro, 2011.

implemented and the probability of success or failure may be statistically predicted or evaluated through a standard risk related function. Genuinely new ideas with little or no previous implementation or success feedbacks are evaluated under uncertainty regarding the final outcome. The uncertainty-based function of this business evaluation describes essentially a process of a double negative selection bias, taking as an input for choice a new idea for investment. Depending on the level of innovativeness, the knowledge about the expected return on this investment faces different degrees of uncertainty. The least innovative ideas are well known to the market in terms of their aftermaths, and face therefore little uncertainty, and get easily truncated as being *unprofitable*. The innovative ideas for which some degree of knowledge is present at the market will easier get accepted, as they are likely to be associated with *normal profits*. The most innovative ideas, which potentially may be the *most profitable* ones, get often truncated (excluded) from the set of propositions for choice, as the level of uncertainty about the aftermaths of their implementation is very high. Ultimately, this is how an uncertainty-driven selection bias generates a pool of entrepreneurially non-active individuals, among whom both the least innovative and the most innovative actors can be found.

Our study aims to delve further into – and to enrich - the original Shacklean potential surprise function by distinguishing between different levels of uncertainty shaping the actor's choice mechanism, that represent a classical focus in the entrepreneurship literature (see Zhao et al., 2010), in which many authors (Aizen, 1991; Fritsch and Wyrwich, 2017, 2014; Huggins and Thompson, 2015; Stuetzer et al 2015; Tubadji and Nijkamp, 2015a) have identified the local *milieu* as a source of entrepreneurial spirit and persistence. The distinction between individual and context is naturally a well-known distinction in bounded rationality approaches (see for instance Munier et al, 1999).

To express the idea of a dual level of uncertainty behind the potential surprise function, we focus on both the uncertainty-related inclinations of the entrepreneur (*individual uncertainty*) and the uncertainty-related attitude characterizing the spatial cultural context in which an entrepreneur makes her/his investment decision (*local uncertainty*). Our aims are, therefore:

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<sup>4</sup> Birch, 1987; Loveman and Songenberger, 1991; Neumark et al., 2011; Kok and de Wit, 2014.

- To conceptualize the mechanism linking the individual uncertainty of the entrepreneur to the fact that the success of a new enterprise is a surprise to society;
- To analyze how individual attitudes toward uncertainty and the local surprise from the entrepreneurial idea jointly shape the innovation process;
- To address and test empirically the hypothesis that individual and local uncertainty may determine the outcome of innovative processes.

The structure of the paper is as follows. Section 2 reviews the literature on how uncertainty relates to a potential surprise function. Section 3 presents a testable model of the link between Shacklean uncertainty and a Schumpeterian Quality Ladder (QL) model leading to an entrepreneurial investment decision. Section 4 introduces the data base and the estimation strategy, while Section 5 describes the empirical results. Finally, Section 6 offers concluding remarks.

## **2 Entrepreneurial Investment Choice, Knowledge and Culture**

Uncertainty is a condition for human choice. Since Herbert Simon (1955), human choice in economics has often been discussed in a perfect-rationality vs. bounded-rationality antagony. When faced with choice situations characterized by insufficient knowledge about the implementation or social acceptance of discussion on projects, individuals experience uncertainty and tend to avoid often such projects, even if these would be potentially profitable. This leaves the question open as to how boundedness in knowledge can be overcome on an aggregate (local) level. To answer this question, one should state which are the levels of uncertainty relevant to investment choice by potential entrepreneurs.

Firstly, every choice depends on individual knowledge, which in turn is only a segment of the body of human knowledge and can be said to operate under conditions of epistemic uncertainty (Tversky and Kahneman, 1973; Kahneman, 2011; Shackle, 1949). This individual epistemic uncertainty has a different weight in one's choice. In fact, the human agency issue behind a certain choice may rest with the decision-maker, a second person or a group (Bandura, 1986; Demayer, 1991; Shepherd, 2011). Thus, the nature of

these economic choices will be different with regard to who bears the responsibility for the aftermaths as well as the benefits from the outcome of the choice (Shepherd and Zacharakis, 1997)<sup>5</sup>.

Moreover, if identical agents are observed and the available economic input is controlled for, the individual attitude towards uncertainty remains the only barrier to choice. Yet, even when we take responsibility only for ourselves, we still strive to remain rational and minimize our chances for failure to a reasonable extent. Therefore, when taking a risk, we aim at finding a road that better addresses the economic production mechanism and serves the supply and demand mechanisms in a way that under profit-maximizing conditions will minimize the risk of eventual loss. Yet, for many options we do not know the exact risk faced because of a lack of previous observations on a probabilistic estimation of potential outcomes. This process of considering uncertain options is known as the epistemic (knowledge) challenge for innovation, tapping on the 'unknown unknowns' (Arrow, 1971; Shackle, 1983). This phenomenon can be formally represented, following Schumpeter, with a 'Quality Ladder model'<sup>6</sup>, where a jump from one level of knowledge to another drives the process of creative destruction in the economy.

Secondly, local uncertainty shapes the culture of any given part of a territory and ultimately affects the outcome of individual economic choice. The individual attitude regarding conditions of uncertainty is a function of personal psychological tolerance to uncertainty. Homophily brings people with similar preferences spatially sorted in groups (Axelrod, 1997). But since local culture is an aggregate of idiosyncratic individual uncertainties, its average level is always different from the specific individual level regarding uncertainty. This local culture might even intensify the individual attitudes in an aggregate form. On the one side, this is consistent with the type of agent-based model put forward by Schelling (see Arribas-Bel et al., 2016), and on the other side with the National Systems of Entrepreneurship approach that entrepreneurial processes are embedded in the local institutional framework (Acs et al., 2014). Therefore, in every choice the decision-maker, as part of society, has to handle – on top of her/his own uncertainty – the uncertainty experienced by her/his group and society at large, which are eventually

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<sup>5</sup> When taking a personal choice, we obviously have less responsibility to anyone else but ourselves for its outcomes and aftermaths. It is therefore up to the decision-maker to what degree of risk and uncertainty she/he wants to expose her/himself, the individual interest being the only barrier for making a choice. The highest level of uncertainty without local cultural constraints by the potentially inflicted damage to third parties may be accepted by the entrepreneur.

stakeholders (or evaluators) of the choice made. The inclusion of local uncertainty in one's own personal choice is termed here cultural embeddedness (see also Kloosterman and Rath, 2001; Kloosterman et al. 2010).

Cultural embeddedness applies to every human choice. But why is it especially relevant for choice under uncertainty? It is known that in a cognitive process we can think fast (spontaneously) or slow (analytically) (Kahneman, 2011). Accordingly, we are able to react spontaneously – through our heuristics – to small or emergent threatening circumstances that require immediate action. But normally, we base our decisions regarding economic investments, among others, on rational and strategic cognitive processes. In such choice situations, we involve more of our skills and knowledge: As stated in the relevant literature, those processes are subject to contextual cultural embeddedness<sup>7</sup>. Yet, only a few studies have shed light on the mechanistic link between probabilistic rationality and group-heuristic preferences and rules. Meanwhile, the latter are influential, as they are culturally institutionalized (as informal institutions in Douglass North' (1990) sense) in a locality. They represent a serious barrier to free decision-making and its cost-benefit analysis (Becker, 1968).

We can now analyze the way individual and local uncertainty influences the potential surprise function in terms of a precise determining mechanism. As Shackle (1949) explains, venturing into innovation implies facing the world of the 'unknown unknowns'; i.e., it requires deciding on propositions beyond those about which the probability of success or failure is possible to statistically predict, based on past experiences. Thus, risk of an unknown level is addressed by the decision maker in a situation of uncertainty (Knight, 1921; Soros, 2014; Amoroso et al., 2016). This situation is perceived as a threat by our cognitive system, which therefore activates what Kahneman (2011) terms the 'fast thinking' mechanisms. As a result, propositions which are in the domain of the 'unknown unknowns' get 'fastly' truncated (excluded) from

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<sup>6</sup> See e.g. also King and Levine, 1993; Ericson and Pakes, 1995; Cohen and Klepper, 1996a,b; Klette and Griliches, 2000; Barro and Sala-i-Martin, 1995.

<sup>7</sup> See Rawls, 1971; Ajzen, 1991; Davidsson, 1995; Westlund et al., 2014; House et al., 2002; Hofstede and McCrae, 2008; Tubadji et al., 2016; Laspita et al., 2012; Huggins and Clifton, 2011; Huggins and Thompson, 2015). Culture as a local factor for individual choice is often termed differently in the literature: cultural habitus (Bourdieu, 1986; Spigel 2016), embeddedness of decision making (Rawls, 1971), or culture as a set of "shared values legitimating social practices" (Wildavsky, 1987, 1988). In the economics literature, local culture has been frequently analysed, among others, by Burt (1992 and 2000); Ajzen, 1991; Leibbrandt et al., 2013; Alesina and Giuliano, 2015.

the set of those considered for choice. This truncation mechanism is the potential surprise function suggested by Shackle (1949).

Our proposition regarding the analytics of this phenomenon is to adopt the Culture Based Development (CBD) approach of considering together in an explanatory model the individual and local cultural preferences and their interaction (Tubadji and Nijkamp, 2015b). And therefore, we suggest that the truncation in the potential surprise function has two levels – a truncation due to one’s individual uncertainty and a truncation due to the local uncertainty, with the interaction between them reflecting internal conflicts with the preferences in the environment at hand. When our own slow analytical thinking is challenged by lack of knowledge, we make our choice by switching to fast heuristic thinking which feeds on local culture and its cultural uncertainty level.

Thirdly, the nexus that remains to be considered here is what makes entrepreneurs different from non-entrepreneurs, and how decision makers become heterogeneous on an uncertain level of deciding without previous experience for comparison. According to Shackle, openness to the ‘unknown unknowns’, in spite of their uncertainty, is what makes a difference in innovative choice (Shackle, 1949). Thus, while risk uses existing knowledge, uncertainty uses the local cultural attitude and its heuristics to determine choice. The local uncertainty may truncate on its own right useful ideas, even if we are ready to accept the uncertainty. Thus, the pool of people locally constrained from entrepreneurial investment are both people who don’t have innovative ideas at all, and people whose ideas have been rejected as a consequence of individual or local uncertainty. This process results in Weberian local differences in rationality (Weber, 1905; Tubadji, 2014), implying people from different localities ending up with differences in their rational thinking and in the generated solutions for the same problem. Since local uncertainty drives innovative choice, the quality and quantity of innovation (and of lost (truncated) innovation) will thus differ among regions due to the cultural relativity across space.



### 3 A Culture Based Development Perspective on Uncertainty in the Schumpeterian Quality Ladder Model

Schumpeter's (1934) Quality Ladder (QL) model has drawn much theoretical and empirical attention. It states that, at a given level of knowledge, the price of a project is set through a net present valuation based on: (i) the available investment and (ii) the expected return on investment components. This model can be associated with Shackle's (1949; see also Cowen, 2003) work on the 'unknown unknowns' and the related potential surprise function. According to this concept, every individual learns through her/his unique path of experience, so that every person's perception of rationality and risk is somewhat unique.

The Culture Based Development (CBD) model adds to Shackle's view a neo-Weberian perspective on the significance of the local factor and the spatial sorting of people according to their preferences. Even if unique, people tend to spatially sort according to their cultural proximity (Axelrod, 1997; Hofstede, 1983; 2001; Tubadji and Nijkamp, 2015b).

Both individual epistemic uncertainty and local group cultural embeddedness are, therefore, to be taken into consideration. The following general model of uncertainty, culture and innovation augments the Schumpeterian QL model with Shackle's surprise function of the 'unknown unknowns':

$$Y_{ij} = f_{CC}(A_j, (1-A)_i, Z, r_{ij}) \quad (1)$$

where the index  $i$  stands for the individual  $i$ , and  $j$  for the locality  $j$ , while  $Y_{ij}$  is the entrepreneur's economic success measure,  $A_j$  is the available level of knowledge in one's habitus (i.e. the locally known part of the world where he belongs to intellectually),  $(1-A)_i$  is the individual share of local knowledge not known to the individual (i.e. her/his personal 'unknown unknowns' domain, which is different than her/his skill level)<sup>8</sup>,  $Z$  is the capital investment required for implementing the entrepreneurial idea under consideration,

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<sup>8</sup> In the classical QL model,  $A_j$  is a constant, which may hold true only in given moments of time/localities.  $(1-A)_i$  is a person-specific unique number denoting one's path of experience and training, and it is just one of the elements integrated in  $A_j$ . When  $A_j$  is a monotonous constant function, the integral and the direct sum of the individual pieces of knowledge are not the mathematical identity due to *a*) Shellings' A-B type of intensification of beliefs on an aggregate level on one side (so some pieces of individual knowledge have been truncated from the aggregate belief function), and *b*) the fact that some pieces of individual knowledge coincide between individuals, and this counts as one piece of true knowledge in  $A_j$  and is not multiplied by the number of individuals in possession of it. Thus, true knowledge in possession of people in locality  $j$  is a non-additive constant, while individual knowledge is a function of it which follows an individually specific random process of cognitive

and  $r_{ij}$  is the rate of return from this investment over time for the specific entrepreneur  $i$  in the specific locality  $j$  (which is a probabilistic function of the past preferences of the local market about similar goods/services as the proposition under consideration). The output of this function tends to move to a different level of innovation depending on the cultural limit imposed by local cultural relativity and is denoted here as CC (i.e., local cultural capital) (Tiebout, 1956; Tubadji et al., 2015a).

Based on the above model (1), we can now state our testable hypothesis as follows:

***H01:** Under ‘consideration-for-investment’ choice conditions, both individual and local uncertainty are formative for the predicted future profitability of an idea for innovation, and thus they predetermine ceteris paribus<sup>9</sup> how close to the optimal economic success (i.e. innovativeness) the chosen idea will be.*

The innovative potential of the entrepreneur is a function of the transformation of her/his utility from uncertainty avoidance into a risk preference which is culturally embedded, i.e. dependent on local culture. The empirical testing of the above hypothesis using model (1) is the subject matter of the next section. Two different econometric approaches will be combined in our operational modelling approach in order to triangulate (i.e., to confirm as a final inference from two alternative estimation methods applied on the same query) the conclusions reached in this study.

## **4 Operationalization of the CBD Uncertainty QL Model**

### **4.1 Database**

Our goal is to explore whether it is the individual or the local uncertainty that is decisive in the entrepreneurial process, using the UK as a case study. The dependent variable is the degree of entrepreneurial innovativeness that an individual has engaged in. The independent variables are divided into two groups: (i) economic factors (the investment needed and the risk of the investment – probabilistically known from past experiences – based on Schumpeter’s QL model; and (ii) cultural factors – comprising the epistemic uncertainty proposed by Shackle (1949), driving the potential surprise function

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formation of the individual. It is  $(1 - A_j)$  and  $(1 - A_i)$  that gives the sum of absolute full truth which is epistemically unknown to the individual due to bounded rationality.

which is responsible for the generally low number of innovative individuals in every society – and the Culture Based Development (CBD) and cultural-gravity motivated variables: local cultural embeddedness and an interaction term between individual uncertainty and local uncertainty of the *milieu* in which the individual is embedded. For a summary description of our variables, see Table 1 below.

+++ Insert Table 1 about here +++

To quantify the relevant variables, we use two datasets – (i) the Global Entrepreneurship Monitor (GEM) and (ii) the psychological types of the UK regions on a NUTS1 level, obtained from Rentfrow et al. (2015). The GEM data is the main source, informing our dependent variable and most of the explanatory variables, while the Rentfrow et al. (2015) dataset is used to provide a measure for local uncertainty, as an alternative to the self-reported individual perceptions available from the GEM dataset. The GEM data cover the years 2005 and 2009. While the year 2005 is only used as a control dataset<sup>10</sup>, the data for the year 2009 is the main dataset, containing over 30,000 observations and a regional identifier on the NUTS1 level for every individual observation..

Our variables are grouped into three categories: (i) standard QL model variables, (ii) cultural uncertainty variables which are the main variables of interest for our Shacklean working hypothesis for the significance of uncertainty as a driver behind the potential surprise function; and (iii) personal controls. For the derivation of these variables from the GEM questionnaire, we refer to Appendix 1.

Specifically, the main dependent variable is labelled  $y$  and indicates the level of innovativeness chosen by the individual. This choice indicator varies between 0 and 10. It has been obtained on the basis of the ranked levels of individual involvement into entrepreneurship (respectively, rank 4 if running a private company and being involved in its operation, rank 3 if being employed in an entrepreneurial activity, rank 2 if being an owner of an entrepreneurial activity, and the lowest rank 1 if only intending to open a business in the next 3 years). As an individual might be involved in more than one type of activity, we aggregate additively the reported types of activities per individual. For more details on the precise

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<sup>9</sup> On the limitations of the *ceteris paribus* concept see Nijkamp (2007), as well as Kahneman's (2011) work on random success.

<sup>10</sup> The year 2005 is only used as a control dataset, due to the crisis period proximity of the year 2009 and the eventual shock-driven deviations from the usual economic performance, as the concept of cultural hysteresis would suggest as a plausible explanation (see for details Tubadji et al., 2016).

quantification of  $y$ , we refer to Appendix 1. Based on  $y$ , a dummy variable equal to 1 is generated for the cases when the dependent variable needs to be dichotomous. This dummy variable is labelled  $dy$  and is equal to 1, when  $y$  is different from 0.

Additionally, the innovation choice has to be explained with the economic capital available for investment ( $Z$ ) and the expected return on the investment ( $r$ ).  $Z$  is calculated by the authors on the basis of information from the GEM questions about the amount of capital available to the entrepreneur. The expected return on investment  $r$  is quantified in a different manner for the different types of entrepreneurial categories due to the different questions suitable for this purpose. These involve alternatively either a ratio between employed personnel and expected employed personnel in a five-years period ahead, or a self-reported percentage of expected return. For a precise description of the quantification of  $Z$  and  $r$ , see Appendix 1.

Our uncertainty-related variables are thus individual and local. The individual epistemic uncertainty attitude is measured through a dummy variable, labelled as  $EpU$ , equal to 1, if fear of failure is self-reported as a barrier to venturing into entrepreneurship. The local attitude to uncertainty is alternatively quantified through the GEM or Rentfrow et al. (2015) dataset. The GEM measure is the self-reported perception of the level of local openness to entrepreneurial activity. This is a dummy variable labelled  $CEmb$ , equal to 1, if the locality is considered pro-entrepreneurial in spirit by the individual. The motivation of  $CEmb$  is based on an individual experiencing cultural embeddedness in a locality with a lower level of fear of uncertainty (higher tolerance to uncertainty) when  $CEmb$  increases. Alternatively, Rentfrow et al. (2015) provide the level of each of five psychological types for 12 (out of 14 in total) UK NUTS1 regions. These five psychological types – usually referred to as the “Big Five traits” (cf., among others, Gosling et al., 2003; McCrae and Costa, 2003; Obschonka et al., 2013; Stuetzer et al., 2015) - include: extraversion, agreeableness, conscientiousness, neuroticism and openness. We use the level of neuroticism (i.e. level of emotional stability) to approximate a higher level of uncertainty avoidance as it is the closest in its essence among the Big Five to the nature of uncertainty. This variable is labelled  $RFI$ . We will pursue the estimations with all available alternative variables, but will report here on the basis of  $RFI$  and eventual deviations from its performance by the other psychological type variables. Also, we note that

our two alternative measures for local attitudes to uncertainty, *CEmb* and *RFI*, are expected to have opposite impacts on innovation, since the increase in the GEM based variable signifies a decrease of uncertainty avoidance, while the increase in the *RFI* variable signifies an increase of uncertainty avoidance.

In addition, personal characteristics obtained from the GEM dataset are used as control variables. These include: the age category of the individual (variable labelled *age*), a dummy variable equal to 1 if the gender is male (variable *male*); the educational level of the individual, a dummy variable equal to 1 when the person has the highest (university level) educational degree (*hc*); and a dummy variable equal to 1 if the individual is unemployed (labelled *unempl*). Finally, we do not include controls for distance to university as it is well known from the literature about UK that the latter does not have overall sufficient explanatory power for local innovation (see, for instance, Abramovsky and Simpson, 2011).

## 4.2 Estimation Strategy

The use of the above empirical data on innovative behaviour and entrepreneurship, as presented in model (1), leads us to pursue the analysis of innovation and entrepreneurial propensity as a limited dependent variable case. We have a “double negative” potential surprise function, where an innovative idea might be assigned a zero potential surprise and be excluded as a potential choice due to being either too much below or too much above the current quality-ladder level attainable to the average decision-maker’s knowledge. The resulting variable can have a value of 1, 2 or 3 etc. depending on the mode of one’s entrepreneurial/innovative involvement (i.e. entrepreneur, employee in an entrepreneurial activity, investor in someone’s entrepreneurial activity, etc.). However, if an individual is observed as non-innovative, she/he is assigned the level of zero innovative choice. This condition can be summarized as follows:

$$Y_{ij} = [ y^*, \text{ if } Y_{ij} > 0, \text{ and } y^* = 0, \text{ if } Y_{ij} \leq 0 ] \quad (2)$$

The above expression (2) means that the potential innovative choice is what is observed in the data only when the choice has actually been made, and then its value is different from zero depending on the level of

innovativeness of the idea as perceived by the decision-maker. Yet, when the potential innovative choice is not undertaken, and is registered as zero, this zero might stand for either: (i) real lack of innovative option for choice, or (ii) an overly innovative option for choice that the individual could not realize. Thus, our dataset has a double negative zero – denoting both least and most innovative propositions for choice. In other words, the entrepreneurial innovative choice dataset is censored from below, with zero as the cutting value for the censoring.

Thus, since we have a sample censored from below (left) at zero, we should apply an estimation method fit for dealing with this type of situation: either a Tobit model, or – the assumptions-wise more relaxed – Cragg model which allows for different independent variables to be used for explaining the selection process and the choice process. Finally, a Heckman selection model may also be appropriate, as our dependent variable of interest is innovation choice, while we are approximating it with a choice for venturing in entrepreneurial activity. This leaves open the probability that some of the people who do not engage in entrepreneurship still may have innovative ideas and avoid the choice due to cultural barriers of uncertainty. A test of log likelihoods for the Tobit, Cragg's and Heckman models will be inferred to choose the most appropriate of these three estimation approaches.

In specific terms, our empirical operationalization of model (1) has the following form:

$$\begin{aligned} \Pr(Y>0) &= F(\beta_0 + \beta_1Z + \beta_2r + \beta_3CC), \text{ considering that} \\ E(Y|Y>0) &= F(\beta_4 + \beta_5Z + \beta_6r + \beta_7CC) + \text{Adj} \end{aligned} \quad (3)$$

Model (3) shows that we will estimate a Probit model for the effect of the size of investment needed  $Z$ , the rate of expected return  $r$ , and the cultural bias through uncertainty  $CC$ , on the level of innovativeness of choice by the entrepreneur approximated with the type of entrepreneurial activity the person gets involved in (an individual entrepreneur, an investor (or a future investor) in entrepreneurial activity or an employee in entrepreneurial activity). We will adjust then the estimation of the same model for the case of the truncated sample, where the zeros are removed, but this removal is accounted for with the factor  $\text{Adj}$ , which accounts for the dual limit of the probability of  $Y$  being equal to or less than 0 (where  $\text{Adj}$  takes its specific standard mathematical form depending on whether we apply the Tobit, Cragg's or Heckman model, respectively). The theoretical underpinning of this truncation explaining estimation stems directly

from the truncating Shacklelean potential surprise function based on uncertainty as driver for the 0 and 1 switch. Finally, as clarified in the theoretical section of this paper, the culturally limited uncertainty of the chooser, noted as CC, can be viewed as composed of two elements – one’s personal epistemic uncertainty, which is individually specific, and the local cultural *milieu* in which one is embedded (Rawls, 1970). Thus CC can be disintegrated into individual and local components as follows:

$$\begin{aligned} \Pr(Y>0) &= F(\beta_0 + \beta_1 Z + \beta_2 r + \beta_3 EU_i + \beta_4 CE_j + \beta_5 EpU_i * CEmb_j), \text{ considering that} \\ E(Y|Y>0) &= F(\beta_6 + \beta_7 Z + \beta_8 r + \beta_9 EU_i + \beta_{10} CE_j + \beta_{11} EpU_i * CEmb_j) + Adj \end{aligned} \quad (4)$$

where the  $CC_i$  independent variable from model (3) is substituted for the personal epistemic uncertainty  $EpU_i$  (self-reported fear of failure) and the local cultural embeddedness effect  $CEmb_j$  (average local openness to entrepreneurship or level of the local neuroticism as a psychological type) and their interaction term  $EpU_i * CEmb_j$  for the particular individual decision maker<sup>11</sup>.

At a next major step, we account for the fact that our Heckman model is very close to a zero-inflated Poisson regression implementation. The latter would be actually an even more suitable approach in the case of our data, which indeed has an inflated (i.e. over-represented) zero population, since a smaller percentage of people (about 10% of the overall population) is involved in entrepreneurship. Thus, the zero-inflated Poisson regression might perform better than our Heckman selection model, because it is more suitable for count data models. The zero-inflated Poisson model is used to model count data that has an excess of zero counts, based on the logics that the excess zeros are generated by a separate process (i.e., have other independent variables explaining them) from the count values. In addition, the excess zeros in the zero-inflated Poisson model can be modeled independently. Thus, this model has two parts, a Poisson count model and the logit model for predicting excess zeros; i.e., it is a Heckman selection (for the zero’s) with a count-data Poisson model. Our Heckman model pays attention to the selection-bias, but ignores the fact that our dependent variable is count data (see Table 1 and Table 5) and not a continuous number, as the Heckman model previously discussed would require. However, while our data is zero-inflated count data, the distribution is not exactly a Poisson distribution. Actually, there are indications for over-dispersion in

our count data dependent variable (see Figure 1a and b). Therefore, in a further amendment and to gain more precision, we should actually adopt a zero-inflated negative binomial model in order to express the Heckman selection bias in a quantitative manner best fit for our over-dispersed dependent variable (innovativeness). The zero-inflated negative binomial model also explains the excess zeros by a separate process from the count values. And these excess zero's can be modeled independently, which is the approach adopted by us and theoretically motivated by the double negative space created by the Shacklean potential surprise function (meaning that our zero's have a double meaning of very trivial and very innovative ideas mixed into one dual in nature set of zero's). We explain more the zero's with the cultural embeddedness and individual uncertainty of the people, while in a next stage in a count model we address the truncated model for the innovativeness of the entrepreneurs. We estimate both a Poisson and a negative binomial for zero-inflated models, just for comparing the outcomes.

Finally, we have also the opportunity to quantify the regional uncertainty effect not only through measurement (i.e., an additional variable), but also through estimation (i.e. empirical modeling). Statistically, this signifies that we have a classical hierarchical data structure, of people's choice being nested in local levels of uncertainty by region, which can be expressed by a hierarchical model (see Woltman et al. 2012; Li and Valliant 2015)<sup>12</sup>. Because multiple individual inclinations are measured from the same region, their measurements are not independent. Hierarchical modeling takes that issue into account and offers a clear quantitative measure for the level of nested-ness and the way we can explain it stochastically; in other words, how big is the regional effect and how big is the cultural bias on individual uncertainty in this effect?

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<sup>11</sup> When the estimating procedure allows for it, we may exclude  $Z$  and  $r$  from predicting the selection bias in the first equation of model (4), thus avoiding endogeneity and measurement limitations.

<sup>12</sup> The use of hierarchical models started first in health services and education-related research, but lately there have been several successful applications of this method for both entrepreneurial and regional development analysis. See the hierarchical linear modelling as in Laspita et al. (2012) for analyzing the transmission of entrepreneurial intentions between children nested in the same schools and states, and in Kourtit et al. (2014) for regional development differences on city level.



## 5 Empirical Results

We explore these two GEM datasets – for 2005 and for 2009, respectively, before and after the global financial crisis – in order to control for eventual economic shock differences. The exact definition of every variable, and its main descriptive statistics for each year, are presented in Table 1a, while the exact questionnaire question that a variable is based on in our 2005 and 2009 datasets is given in Appendix 1. We have only for 2009 the regional identifiers linking each individual observation to one of the 14 NUTS1 regions in the UK. As can be seen from Table 1b above, the dataset for 2009 is also three times bigger in terms of number of observations, but both datasets are representative for the country. Some further statistical details about the heterogeneity of the data and the main dependent variable are presented in Table 1b below.

+++ insert Table 2 about here +++

As seen from Table 2, the main output variable of interest, normally pro-innovative choice, measured through venturing into an entrepreneurial activity (with a degree of innovativeness varying between 1 and 10) reflects in both years about the same 0.35 value (representing the level of innovativeness). This similarity holds true even when we look in greater detail at the dependent variable, distinguishing between the censored sample (including the positive observations for the  $y$  and the zero observations) and the truncated sample (only the positive observations for  $y$ ). It is also interesting to note that in both 2005 and 2009 the mean for the truncated sample is about 10 times higher than the mean for the censored sample, which is an indication of the above mentioned limited dependent variable issue in handling this dataset. The only slight statistical difference in the datasets is the age composition, with the number of young people decreasing from 2005 to 2009. These descriptive statistics lead to two intuitive notions: (i) the individual characteristics are likely to be relevant, since the level of innovativeness of people entering into entrepreneurial activity is about 10 times higher than that of those who opt altogether out of pro-innovation activities; (ii) as the results for innovativeness are similar for 2009 and 2005, we may expect certain place-related patterns of innovation and local persistence in the levels of entrepreneurial activity.

Since individuals face indeed a limited dependent variable dataset, we first approach the analysis with a Tobit model estimation, suitable for censored datasets. An OLS estimation is implemented for comparison

purposes, as shown in Table 2a, b, and c below. In a next step, a Tobit and a Cragg model are estimated. A Tobit model estimation involves the same explanatory variables in both the censored and the truncated model estimation, which rule is relaxed in the Cragg model. Our Cragg model is estimated combining a Probit model for entering at all in entrepreneurship and a truncated regression for the level of innovativeness. In estimating this Cragg model, we are allowed to involve only the uncertainty-related variables and personal controls in the Probit model, whereas the available economic investment  $Z$  and the expected rate of return  $r$  on top of the personal controls are included in the truncated regression. This is important because of the quantification of  $Z$ .

+++ insert Table 3a, b, and c about here +++

Table 3a, b, and c present an estimation for the degree of innovativeness (varying between 0 and 10, and left censored from below at 0), explained by available economic capital ( $Z$ ), past-probability-based rationally expected rate of return ( $r$ ) and controls for personal characteristics (i.a. human capital, age, gender, employment status). We also include uncertainty-related variables inferring individual uncertainty ( $EpU$ ) and local uncertainty (alternatively either the self-reported  $CEmb$  from GEM or the psychological type  $RFI$  measuring a level of “neuroticism”<sup>13</sup> in the UK regions, available from Rentfrow et al. (2015)). We compare the results from our three types of estimation. Table 2a presents the results for year 2005, Table 2b presents the results for 2009, which are identical as a quantification strategy to the ones in Table 2a. Namely, the local uncertainty is measured with the GEM-based variable  $CEmb$ , which indicates a perceived positive local attitude to entrepreneurial activity. Table 2c presents the results for 2009, where local uncertainty is measured with the psychological type variable  $RFI$  for neuroticism. Thus  $CEmb$  (in Table 2a&b) and  $RFI$  (in Table 2c) are expected to have opposite signs of impact on the pro-innovation choice of individuals.

The results from Table 2a, b, and c show that the financial feasibility  $Z$  is indeed a determinant of the decision to engage into entrepreneurship together with the rate of return ( $r$ ), as expected by a

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<sup>13</sup> The definition of neuroticism, found in McCrae and Costa (2003: 47) states that it “is the polar opposite of emotional stability”. In this sense, we assume the opposite of emotional stability can be understood also as uncertainty and therefore, we consider this measure very suitable for the characteristics of the cultural milieu most relevant in our context of innovation and

Schumpeterian QL model. Among the personal characteristics, the findings show the usual male dominance and a positive impact from human capital and the model is generally performs as well-specified and stable. Age seems irrelevant for distinguishing the level of innovation ventured by an individual in UK. The positive association between unemployment status and the likelihood of venturing into more innovative entrepreneurship supports both the notion that: (i) entrepreneurship is used as a way out of unemployment and (ii) there is higher proneness to facing uncertainty under higher incentives for profit. The most interesting finding for the purposes of our analysis is that the dominating uncertainty-related factor for pro-innovative choice is the local level of uncertainty. Irrespective of whether it is measured by the self-reported *CEmb* or by the psychological type *RFI*, we always observe that the local uncertainty outperforms the individual uncertainty measure and that their interaction is relevant due to the strong local uncertainty component<sup>14</sup>. These results suggest that the level of uncertainty in which an individual is locally embedded has a stronger impact on choice than individual uncertainty. Clearly, part of the individual uncertainty may be difficult to distinguish from the expected rate of return on individual level, which would explain the lower level of significance of the individual uncertainty variable (*EpU*). But this does not seem to affect the results for *r* when included or excluded from the OLS estimations. Moreover, the Tobit model also generates the expected difference in signs between the *CEmb* and *RFI* variable. This is the case for both the Tobit and the generally more flexible Cragg model. But our post-estimation Tobit vs. Cragg model test<sup>15</sup> is in favour of the Tobit model, so we consider these results as more reliable and plausible.

We use next a Heckman model which accounts for the co-variance between Probit and truncated regression in the Cragg type of model and is thus a more precise approach to the impact from the uncertainty-based

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entrepreneurial decisions. We conducted alternative estimations with each of the Big Five, but neuroticism, as theoretically expected as closest to the state of uncertainty, performed most statistically powerfully.

<sup>14</sup> Our results regarding the psychological types in UK are also consistent with the findings of Stuetzer et al. (2015), who use the same data.

<sup>15</sup> The essence of our test of Tobit vs. Cragg model is the falsification of the restriction for some coefficients in the discrete and continuous decisions, which restriction holds true for the Tobit and is relaxed for the Cragg model. Thus, in the test for Tobit vs. Cragg model, we save the log likelihoods of our Probit, truncated regression and Tobit models. We obtain a likelihood ratio t-statistics by adding the log likelihoods of the Probit and truncated regression (i.e. the Cragg model) and subtracting the log likelihood of the Tobit model. The result is multiplied by 2. The obtained log likelihood ratio has a chi-square distribution and degrees of freedom equal to the independent variables and the intercept. The test rejects the Tobit model, if the obtained log likelihood ration t-statistics exceeds the critical value of the chi-square.

pre-selection bias of the sample. This is an unique opportunity to express the theoretical Shacklean preselection through the potential surprise function through a precise empirical model replica of the logics of the operation of the mechanism. The results from our Heckman model estimations are presented in Tables 4 and 5 below.

+++ insert Table 4 and Table 5 about here +++

Table 4 shows two types of specifications of a Heckman model: (i) where the selection bias is estimated on the basis of individual and local uncertainty and their interaction; (ii) where the selection bias is explained by the latter uncertainty-related measures and personal characteristics as well. Estimations for the year 2005 and for the year 2009 are shown, where for 2009 we have the quantification of local uncertainty levels alternatively with only the GEM based self-reported variable *CEmb* or with the psychological type *RFI* variable measuring the level of neuroticism in the region where the observed individual is an active economic agent.

Our results demonstrate that the pre-selection bias is always driven by the local uncertainty component, irrespective of its way of quantification and consistent with the expected sign and economic meaning of the alternative measures (positive for *CEmb* and negative for *RFI* when significant). This effect holds also when personal characteristics controls are involved. Among the personal controls, we see a consistent dominance of the male gender for selection into entrepreneurial activity, and a secondary strength of significance of human capital and unemployment status. These results indicate that one's personal characteristics indeed matter as such (i.e., a strong individual uniqueness effect as supposed by Shackle). Still, a person's proneness to venturing into an entrepreneurial activity is highly pre-determined by the local level of uncertainty in the region where she/he is active, which is the CBD cultural limit augmentation of the Shacklean hypothesis. The marginal effects for the Heckman model estimations are presented in Table 4. The results confirm the relevance of a Schumpeterian QL model, with strongly significant standard components of the model ( $Z$  and  $r$ ), as key factors for the level of one's innovativeness. Yet, these factors enter into play only after a strong truncation based on the Shackle potential surprise function and its core local uncertainty-avoidance limit, determining who will at all venture into entrepreneurship and which individual will not. Furthermore, we note that both the expected return on investment and the positive

effect from the local cultural embeddedness increase in year 2009 in comparison to year 2005. This can be accepted as a finding consistent with the cultural hysteresis concept, according to which the crisis period faces a decreased enthusiasm for entrepreneurial activity *per se* (see Tubadji et al. 2016). Finally, the distribution of zeros and non-zero observations shows a possibility for amelioration of the precision of the estimation approaches, as shown in Table 6 below.

+++ insert Table 6 about here +++

Table 6 shows that for both the year 2005 and the year 2009 we have about 88% of zero observations. Thus, our dataset is not only censored but also zero-inflated. In order to decide what type of zero-inflated model to estimate, in Figure 1a and b we look at the dispersion of the data.

+++ insert Figure 1a and b about here +++

For both 2005 (Figure 1a) and 2009 (Figure 1b), the positive observations of innovativeness ( $y > 0$ ) vary significantly. Most of the observations concentrate at around a level of 2 and then gradually decrease. The dispersion suggests a Poisson distribution, but this does not fit precisely, although an over-dispersion is also difficult to infer conclusively. Thus, we estimate both a zero-inflated Poisson model (suitable for a Poisson distribution) and a zero-inflated negative binomial (suitable for cases with over-dispersion). The results in Table 5 also indicate that only about 12% of the population in UK actually engages in innovative activity. This finding is consistent with previous studies on the UK with the GEM dataset (see Levie and Hart, 2009: 14).

The results from our zero-inflated models are presented in Tables 7 and 8 below.

+++ insert Table 7 and 8 about here +++

Table 7 presents a model for explaining the level of innovation through economic capital ( $Z$ ), expected rate of return ( $r$ ) and personal characteristics, this accounting for the zeros in the dataset explained by our set of individual and local uncertainty measures and their interaction. In a manner analogous to the preceding estimations, we have now estimations for 2005 and 2009 with only GEM data and an estimation for 2009, where the local uncertainty is approximated with the RF1 variable (measuring the local level of neuroticism). The results in Table 6 are similar in terms of their economic interpretation to what we saw in the previous estimations. This means that a methodological triangulation, in line with Downward and

Mearman (2007), supports the findings that in a standardly performing Schumpeterian QL model for entrepreneurial choice<sup>16</sup>, the local level of uncertainty plays a significant role in explaining the zeros of innovation, i.e., the people who are not involved in entrepreneurial activity *per se*. This result is in line with our main combined CBD-Shacklean hypothesis for truncation of innovation as a result of an uncertainty avoidance limit on the potential surprise function. Moreover, we find again the local uncertainty avoidance and one's embeddedness in it as dominating over the personal avoidance of uncertainty as such. As the zero-inflated model explains the zeros rather than the positive observations, the uncertainty effect on truncation shows reverse signs. However, the expected economic meaning of *CEmb* and *RFI* is opposite to each other, and in line with our theoretical expectations and empirical findings. In fact, the coefficients recording the positive impact of cultural embeddedness are somewhat lower for 2009, as well as the expected rate of return (which changes from 0.04 to 0.02). Table 8 presents the average marginal effects for our estimated zero-inflated models. The results are fully consistent with the previous findings as well, and are reported here only for complete documentation of the obtained results. The triangulation of our findings seems to be robust for a variation of the estimation method applied. Embeddedness in a local cultural *milieu* that is positive to entrepreneurship (i.e., lower uncertainty avoidance) promotes entrepreneurial involvement on average, and the opposite for a highly uncertainty avoiding environment.

This strong message for local cultural embeddedness imposing a limit to the local innovation function appears to be particularly interesting. Therefore, in a last exploratory step, we will focus our attention on a better disentangling of the local effect on innovativeness and the role of the cultural tendency to uncertainty avoidance in the regional effect. Table 8 presents the composition of the data by geographical NUTS1 regions.

+++ insert Table 9 about here +++

Table 9 shows the 14 NUTS1 UK regions for which there is an identifier in our 2009 GEM dataset. We know for each individual observation the NUTS1 region it belongs to. However, the psychological type data from Rentfrow et al. (2015) excludes Belfast and Other North Ireland, thus the number of observations

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<sup>16</sup> The main factors economic capital  $Z$  and return on investment  $r$ , and some personal characteristics such as gender (male), human capital and unemployment, are also included in the estimation.

amounts to 27,003, when variable *RFI* is used. What is of more interest here however, is whether there is indeed a different pattern of innovativeness across the regions of UK. Figure 2 provides the answer according to our data analysis.

+++ insert Figure 2 about here +++

Figure 2 presents the relationship between amount invested and level of innovation achieved in the 14 UK NUTS1 regions. The pattern of investment and the level of innovation appear to be rather different in the different regions<sup>17</sup>. A similar figure is obtained if innovation is mapped against the local level of uncertainty. These results confirm that the data needs further exploration with regard to the nested-ness of individuals within regions in order to explain their level of cultural embeddedness and the resulting truncation of innovative ideas for entrepreneurial investment.

To address this regional nested structure of the dataset and its cultural uncertainty-related attitude component, we adopt the hierarchical (multi-level) regression method that allows us to differentiate between fixed and random parts<sup>18</sup> of the error from the OLS regression, accounting for the nested structure and quantifying the level of its impact and the role of uncertainty in this regional effect explained in a stochastic manner. The results are presented in Table 10 below.

+++ insert Table 10 about here +++

Table 10 presents results from the estimation of a Schumpeterian QL model, driven by the economic capital invested (*Z*), the expected rate of return (*r*), and personal controls. The local effect is accounted for and stochastically explained in turn by the individual and local level of uncertainty avoidance and their interaction. The first, basic specification accounts only for the part of the variance in the data due to the random variation between the observations and the part of it which is fixed and associated with the regional clustering. Specifications 2 to 4 disentangle further this regional clustering effect, by explaining it stochastically through different modes of approximation of the local uncertainty avoidance trends. Namely, specification 2 explains the local variation with the self-reported perceived local level of uncertainty avoidance (*CEmb*). Specification 3 replaces the latter with our alternative measure of local embeddedness

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<sup>17</sup> Available upon request.

<sup>18</sup> See Graubard and Korn (1996), Raudenbush and Bryk (2002).

in the uncertainty-related local cultural attitude, alternatively approximated by the neuroticism psychological type from Rentfrow et al. (2015) - variable *RF1*. Specification 4 uses the self-reported GEM variable *CEmb* and interacts it with the individual uncertainty avoidance levels. Specification 5 infers the interaction between the *RF1* and the individual uncertainty avoidance levels.

The results from the QL model confirm the previous findings regarding the main factors as well as the individual control characteristics. Besides, they now do not only allow to confirm the significance of the local level of uncertainty, but also to report its quantitative size and the size of its dependence on the local cultural attitude to uncertainty. Firstly, the local clustering accounts for 0.06 of the differences in pro-innovative choices in the UK. Next, when we explain stochastically local innovativeness with the standard QL model and individual controls, the regional effect decreases to 0.04. When we stochastically explain the regional difference with local levels of uncertainty, we find a significant part of the local effect being associated with the local cultural attitude of uncertainty<sup>19</sup>. Interaction between individual and local uncertainty is confirmed to be a significant source for the regional differences in levels of innovation. Thus, while indeed entrepreneurs are a specific small part of the population in the UK, their local innovativeness is not due to their individual traits only, but also to the innovativeness function operating under a cultural limit imposed by the local tendency to uncertainty avoidance. It is not only *who* one is, but also *where* one is in terms of spatial sorting – and these two factors acting in interaction – to determine the regional level of innovation achieved. Thus, the Shackleian individual uniqueness and the Schumpeterian QL model jointly explain individual innovativeness in the UK. Finally, it is noteworthy that the local cultural limit to the potential surprise function explains about one third of the variation in innovation across the UK NUTS1 regions.

## 6 Conclusions

Our findings show that innovative choices originate mostly from a tolerance to uncertainty in the locality where an individual economic agent operates. Thus, our main working hypothesis that a locally-specific



cultural limit to Shacklean uncertainty behind the individual potential surprise function imposes a local cultural attitude-driven selection bias on the local level of innovation cannot be rejected.

The above findings have two main consequences. First, they demonstrate that innovation and local concentration of innovative people are a function of the local proneness to innovation, which is in turn a function of the local cultural attitude to uncertainty. This finding is in line with the cultural gravity concept (Tubadji and Nijkamp, 2015) according to which the most creative people concentrate in places which have a cultural *milieu* most favorable to creativity and more open to uncertainty. Second, they show a lower positive impact from the (positive) local cultural *milieu* in the years closer to the Global Financial Crisis period. This is consistent with the concept of cultural hysteresis, according to which, in crisis periods, there is a fall in the efficiency of the usual incentives for entrepreneurship. Both the concept of local cultural attitude to uncertainty and that of cultural hysteresis are part of the Culture Based Development (CBD) paradigm about the existence of cultural mechanisms affecting entrepreneurial innovation. According to the CBD, what drives the economically relevant human choices is mostly the local cultural *milieu* in interaction with the individual unique cultural attitudes and preferences, while economic input comes only second in importance<sup>20</sup>. Such findings in support of the local cultural attitude are in line also with the place-based development concept (see Huggins and Thompson 2015, Stuetzer et al. 2015) (similar in its basic hypothesis to CBD), and the theory of planned behavior (Ajzen 1991) which accounts for the significance of the context as a major factor for the choice made by the economic agent. Clearly, this can next be extended as a support to Sen's (1993) hypothesis that individual preferences are context-regulated and to Rawls' (1970) concept of embeddedness of the individual choice in a social context.

A possible limitation of the present study is that in the hierarchical model, when stochastically estimating the regional effect, besides the local cultural factor also local economic inputs might be relevant to be included as regressors. Data on local physical capital, however, is difficult to obtain, while labour, human capital and the generated local economic output (local GDP or GVA) are all culturally endogenous. A possible resolution to take into consideration this data constraint is to identify the centroids of each NUTS1

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<sup>19</sup> This is about 30% of this effect when we use the self-reported measure for local uncertainty from the GEM dataset.

and include an economic concept such as central place theory in using this geo-coded data as approximation for economic inputs (see Nijkamp and Reggiani, 1998). This idea remains clearly an avenue for future research.

In sum, our study shows evidence for a culture-based truncation of the possibilities for innovation in a region or locality, based on Shackle's uncertainty-driven potential surprise function. While people's proneness to innovation is to a large extent rational, according to a Schumpeterian QL model, there seems to exist indeed also a regional and local cultural *milieu*-related selection bias ruling over this individual economic choice. From a policy perspective, these findings also mean that a clearly significant factor for regional innovation disparities is found to be the local average proneness to embracing uncertainty. This last conclusion provides an interesting starting point for gathering further empirical evidence on the significance of an uncertainty-loving local cultural *milieu* as a factor for local innovation and economic prosperity of a region.

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<sup>20</sup> This is in essence a neo-Weberian view that a locally different cultural attitude (culturally relative rationale) determines the local disparities in economic welfare.

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**Table 1: List of Variables: Definition and Descriptive Statistics**

year		2005						2009					Theoretical motivation
Variable description	Code	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max		
Dependent variable	<b>Level of innovativeness</b> chosen by the individual - approximated with number of innovative activities one is self-reportedly involved in	y	11181	0.35	1.10	0	10	29962	0.34	1.12	0	10	Schumpeter's Quality Ladder Model
		dy	11203	0.12	0.33	0	1	30003	0.12	0.32	0	1	
Economic factor	<b>Economic input</b> (size of investment)	Z	11203	2507	49900	0	1000000	30003	4356	65700	0	1000000	
	<b>Probabilistically known risk</b> (reflecting current level of knowledge A) - approximated with self-reported expected return on investment	r	11203	0.09	0.78	0	55.56	30003	0.02	0.30	0	33.33	
Cultural factor	<b>Epistemic uncertainty</b> (individual domain of 'unknown unknowns' about the implementation of the innovative idea) - approximated with self reported fear of failure	EpU	11203	0.20	0.40	0	1	30003	0.19	0.39	0	1	Shackle's potential surprise function
	<b>Cultural embeddedness</b> (influence on choice from the local/group cultural milieu) - approximated with self reported good attitude of the locality towards entrepreneurial activity or alternatively by the local average psychological level of neurosis	CEmb	11203	0.25	0.43	0	1	30003	0.29	0.46	0	1	Culture Based Development (cultural gravity)
	<b>Interaction between individual epistemic uncertainty &amp; local cultural embeddedness</b> (i.e. the effect of the group uncertainty on the individual uncertainty)	inter_EpU~b	11203	0.02	0.15	0	1	30003	0.03	0.16	0	1	
Control variables	<b>Demographic and personal characteristics</b> (self reported age, sex, educational level, unemployment status)	age	10872	45.4	15.4	16	80	30003	72.8	143.2	16	80	Standard controls for an empirical micro-economic model
		male	11203	0.41	0.49	0	1	30003	0.40	0.49	0	1	
		hc	11203	0.69	0.46	0	1	30003	0.51	0.50	0	1	
		unempl	11075	0.05	0.21	0	1	30003	0.06	0.23	0	1	

Legend:

The table presents descriptive statistics of the dependent and independent variables and controls used in our empirical model. The definition, quantification strategy and theoretical motivation are indicated for each variable. Economic input is in thousands of British pounds. The exact definition of each variable per dataset and the corresponding question from the questionnaire used is available in Appendix 1.

**Table 2: Data Heterogeneity by Individual and by Type of Innovation-related Choice**

year	2005			2009						
Age	Freq.	Percent	Cum.	Freq.	Percent	Cum.				
0-17	190	1.75	1.75	351	1.17	1.17				
18-24	789	7.26	9	1382	4.61	5.78				
25-34	1,927	17.72	26.73	3,198	10.66	16.44				
35-44	2,531	23.28	50.01	5,436	18.12	34.55				
45-54	2,169	19.95	69.96	6,365	21.21	55.77				
55-64	1,876	17.26	87.21	6,500	21.66	77.43				
65-120	1,390	12.79	100	6,771	22.57	100				
Total	10,872	100		30,003	100					
year	2005			year	2009_GEMonly					
y				y						
Percentile	Smallest			Percentile	Smallest					
1%	0	0		1%	0	0				
5%	0	0		5%	0	0				
10%	0	0	Obs	11181	10%	0	0	Obs	29962	
25%	0	0	Variance	11181	25%	0	0	Sum of W <sub>i</sub>	29962	
50%	0		Mean	0.351579	50%	0		Mean	0.336593	
	Largest		Std. Dev.	1.104429		Largest	Std.	Dev.	1.116648	
75%	0	10			75%	0	10			
90%	2	10	Variance	1.219762	90%	2	10	Variance	1.246903	
95%	2	10	Skewness	3.987536	95%	2	10	Skewness	4.407148	
99%	6	10	Kurtosis	21.63495	99%	6	10	Kurtosis	25.98235	
y>0				y>0						
Percentile	Smallest			Percentile	Smallest					
1%	1	1		1%	1	1				
5%	1	1		5%	2	1				
10%	2	1	Obs	1364	10%	2	1	Obs	3452	
25%	2	1	Sum of W <sub>i</sub>	1364	25%	2	1	Sum of W <sub>i</sub>	3452	
50%	2		Mean	2.881965	50%	2		Mean	2.921495	
	Largest		Std. Dev.	1.645376		Largest	Std.	Dev.	1.808711	
75%	4	10			75%	3	10			
90%	6	10	Variance	2.707261	90%	6	10	Variance	3.271436	
95%	6	10	Skewness	1.708608	95%	7	10	Skewness	1.845902	
99%	9	10	Kurtosis	5.715258	99%	9	10	Kurtosis	5.783403	

Legend:

*The table presents descriptive statistics of individual characteristics (age group) and a detailed comparison between 2005 and 2009 of the dependent variable y (level of innovation of the entrepreneurial choice, varying from 0 to 10).*



**Table 3: Tobit and Crag's Model Estimations for Pro-Innovation Choice**

year	2005																
	OLS				Tobit				Cragg's model (Probit & Truncated Reg)								
y	coef.	t-value	coef.	t-value	coef.	t-value	marg eff censored	marg eff trunc	coef.	z-value	coef.	z-value	marg eff				
age	0.000	0.60	0.000	0.49	0.002	0.45	0.000	0.45	0.000	0.66	0.000	0.06	0.000	0.06			
male	0.236	12.12	0.223	11.56	1.856	12.58	0.196	12.87	0.319	12.88	0.450	13.76	0.103	0.89			
hc	0.147	7.07	0.123	5.92	1.354	7.78	0.143	7.91	0.233	7.87	0.349	8.85	-0.247	-1.67			
unempl	-0.088	-1.91	-0.079	-1.72	-1.190	-2.86	-0.125	-2.87	-0.205	-2.86	-0.265	-2.81	0.841	2.43			
Z	0.000	18.74	0.000	18.50	0.000	8.75	0.000	8.60	0.000	8.76	-	-	0.000	5.49			
r	0.519	42.19	0.513	42.12	1.188	20.15	0.125	18.48	0.204	20.35	-	-	0.230	9.71			
EpU	-	-	0.007	0.28	0.187	0.91	0.020	0.91	0.032	0.91	0.042	0.90	-0.141	-0.80			
CEmb	-	-	0.223	9.45	1.893	11.18	0.200	11.34	0.326	11.38	0.477	12.61	-0.229	-1.79			
inter_EpU	-	-	0.597	8.56	2.462	6.05	0.260	6.01	0.424	6.06	0.663	6.84	0.079	0.28			
_cons	0.086	2.54	0.042	1.22	-8.028	-23.35	-	-	-	-	-1.844	-28.87	2.632	11.24			
/sigma					4.478647	4.268739							1.770902	35.41			
Tobittest	-14582.3																
F/chi	F(6,10718)=430.8				F(9,10715)=321.05				chi2(9) = 1157.56				chi2(7)=657.02			chi2(9)=146.64	
Prob>F(ch	0.0000				0.0000				0.0000				0.0000			0.0000	
R-sq	0.19		0.21				-		-						-		
Adj. R-sq	0.19		0.21														
N	10725		10725		10725						10725		1310				

year	2009_GEMonly																
	OLS				Tobit				Cragg's model (Probit & Truncated Reg)								
y	coef.	t-value	coef.	t-value	coef.	t-value	marg eff censored	marg eff trunc	coef.	z-value	coef.	z-value	marg eff				
age	0.000	-0.99	0.000	-0.86	0.000	-0.43	0.000	-0.43	0.000	-0.04	-0.001	-1.59	0.000	-1.59			
male	0.267	21.48	0.257	21.03	2.180	22.24	0.214	22.83	0.367	22.87	0.463	23.02	0.374	4.00			
hc	0.148	12.04	0.114	9.36	1.069	10.92	0.105	11.01	0.180	11.00	0.234	11.32	0.106	1.11			
unempl	0.058	2.20	0.042	1.65	-0.082	-0.40	-0.008	-0.40	-0.014	-0.40	-0.071	-1.58	1.197	6.39			
Z	0.000	50.55	0.000	49.99	0.000	22.28	0.000	21.31	0.000	22.37	-	-	0.000	14.28			
r	0.521	26.13	0.496	25.33	1.585	16.82	0.156	16.47	0.267	16.89	-	-	0.042	0.92			
EpU	-	-	0.025	1.51	0.259	1.83	0.025	1.83	0.044	1.83	0.035	1.16	0.256	1.72			
CEmb	-	-	0.231	16.41	2.093	19.15	0.206	19.51	0.352	19.55	0.461	20.47	-0.055	-0.53			
inter_EpU	-	-	0.837	19.99	3.433	13.50	0.337	13.30	0.577	13.53	0.951	16.80	-0.339	-1.61			
_cons	0.124	11.90	0.052	4.58	-8.472	-50.54	-	-	-	-	-1.762	-79.76	1.936	15.36			
/sigma					4.837488	4.697992							2.138989	49.97			
Tobittest	-38836.4																
F/chi	F(6,29955)=709.78				F(9,29952)=604.52				chi2(9) = 2789.83				chi2(7)=2066.45			chi2(8)=.	
Prob>F(ch	0.0000				0.0000				0.0000				0.0000			.	
R-sq	0.12		0.15				-		-						-		
Adj. R-sq	0.12		0.15														
N	29962		29962		29962						29962		3452				

year	2009_GEMwithRF1																
	OLS				Tobit				Cragg's model (Probit & Truncated Reg)								
y	coef.	t-value	coef.	t-value	coef.	t-value	marg eff censored	marg eff trunc	coef.	z-value	coef.	z-value	marg eff				
age	0.000	-0.99	0.000	-0.79	0.000	-0.36	0.000	-0.36	0.000	-0.01	0.000	-1.42	0.000	-1.42			
male	0.267	21.48	0.270	20.43	2.261	21.52	0.242	22.14	0.391	22.11	0.463	22.53	0.328	3.38			
hc	0.148	12.04	0.146	11.18	1.335	12.72	0.143	12.87	0.231	12.85	0.280	13.32	0.121	1.22			
unempl	0.058	2.20	0.063	2.25	0.048	0.22	0.005	0.22	0.008	0.22	-0.031	-0.69	1.199	6.17			
Z	0.000	50.55	0.000	48.53	0.000	22.08	0.000	21.26	0.000	22.20	-	-	0.000	13.93			
r	0.521	26.13	0.489	24.24	1.613	16.39	0.173	16.12	0.279	16.46	-	-	0.040	0.88			
EpU	-	-	0.066	0.29	-0.463	-0.28	-0.050	-0.28	-0.080	-0.28	-0.216	-0.63	1.418	0.93			
RF1	-	-	-0.003	-1.30	-0.044	-2.90	-0.005	-2.90	-0.008	-2.90	-0.010	-3.38	0.038	2.67			
inter_P_R	-	-	0.001	0.13	0.025	0.76	0.003	0.76	0.004	0.76	0.007	1.10	-0.024	-0.83			
_cons	0.124	11.90	0.243	2.37	-5.766	-7.22	-	-	-	-	-1.055	-6.54	-0.042	-0.06			
/sigma					5.025063	4.872561							2.130922	47.99			
Tobittest	-37211.3																
F/chi	F(6,29955)=709.78				F(9,26958)=434.57				chi2(9) = 1664.26				chi2(7)=833.44			chi2(8)=.	
Prob>F(ch	0.0000				0.0000				0.0000				0.0000			.	
R-sq	0.12		0.13				-		-						-		
Adj. R-sq	0.12		0.13														
N	29962		26968		26968						26968		3151				

Legend:

The table presents the Tobit and Cragg model (the latter with a different set of variables in the Probit and truncated regression parts) operationalizing a QL model (where investment Z and expected rate of return r determine price), with individual controls (age, gender, human capital and unemployment status) and uncertainty-related variables – individual uncertainty (EpU) and local uncertainty (alternatively self-reported perception of local positive attitude to entrepreneurial activity CEmb and local level of the psychological type neuroticism RF1). Coefficients and marginal effects are presented.

**Table 4: Heckman Selection Model Estimations for Pro-Innovation Choice**

year	2005				2009_GEMonly				2009_GEMwithRF1			
	Heckman - Model 1		Heckman - Model 2		Heckman - Model 1		Heckman - Model 2		Heckman - Model 1		Heckman - Model 2	
	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value
dep.var1	y				y				y			
age	0.0004	0.13	0.0005	0.18	-0.0004	-1.66	-0.0004	-1.66	-0.0003	-1.47	-0.0003	-1.45
male	0.075	0.85	0.172	1.67	0.234	3.87	0.281	4.22	0.203	3.2	0.211	1.09
hc	-0.191	-1.69	-0.114	-0.93	0.067	1.08	0.091	1.38	0.074	1.14	0.078	0.58
unempl	0.683	2.42	0.624	2.18	0.878	6.52	0.871	6.46	0.886	6.3	0.886	6.27
Z	0.000	5.73	0.000	5.73	2.41E-09	15.22	2.41E-09	15.22	2.48E-09	14.94	2.48E-09	14.95
r	0.209	10.47	0.209	10.47	0.031	0.92	0.031	0.92	0.030	0.9	0.031	0.91
_cons	2.352	7.99	2.232	6.26	2.425	16.48	2.387	13.64	2.378	2.97	2.605	2.64
dep.var2	dy				dy				dy			
age	-	-	0.001	0.66	-	-	0.000	-0.04	-	-	0.000	-0.01
male	-	-	0.450	13.76	-	-	0.463	23.02	-	-	0.463	22.53
hc	-	-	0.349	8.85	-	-	0.234	11.32	-	-	0.280	13.32
unempl	-	-	-0.265	-2.81	-	-	-0.071	-1.58	-	-	-0.031	-0.69
EpU	0.032	0.70	0.042	0.90	0.027	0.93	0.035	1.16	-0.194	-0.57	-0.216	-0.63
CEmb	0.498	13.60	0.477	12.61	0.469	21.32	0.461	20.47	-	-	-	-
inter_EpU_CEmb	0.673	7.15	0.663	6.84	0.998	17.83	0.951	16.80	-	-	-	-
RF1	-	-	-	-	-	-	-	-	-0.012	-4.16	-0.010	-3.38
inter_P_RF1	-	-	-	-	-	-	-	-	0.007	1.05	0.007	1.10
_cons	-1.374	-61.18	-1.844	-28.87	-1.420	-98.22	-1.762	-79.76	-0.575	-3.68	-1.055	-6.54
mills												
lambda	0.263	1.74	0.272	1.72	0.126	1.51	0.128	1.46	0.157	0.33	0.018	0.04
rho	0.169		0.174		0.073		0.074		0.090		0.010	
sigma	1.558		1.559		1.736		1.736		1.738		1.732	
Wald chi2(5)	122.24		122.98		62.45		64.80		53.81		45.03	
P>chi2	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
N	11127		10725		29962		29962		26968		26968	
Censored	9817		9415		26510		26510		23817		23817	

Legend:

The table presents a Heckman selection bias model, operationalizing a QL model (where investment Z and expected rate of return r determine price), with individual controls (age, gender, human capital and unemployment status. The selection bias is driven by uncertainty-related variables – individual uncertainty (EpU) and local uncertainty (alternatively self-reported perception of local positive attitude to entrepreneurial activity CEmb and local level of the psychological type neuroticism RF1), the interaction between the individual and local level of uncertainty and at a second stage – the individual controls as well.

Source: Authors' calculations.

**Table 5: Marginal Effects for the Heckman Selection Model Estimations**

year	2005				2009_GEMonly				2009_GEMwithRF1			
	Heckman - Model 1		Heckman - Model 2		Heckman - Model 1		Heckman - Model 2		Heckman - Model 1		Heckman - Model 2	
	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value
age	0.0003	0.13	0.0004	0.18	-0.0003	-1.66	-0.0003	-1.66	-0.0002	-1.44	-0.0003	-1.43
male	0.057	0.85	0.132	1.76	0.180	3.85	0.216	4.46	0.154	2.76	0.168	1.30
hc	-0.147	-1.67	-0.088	-0.91	0.052	1.08	0.070	1.40	0.056	1.13	0.062	0.63
unempl	0.526	2.38	0.478	2.12	0.676	6.43	0.670	6.32	0.674	4.37	0.707	4.27
Z	1.38E-09	5.51	1.37E-09	5.47	1.86E-09	14.3	1.86E-09	14.15	1.89E-09	5.64	1.98E-09	5.85
r	0.161	9.14	0.160	8.96	0.024	0.92	0.024	0.92	0.023	0.89	0.024	0.89

Legend:

The table presents the marginal effects for the Heckman model estimations.

**Table 6: Right Tails, Poisson Distributions and Over-Dispersion**

Distribution						
year	2005			2009		
y	Freq.	Percent	Cum.	Freq.	Percent	Cum.
0	9,817	87.8	87.80	26,510	88.48	88.48
1	78	0.7	88.50	143	0.48	88.96
2	818	7.32	95.81	2264	7.56	96.51
3	101	0.9	96.72	206	0.69	97.2
4	180	1.61	98.33	292	0.97	98.17
5	25	0.22	98.55	62	0.21	98.38
6	115	1.03	99.58	301	1	99.39
7	23	0.21	99.79	78	0.26	99.65
8	3	0.03	99.81	3	0.01	99.66
9	16	0.14	99.96	88	0.29	99.95
10	5	0.04	100	15	0.05	100
<b>Total</b>	<b>11,181</b>	<b>100</b>		<b>29,962</b>	<b>100</b>	

Legend:

*The table presents the distribution of the main dependent variable in a comparative manner between the year 2005 and 2009. The purpose is to find out if the tail is distributed as a Poisson distribution or if there is over-dispersion in the data, in order to decide between a zero-inflated Poisson model versus a zero-inflated negative binomial model.*

**Table 7: Zero-Inflated Model Estimations for Pro-Innovation Choice**

year	2005				2009_GEMonly				2009_GEMwithRF1			
	ZI Poisson		ZI Negative Binomial		ZI Poisson		ZI Negative Binomial		ZI Poisson		ZI Negative Binomial	
	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value
dep.var.	y				y				y			
age	-0.0002	-0.20	0.0002	0.12	-0.0002	-1.91	-0.0002	-1.81	-0.0002	-1.77	-0.0002	-1.71
male	0.136	3.50	0.163	3.59	0.193	8.10	0.242	8.62	0.184	7.35	0.238	7.98
hc	-0.015	-0.29	0.046	0.76	0.075	3.13	0.104	3.74	0.093	3.69	0.131	4.42
unempl	0.235	2.17	0.163	1.20	0.304	7.01	0.317	6.05	0.316	7.04	0.336	6.17
Z	0.000	6.28	0.000	5.14	0.000	17.23	0.000	14.78	0.000	16.90	0.000	14.44
r	0.041	11.01	0.097	6.69	0.019	2.26	0.024	2.22	0.018	2.12	0.023	2.08
_cons	0.853	11.48	0.667	7.04	0.773	28.61	0.676	20.19	0.767	26.81	0.659	18.25
	inflate				inflate				inflate			
EpU	-0.068	-0.74	-0.068	-0.73	-0.054	-0.90	-0.053	-0.88	0.402	0.63	0.404	0.63
CEmb	-0.949	-13.68	-0.958	-13.63	-0.904	-21.34	-0.911	-21.31	-	-	-	-
inter_EpU_CEmb	-1.222	-7.06	-1.263	-6.97	-1.709	-16.52	-1.751	-16.28	-	-	-	-
RF1	-	-	-	-	-	-	-	-	0.024	4.17	0.024	4.15
inter_P_RF1	-	-	-	-	-	-	-	-	-0.014	-1.11	-0.014	-1.10
_cons	2.239	48.77	2.166	44.06	2.369	79.26	2.315	74.46	0.725	2.42	0.663	2.19
/lnalpha			-2.16745	-11.46			-2.20048	-17.25			-2.18322	-16.33
alpha			0.114469	0.079022			0.11075	0.086245			0.112679	0.086708
chi2(6)	124.57		142.94		376.78		335.7		354.15		319.37	
Prob>chi2	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
N	10725		10725		29962		29962		26968		26968	
Zero obs	9415		9415		26510		26510		23817		23817	

Legend:

The table presents a zero-inflated Poisson and a zero-inflated negative binomial estimations of our QL model, with relevant personal controls, where the inflation with zeros is explained with the individual uncertainty (EpU) and the local uncertainty attitude (alternatively measured with self-reported local perception of entrepreneurship CEmb or local level of the psychological type neuroticism - variable RF1).

**Table 8: Marginal Effects for Zero-Inflated Model Estimations**

year	2005				2009_GEMonly				2009_GEMwithRF1			
	ZI Poisson		ZI Negative Binomial		ZI Poisson		ZI Negative Binomial		ZI Poisson		ZI Negative Binomial	
	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value	coef.	z-value
age	-7.2E-05	-0.2	4.92E-05	0.12	-4.6E-05	-1.91	-4.8E-05	-1.81	-4.9E-05	-1.77	-5.3E-05	-1.71
male	0.041	3.56	0.047	3.67	0.054	8.30	0.067	8.88	0.057	7.55	0.073	8.25
hc	-0.004	-0.29	0.013	0.77	0.021	3.15	0.029	3.78	0.029	3.73	0.040	4.48
unempl	0.072	2.16	0.047	1.20	0.085	6.96	0.088	6.01	0.099	6.99	0.104	6.14
Z	0.000	6.27	0.000	5.15	0.000	17.00	0.000	14.74	0.000	16.79	0.000	14.50
r	0.012	10.77	0.028	7.02	0.005	2.26	0.007	2.22	0.006	2.13	0.007	2.08
EpU	0.018	0.74	0.017	0.73	0.013	0.90	0.013	0.88	-0.110	-0.63	-0.108	-0.63
CEmb	0.253	13.69	0.242	13.40	0.224	21.52	0.222	21.34	-	-	-	-
inter_EpU_CEmb	0.326	6.94	0.319	6.84	0.424	15.92	0.427	15.68	-	-	-	-
RF1	-	-	-	-	-	-	-	-	-0.007	-4.17	-0.006	-4.15
inter_P_RF1	-	-	-	-	-	-	-	-	0.004	1.11	0.004	1.10

Legend:

The table presents the marginal effects for the zero-inflated Poisson model and the zero-inflated negative binomial models in Table 6.

**Table 9: Regional Nestedness of the Dataset**

Region	Name	Freq.	Percent	Cum.
1	South West	1,002	3.34	3.34
2	Birmingham	1,543	5.14	8.48
3	South East	2,995	9.98	18.46
4	East	998	3.33	21.79
5	Wales	2,998	9.99	31.78
6	Rest of West Midlands	2,455	8.18	39.97
7	East Midlands	3,004	10.01	49.98
8	Yorks Humberside	2,999	10	59.97
9	North West	3,004	10.01	69.99
10	Scotland	1,999	6.66	76.65
11	Belfast	1,301	4.34	80.99
12	Other N. Ireland	1,699	5.66	86.65
13	London Inner and Outer	1,006	3.35	90
14	North East	3,000	10	100
<b>Total</b>		<b>30,003</b>	<b>100</b>	

Legend:

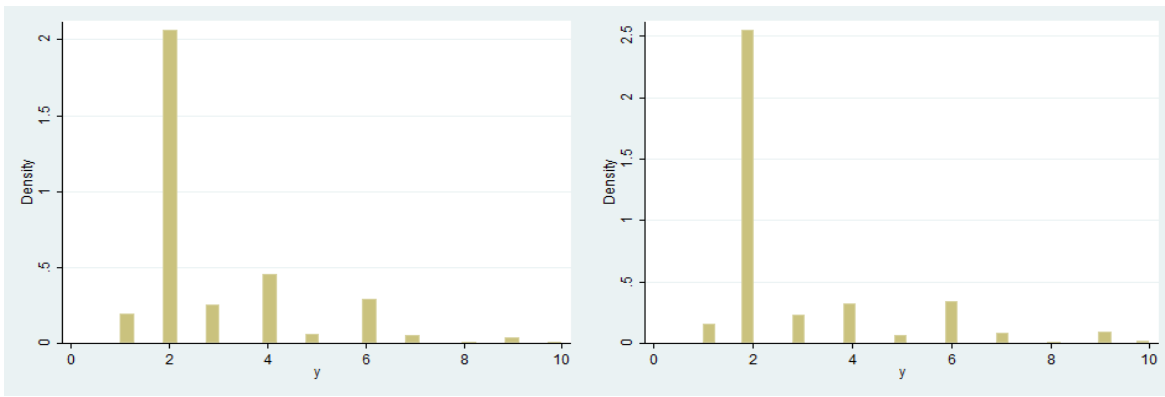
The table presents the regional clustering of the individual observations in the GEM dataset with the 14 NUTS 1 UK regions. The data is for the year 2009, which is the only year for which a regional identifier for GEM is available.

**Table 10: Hierarchical (Multi-level) Model Estimations for Pro-Innovation Choice**

spec.	Basic			CEmb			RF1			EpU*CEmb			EpU*RF1		
	coef.	[95% Conf. Interval]		coef.	[95% Conf. Interval]		coef.	[95% Conf. Interval]		coef.	[95% Conf. Interval]		coef.	[95% Conf. Interval]	
y	0.34	0.3033	0.3739	0.05	0.0263	0.0812	0.13	0.1002	0.1635	0.06	0.0352	0.0906	0.12	0.0879	0.1533
age	-	-	-	-5.2E-05	-0.00013	3.04E-05	-4.4E-05	-0.00013	4.48E-05	-4.2E-05	-0.00012	3.94E-05	-4.1E-05	-0.00013	0.000048
male	-	-	-	0.26	0.2397	0.2881	0.27	0.2412	0.293	0.26	0.233	0.281	0.27	0.2428	0.2946
hc	-	-	-	0.13	0.1018	0.1497	0.15	0.1257	0.1769	0.12	0.0915	0.1391	0.15	0.1217	0.1729
unempl	-	-	-	0.06	0.0107	0.1127	0.07	0.0131	0.1231	0.05	-0.0052	0.096	0.06	0.0087	0.1187
Z	-	-	-	4.68E-09	4.50E-09	4.86E-09	4.81E-09	4.61E-09	5E-09	4.63E-09	4.45E-09	4.81E-09	4.80E-09	4.61E-09	5E-09
r	-	-	-	0.51	0.4702	0.5476	0.49	0.4473	0.5264	0.5	0.4599	0.5367	0.49	0.4476	0.5265
Random-effects															
region:															
sd(_cons)	0.06	0.0395	0.0979	0.03	0.0154	0.0668	0.04	0.0226	0.0697	0.03	0.0163	0.0670	0.04	0.0232	0.0734
sd(CEmb)	-	-	-	0.3	0.2034	0.4368	-	-	-	0.22	0.1519	0.3330	-	-	-
sd(RF1)	-	-	-	-	-	-	2.32E-08	2.31E-14	0.0232	-	-	-	-	-	-
sd(EpU)	-	-	-	-	-	-	-	-	-	1.12E-06	8.62E-12	0.1464	-	-	-
sd(inter_EpU*CEmb)	-	-	-	-	-	-	-	-	-	0.84	0.5754	1.2339	-	-	-
sd(inter_EpU*RF1)	-	-	-	-	-	-	-	-	-	-	-	-	0.0018	0.0010	0.0031
sd(Residual)	1.12	1.1063	1.1242	1.03	1.0266	1.0432	1.05	1.0434	1.0612	1.03	1.0177	1.0341	1.05	1.042746	1.060503
obs	29962			29962			26968			29962			26968		
groups	14			14			12			14			12		

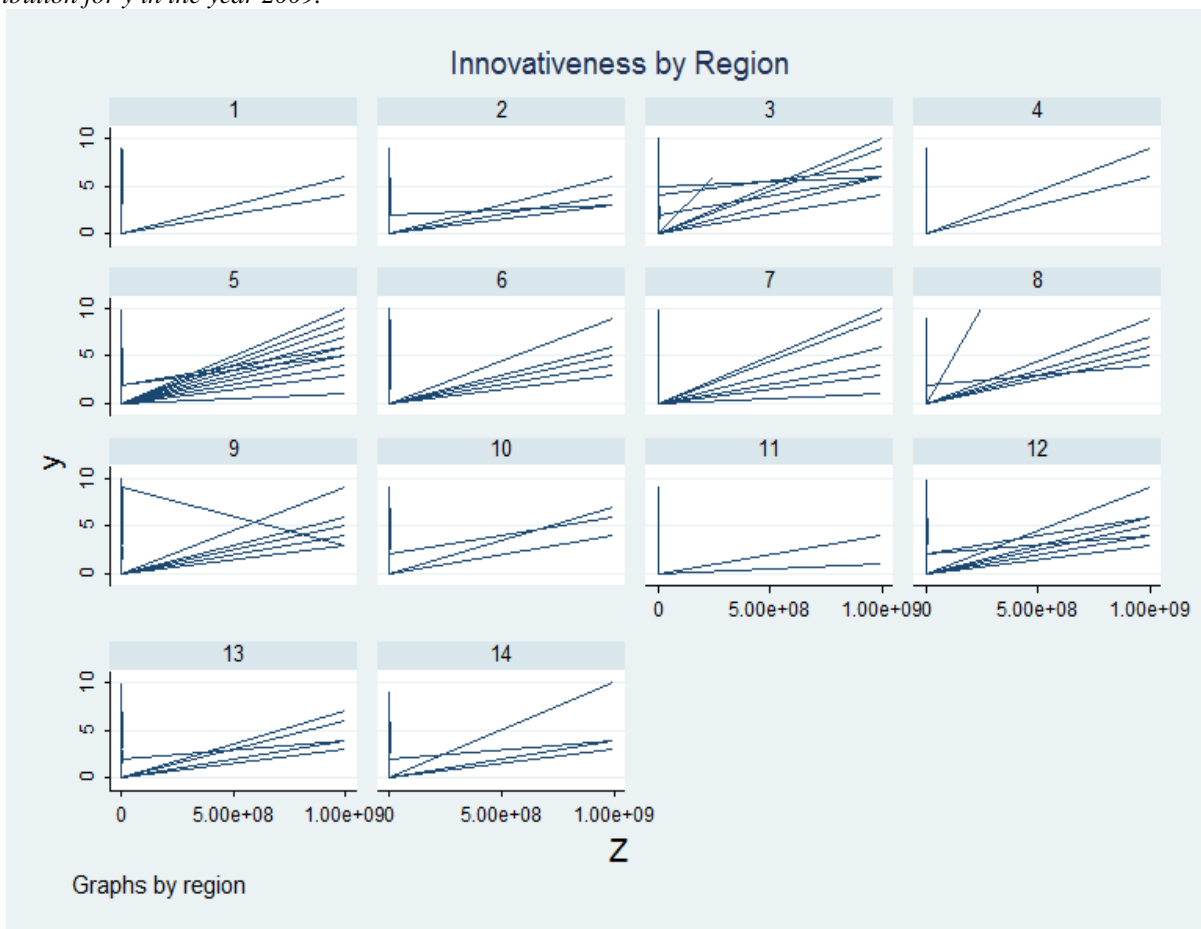
Legend:

The table presents a hierarchical (multilevel model) where the local level of innovativeness is explained by a QL model with individual controls and the local regional effect is accounted for also in a stochastic manner, accounting for the local uncertainty attitudes, the variation of the individual uncertainty in the region and the local and regional interaction terms. Local uncertainty is measured alternatively with the GEM self-reported level of positive attitude to entrepreneurship (CEmb) or the level of the psychological type neuroticism (EF1).



**Figure 1a&b:**

The figure presents the distribution of the positive values of the main dependent variable, once the inflated zeroes have been truncated from the sample. Figure 1a to the left presents the distribution for the year 2005, and Figure 1b to the right presents the distribution for  $y$  in the year 2009.



**Figure 2:**

The figure presents the regional patterns of the relationship between economic investment (available financial capital  $Z$ ) and the addressed level of innovation by the individual's choice as a type of entrepreneurial involvement.



Variable																				Data Source
<b>Uncertainty Related Variables</b>																				
<i>Individual</i>																				
EpU	gen	EpU	= .																	GEM
	replace	EpU	=	1 if	fearfail	==	1													
	replace	EpU	=	0 if	EpU	==	.													
<i>Local</i>																				
Cemb	gen	CEmb	= .																	GEM
	replace	CEmb	=	1 if	nbgoodc	==	0													
	replace	CEmb	=	0 if	CEmb	==	.													
RF1	gen	RF1	=	n (neuroticism)															Rentfrow et al. (2015)	
<b>Individual Controls</b>																				
gender	gen	male	= .																	GEM
	replace	male	=	1 if	gender	==	1													
	replace	male	=	0 if	gender	==	2													
age	tab	age9c																		
hc	gen	hc	= .																	
	replace	hc	=	1 if	gemhhinc	==	3467													
	replace	hc	=	1 if	gemhhinc	==	68100													
	replace	hc	=	0 if	hc	==	.													
unempl	gen	unempl	= .																	
	replace	unempl	=	1 if	gemwork	==	6													
	replace	unempl	=	1 if	gemwork	==	20													
	replace	unempl	=	0 if	unempl	==	.													
	replace	unempl	=	.	if	gemwork	==	9												