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Entrepreneurship in Cities

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Papers in Innovation Studies no. 2021/2

(forthcoming in Research Policy)

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Revision R2, Research Policy, Accepted

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Abstract

Impactful, growth-oriented entrepreneurship is a major research and policy focus. Building on arguments put forward by Jane Jacobs more than 50 years ago, we propose that local knowledge spillovers in a city are enhanced by human agency in that city (e.g. local psychological openness). This effect is critically amplified by the catalyst function of a favorable structural city environment that not only connects these agentic people (via urban density), but also facilitates the production and flow of new knowledge for these connected agentic people (via a diverse industry mix). This three-way interaction effect was confirmed in our empirical investigation of quality entrepreneurship across the MSAs (cities) in the US, using a large-scale dataset of the psychological profiles of millions of people. Local openness shows a robust positive effect on the level of quality entrepreneurship. This effect is further strengthened by a favorable structural city environment (i.e. high density and diversity) by up to 35%. Reviving Jacobs' people focus, the results indicate that the best performing cities in terms of knowledge spillovers and economic performance are those that are not only home to, and attract, agentic people, but also empower these people by means of a physical and industrial city landscape that enables them to act in more innovative and entrepreneurial ways, as envisioned by Jacobs. We discuss the policy implications of our findings and an agenda for future research.

Keywords: Entrepreneurship, Cities, Jacobs externalities, Knowledge Spillovers, Diversity, Density, Personality traits, Openness, Geographical psychology

JEL codes: L26, O18, D91; D83

Research Highlights

- We apply a person-context interaction approach to study knowledge spillovers and entrepreneurship
- We utilize a unique large personality dataset capturing Big Five traits of cities
- People's openness level in a city positively predicts quality entrepreneurship
- A structural city environment with high density and related diversity strengthens this effect
- Open people in a dense and diverse city environment enhance knowledge spillovers, hence quality entrepreneurship

Acknowledgement

Sam Tavassoli is thankful to the Global Business Innovation ECP Office at RMIT University for providing financial support for recruiting a research assistant. Martin Obschonka is grateful to Scott Stern for his mentorship during a research stay at MIT Sloan. The authors also thank Samuel D. Gosling, P. Jason Rentfrow, and Jeff Potter for providing the personality data (Gosling-Potter Internet Project - GPIP). We are also thankful to three anonymous referees, the editor of Research Policy, participants of the ACERE 2020 Conference (Australian Centre for Entrepreneurship Research Exchange), and participants of the CIRCLE seminar series at Lund University for constructive comments on earlier versions of the paper.

1. INTRODUCITON

Cities are recognized as the engine of their own national economies as well as the global economy. About 80% of global GDP is estimated to be produced in cities (Dobbs et al, 2011), and they are often referred to as high quality entrepreneurship hotspots (Guzman and Stern, 2020; Duranton and Puga, 2001) and innovation machine (Florida et al, 2017). Given the role cities play in the knowledge economy, there is an increasing need for both researchers and policymakers to understand how knowledge is generated and transferred within cities.

While disparate views have emerged on how knowledge generation and knowledge spillover mechanisms operate in cities, contemporary thinking and analyses commonly lead back to the ideas of Jane Jacobs (1961; 1969), who was one of the pioneers of what makes cities entrepreneurial and innovative (Beaudry and Schiffauerova, 2009; de Groot et al., 2016)[1]. She believed in urban density and diversity as the favorable structural city environment for novel idea generation and economic performance, because "*the greater the sheer 'number' of and 'variety' of division of labor, the greater the economy's inherent capacity for adding still more kinds of goods and services*" (Jacobs, 1969, p. 59). Scholars have largely confirmed Jacobs' knowledge spillover thesis empirically, mainly focusing on the diversity of 'industries' within cities and regions (e.g. Glaeser et al., 1992; Quigley, 1998; Tavassoli and Carbonara, 2014; Castaldi et al., 2015), and also the density aspect of cities (e.g. Bettencourt et al, 2007; Moroni, 2016; Caragliu et al., 2016).

However, there are four major issues in the knowledge spillover literature broadly, and specifically concerning Jacobs' knowledge spillover. First, many existing (above) studies that analyzed Jacobs' propositions mainly focused on the 'structural city environment' by capturing density and diversity in terms of firms and industries in cities, even though Jacobs herself clearly referred to people, for example: "*The task is to promote the city life of city* ***people****, housed, let us hope, in concentrations both dense enough and diverse enough to offer them a decent chance at developing city life*" (Jacobs, 1961, p. 221, bold font added by authors). Thus, while the literature has thrust Jacobs' argument that density and diversity matter for the economic vitality of cities under the lens of analysis, it might have actually misinterpreted her main point – that it is the people themselves that matter and not *just* the structure of firms and

[1] Whether diversity (Jacobs externalities) or specialization (MAR externalities) of economic activities better promotes economic success has been the subject of a debate in the literature, at least since the seminal work of Glaeser et al. (1992). Nevertheless, in a recent review de Groot et al. (2016) noted that "*the support for Jacobs' hypotheses is relatively most convincing*" (ibid. p.769). This is particularly true when 'success' is captured by new knowledge generation, product innovation, and (high quality) entrepreneurship in denser areas (Beaudry and Schiffauerova, 2009; Caragliu et al., 2016), which is the scope of this study.

industries. Indeed, recent evidence suggests that even cities with the same favorable structural city environment, i.e. highly dense and diverse cities, often differ in their entrepreneurship activity and related economic performance (Agrawal et al., 2014; Roche, 2019).

Second, the literature on the nexus between human capital and knowledge spillover has paid particular attention to Jacobs' people focus, by explaining that human capital of people serves as an important source of knowledge as well as key capacity for absorbing knowledge spillovers (Qian and Acs, 2013; Qian et al., 2013; Rupasingha, et al, 2006). However, the emphasis in the human capital literature has been more on the 'capital' and less on the 'human' side, i.e. what matters is the degree of education and training. Hence the *direct* attention to the human side of people is largely missing in the literature – except in the creative class literature (Florida, 2002).

Third, Jacobs coined concepts such as "eyes on street" to indicate the importance of contact and interaction among people in cities. However, she implicitly considered people as if they are *equally* able and willing to interact with each other and to learn from such interactions. Such an implicit assumption was not adequately addressed and tested in the post-Jacobian existing body of research on knowledge spillovers. This is a shortcoming, because decades of psychology research makes clear that people indeed differ in such *psychological* dispositions[2] (Allport, 1923; Pervin and John, 1999), such as the personality trait *openness to new experience*, which captures people's agentic tendency to produce, and embrace exchange of, ideas and knowledge (McCrae and Sutin, 2009; Woo et al., 2014)[3]. In addition, recent advances in the geography of psychology indicate that not only people but also entire regions differ in their personality characteristics from one another (Ebert et al., 2019; Rentfrow and Jokela, 2016).[4] This has important implications for local knowledge spillovers and economic performance since the local psychological architecture of a city is deemed an essential ingredient in local economic processes (Huggins and Thomson, 2019).

Fourth, a pure focus on either the structural city environment (as in most post-Jacobian empirical studies), or the inter-individual psychological differences, is not sufficient because understanding the role of the objective environment as a shaper of human behavior (in line with Jacobs' thinking) has become another major paradigm in modern psychology (Mischel, 1968; Pervin and John, 1999). In fact, psychological research shows that one often cannot separate

[2] By "dispositions" we mean those psychological characteristics that are relatively stable. We that acknowledge personality traits, e.g. psychological dispositions, are not perfectly stable–they can also change (Caspi et al, 2005).
[3] Such an emphasis on personality differences has important implications for various disciplines such as economics, management, and entrepreneurship research (Almlund et al., 2011; Lee, 2017).
[4] In addition to collective personality traits, cities differ from each other in other collective traits such as political orientation, voting behavior and ethnic diversity (Bishop & Cushing, 2008). We will elaborate on this later.

the study on inter-individual differences and the study of effects of the environment when explaining human behavior and learning. Hence, we can only understand human behavior and learning processes if we consider *both* inter-individual differences (e.g., personality traits) *and* the environment, and particularly their important interactions, i.e. *person-environment interactions* (Bandura, 1997; Edwards, 1994; Walsh et al., 2000). This focus on human heterogeneity in terms of inter-individual psychological differences and associated person-environment interactions are not explicitly explained and tested in Jacobs' approach and the existing research testing her approach as well as knowledge spillover literature broadly.

The purpose of this paper is twofold. First, to make a conceptual contribution, we develop a model that adds to the literature on human capital and knowledge spillovers by explicitly taking into account (i) a psychological perspective and the spatial clustering of individual personality traits (local openness) as well as (ii) important person-environment interactions for learning that reflect Jacobs' perspective of the processes underlying knowledge spillovers by focusing on density and diversity (see Figure 1). Second, for an empirical contribution, we measure and investigate the 'people-focus' in Jacobs' thinking more directly than previous research by analyzing psychological data collected from millions of people about their personality structure. This enables us to test the direct and interactive effect of human heterogeneity – differences in local openness – in the prediction of local economic performance (quality entrepreneurship). Drawing from the fundamental notion of person-environment interactions, we put a main focus on the interplay between local openness and a favorable structural city environment (density and diversity) and conduct various robustness tests.

We contribute to our understanding of local conditions for learning by analyzing how productive knowledge spillovers in cities are conditioned by local personality traits as well as the interaction of such local traits with the structural city environment. To this end, we draw from psychological research showing that one often cannot separate the study of inter-individual differences and the study of effects of the environment when explaining human behavior and learning. It might be this person-context interaction that is key to the economic vitality of cities (e.g. quality entrepreneurship), due to enhancing effects of such interactions on knowledge spillovers.

The rest of this paper is organized as follows. Section 2 gives an overview of relevant theory and research and presents our conceptual model and hypotheses positing a direct effect of local openness as well as its interactive effect with a favorable structural city environment on entrepreneurial performance of cities. Section 3 describes our dataset, variables, and empirical

methodology. Section 4 presents our empirical results while section 5 provides a discussion of these results with implications for research, practice, and policy. Section 6 concludes.

2. THEORY AND HYPOTHESES

To develop our hypotheses, we bridge different literatures and theoretical perspectives. Specifically, we combine Jacobs' concept and related existing research on knowledge spillovers and human capital with a psychological agency perspective to entrepreneurship (Huggins and Thompson, 2019; Shane, 2003) and a geographical psychology perspective (Rentfrow and Jokela, 2016; Rentfrow et al., 2008) that, when taken together, give rise to the idea that people and whole regions show heterogeneity with respect to such agentic tendencies and that it requires a person-environment interaction perspective to understand how people and structural city environments enhance knowledge spillovers and economic performance.

2.1. Types of Knowledge Spillovers

The nature and application of knowledge is a central part in entrepreneurship studies. Along with the shift away from physical capital towards knowledge as the central competitive advantage of places, a fuller understanding of local knowledge spillovers[5] has been a priority focus in economic research in the past three decades. According to the new endogenous growth theory, knowledge spillovers are the engine of growth (Romer, 1986; Lucas, 1988).

Since the seminal work of Glaeser et al. (1992), whether Jacobian (related diversity[6]) or Marshallian (specialization) types of knowledge spillovers better promote economic performance has been the subject of a heated debate in several disciplines including urban economics, innovation and entrepreneurship studies, and economic geography. Both arguments agree on the density and concentration of economic activities (Beaudry and Schiffauerova, 2009), but they disagree on the role of the 'industry structure' of cities in facilitating knowledge spillovers. This literature is surveyed by Beaudry and Schiffauerova (2009) as well as by de Groot et al. (2016). They broadly conclude that there is significant heterogeneity in results across studies, but that Jacobs' knowledge spillover (density and related diversity) appears to have a more robust positive influence on new knowledge generation, creativity, (product) innovation, and high quality entrepreneurship, while specialization is more conducive to

[5] Knowledge spillovers/externalities occur when the new ideas (or innovations) of one agent (unintentionally) lead to an enhancement of the innovations of another agent that does not bear the (full) cost of it.

[6] What matters for knowledge spillover–particularly interindustry Jacobs knowledge spillover–is the presence of related industries, rather than 'pure' diversity of industries. As Frenken et al (2007, p.685) noted: "Jacobs externalities are best measured by related variety (within sectors)".

efficiency and labor productivity. Such a conclusion is also in line with seminal earlier studies (e.g. Feldman and Audretsch, 1999; Duranton and Puga, 2000).

2.2. Jacobs' Approach

The Jacobs' approach can be divided into two non-mutually exclusive categories conceptually. The first one is about the 'structural city environment'. The idea that density (as a physical aspect of cities) and industry diversity (as a functional aspect of cities) promote inter-industry knowledge spillovers and hence facilitate new knowledge generation, innovation, and high quality entrepreneurship is commonly associated with her writings (Jacobs, 1961; 1969). The Duranton and Puga's (2001) Nursery Cities model further developed micro-foundations for the role that diversified cities play in fostering search and experimentation for entrepreneurs, which is required for novel knowledge generation and high quality entrepreneurship. Desrochers and Leppälä (2011) further elaborated how diversified cities foster learning by identifying three main processes through which knowledge is actually transmitted between two entities (e.g. firms or individuals): (i) adding to, switching or adapting specific know-how to new context (e.g. through job mobility of individuals); (ii) observing something and incorporating it into another environment; and (iii) formal or informal collaboration of individuals possessing different skills and backgrounds.

Apart from the 'diversity' aspect in cities, Jacobs reemphasized that successful cities are the places that *concentrate* people. She therefore put 'density' of people (alongside diversity of people as discussed above) in the center of her argumentation: "*people gathered in concentrations of city size and density can be considered a positive good… because they are the source of immense vitality, and because they do represent… a great and exuberant richness of differences and possibilities, many of these differences unique and unpredictable*" (Jacobs, 1961, p. 220). It is important to note that the concept of 'concentration' of economic activities is not new and dates back to at least Alfred Marshall's writings in the nineteenth century and subsequently to a rich literature in agglomeration economies in the twentieth (cf. Hidalgo et al., 2018) as well as more recent literature in urban scaling, which indicates that population density affects the cities' economic outputs superlinearly (Bettencourt et al., 2007). Nevertheless, it was probably Jacobs' writing that put the concentration and diversity of 'people' in the center of attention in the academic literature. She essentially anticipated that spatial concentrations and diversity of people in a diversified environment would enhance what subsequently became characterized as knowledge spillovers (Romer, 1986) and even more poignant as knowledge spillover entrepreneurship (Audretsch et al., 2006).

The second part of Jacobs' approach is her focus on the people themselves. She put people and the city life of people in the center of her thinking by coining concepts such as "ballet of sidewalk" or "eyes on street" to indicate the importance of contact and interaction among people in neighborhoods and cities. She implicitly considered people as if they are equally able and willing to interact with each other and to learn from such interactions. This might make sense in the temporal-spatial context that she was observing the people, e.g. New York City and Chicago in the 1960s and beyond. However, her focus on the particular context can also imply that she potentially disregarded important regional psychological differences (i.e. local populations may differ in their agentic tendencies) in other cities, regions, and countries. Indeed recent advances in geographical psychology make clear that not only people but also even whole regions differ in their personality characteristics (Ebert et al., 2019; Rentfrow and Jokela, 2016). We will come back to this in detail in the Section 2.4.

2.3. Empirical Tests of Jacobs' Approach: Support, Inconsistencies and Open Questions

Although Jacobs' density and diversity argument is widely accepted as conducive to the cross-fertilization of ideas and fostering the generation of new knowledge, the empirical evidence seems to be mixed. While some studies find evidence to support Jacobs' spillovers (e.g., Glaeser et al., 1992; Van Stel and Nieuwenhuijsen, 2004; Tavassoli and Jienwatcharamongkhol, 2016), various other studies found little or no positive evidence of Jacobs' spillovers (Henderson, 2003; Almeida, 2007; Song et al., 2019). These mixed findings raised the curiosity of scholars to properly investigate the empirical evidence. Following Beaudry and Schiffauerova (2009)'s comprehensive literature review, recently de Groot et al. (2016) also performed a meta-analysis of 73 scientific articles, all building on the work of Glaeser et al. (1992) about the effect of various types of knowledge spillovers (externalities) on economic outcomes of regions/cities. They found more robust evidence in favor of Jacobs' knowledge spillovers relative to other types of spillover such as MAR when looking at their effect on various dependent variables, particularly entrepreneurship and innovation. Nevertheless, still slightly more than 50% of the reviewed articles do not show any significant result (and even a small portion shows negative effects) concerning empirical evidence of Jacobs' spillovers. The authors conclude that "*New lines of inquiry, using rich microlevel data on firms and workers, can enhance our understanding of how agglomeration externalities continue to fuel our increasingly urbanized world*" (de Groot et al., 2016, p. 776). Scholars have responded to this request in providing such 'new lines of inquiry' by (i) investigating the micro-geography of diversity versus specialization by analyzing the effects at neighborhood

level (Andersson et al., 2019), (ii) providing deeper understanding of underlying processes of knowledge spillovers (Desrochers and Leppälä, 2011), (iii) differentiating between technology intensity of industries and observing differentiated effects of specialization and diversity (Liang and Goetz, 2018), and (iv) analyzing the effect of physical layout of cities, such as 'connectivity' of neighborhood blocks (Roche, 2019). These recent endeavors have increased our understanding of Jacobs' spillovers, e.g. it might not be the 'either/or' condition for diversity vs. specialization debate, rather 'it depends' on for example, geographical unit of analysis or type of industry sector. However, such recent studies are still highly occupied with analyzing the 'industry' mix in the local environment (i.e. again the industrial diversity vs industrial specialization debate).

In contrast to such focus on the structural city environment, one of Jacobs' essential, albeit less discussed and barely empirically analyzed, arguments centers on 'people'. In explaining the economy and growth of cities, Jacobs (1969) essentially focuses on people's city life by proposing that it is particularly *the intense interaction and learning* between people in cities that enables them to get ideas, innovate, and add new jobs. The subsequent conceptual and empirical studies that paid attention to Jacobs' people focus, have captured 'people' either indirectly (e.g., the composition of the local industries mix that employ people), or somewhat superficially (e.g., the mere density of people) (Bettencourt et al, 2007; 2014). Richard Florida's writings pay particular attention to people and talent, however, it mainly captures people and their open-mindedness again indirectly, through a tendency of people in a particular city or region to exhibit *tolerance*, in that they can embrace diversity (Florida, 2002).

The human capital approach is perhaps as far as the literature goes when it comes to explicitly taking into account the role of people and the heterogeneity of people for knowledge spillovers. First, in the human capital externalities literature, the differences between individuals is mainly identified through individuals' heterogeneity in terms of their prior knowledge stock, stemming from their educational attainments and work experiences (Lucas, 1988; Rupasingha, et al, 2006; Qian and Acs, 2013; Qian et al., 2013). This implies that the literature implicitly tends to treat individuals with *the same* education level or skill as being equally good (or equally bad) in terms of tendency to interact and learn from one another. Moreover, the emphasis in the human capital literature is more on the 'capital' and less on the 'human' side, i.e. what matters is the degree of education and training, which translates into an equivalent of capital found in things rather than in people. Second, in the Community Capitals Framework (CCF), Flora and Flora (2008) took a more comprehensive stance on the definition of capital in general and human capital in particular. They define human capital as comprising

the skills and abilities of people, particularly the ability to access outside resources and bodies of knowledge to increase their understanding and identify promising practices. Their emphasis on human capital is consistent with the overall literature on knowledge spillovers, which has identified that human capital plays a key role as a key mechanism facilitating the transmission of knowledge from the agent or organization creating it to the agent or organization actually commercializing it through innovative activity.

We argue that the direct attention to people beyond traditional human capital approach, and particularly their agentic tendency stemming from their differentiated psychological traits, is however very important because the essence of the contemporary knowledge spillover literature is about learning occurring between two entities, which at its most fine-tuned level, corresponds to learning between two 'individuals'. In this vein, Puga (2010) argues that among the causes of agglomeration economies, learning in cities and its microeconomic foundations are the least understood aspects. Desrochers and Leppälä (2011) suggest that "*the only way forward in this debate is to document how innovative know-how is actually created, diffused, adapted and combined by individuals with different occupations, skills and backgrounds*" (ibid. p.844). The essential enquiry here concerns whether and how individuals interact and learn from one another in cities, which is often implicitly considered in the literature aiming to empirically understand the characteristics of successful cities, e.g. in terms of entrepreneurial performance.

2.4. Psychological agency and geographical psychology: The spatial clustering of inter-individual differences and person-environment interaction

A more direct and explicit way of addressing the role of the people in a city in the generation of local knowledge spillovers may be offered by geographical psychology (Rentfrow and Jokela, 2016; Rentfrow et al., 2008). In this field, research demonstrated that personality characteristics, including those personality traits that predispose people towards more human agency, creativity, exchange of ideas and embracing diversity of ideas (e.g., openness to new experience, McCrae and Costa, 1997; McCrae and Sutin, 2009; Woo et al., 2014), often cluster regionally (Ebert et al., 2019; Garretsen et al., 2020; Rentfrow et al., 2008). In other words, whereas personality psychology is based on the fundamental assumption that people differ in their psychological characteristics, like personality traits (inter-individual differences at the individual level (Allport, 1923; Pervin and John, 1999), geographical psychology shows that this also applies to entire regions such as cities. In other words, cities and regions, not just individuals, have a 'personality' too (Florida, 2010). Besides such regional differences in personality traits, there is also compelling research evidence showing regional differences and

clustering of other collective[7] traits, such as political orientation, voter values and voting behavior (Bishop & Cushing, 2008; Johnston, Manley, & Jones, 2016) and ethnic diversity (Lee et al. 2017).

Here we propose that regional differences in the personality trait *openness to new experience*[8] play a key role in local knowledge spillovers. Many modern economic theories implicitly assume that people play a key role in the generation of knowledge spillovers because of their human agency such as enhanced interactions and exchange between people. Acknowledging that regions do differ in such openness (e.g., Garretsen et al., 2020), we propose that those cities with more open people (higher local openness as indicator of stronger human agency with enhanced interactions and exchange between people) achieve more knowledge spillovers. Our argument is in line with the notion of *absorptive capacity* (Cohen and Levinthal, 1990), however we go beyond the complementary human capital and skill of people as facilitators of knowledge spillover. Instead, we highlight the importance of psychological traits of cities (i.e. local openness) for knowledge spillovers to occur and if this local openness is particularly high then the generation of knowledge spillovers will be more enhanced, and hence the local economic performance and vitality[9]. Such regional differences in personality traits, in turn, are likely to be a result of selective migration patterns (Bishop & Cushing, 2008; Rentfrow & Jokela, 2016), but can also be shaped by local social influence (Obschonka et al., 2018; Rentfrow et al., 2008).

Our proposition is based on seminal entrepreneurship and innovation theories giving human agency a unique role (Schumpeter, 1934; Shane, 2003) as well as on Rentfrow et al.'s (2008) theory of the emergence, persistence, and expression of regional personality differences, which explains why a region's personality makeup (e.g., openness) shapes the behavior shown in this region. According to this theory, more open and agentic people in a region shape the personality structure of the whole region towards a more open and agentic *local* personality structure and psychological climate, which in turn may lead to more knowledge spillover behaviors (i.e. enhanced exchange of ideas and interactions between people) in these regions (McCrae and Costa, 1997; McCrae and Sutin, 2009; Woo et al., 2014). In addition, according to McCrae (2001, 2004), such a trait psychology approach aggregating individual level personality traits

[7] By "collective" we mean elevated regional levels and regional clustering in a trait. We do not define it here as collectivist culture.

[8] People's "openness to new experience" is one of the Big Five personality traits. We will elaborate it and explain how we measured it in section 3.3. We also acknowledge that while psychological openness is one (central) proxy for human agency, there are of course various other psychological indicators of human agency.

[9] Institutions for collaboration such as universities and other organizations can facilitate the matchmaking between firms (and their people) and hence can induce openness among people.

to the regional level can be also understood as a measure of the local culture (Davidsson and Wiklund, 1997; Obschonka et al., 2015; Stuetzer et al., 2018). Taken together, these local psychological agency levels deeply rooted in the personalities of people living in a region are an important *direct* driver of local knowledge spillovers and economic vitality of regions, such as quality entrepreneurship (Lee, 2017; Huggins and Thompson, 2019). The effect of local openness should be particularly strong for the generation of more novel ideas, hence high potential and high quality entrepreneurship (see Figure 1). This is because complex tasks, that involve tacit knowledge and generation of novel ideas, particularly require face-to-face contact between (open) people (Storper and Venables, 2004). Against this background, we propose the following hypothesis.

Hypothesis 1: Local openness has a positive effect on entrepreneurship quality of cities.

Considering the role of the objective environment and drawing from the essential notion of person-environment interaction as a leading paradigm in the modern social sciences studying human behavior and learning (Bandura, 1997; Edwards, 1994; Walsh et al., 2000), including geographical psychology (Jokela et al., 2015; Zhou et al., 2019), there is a strong conceptual and empirical basis suggesting that local personality features 'interact' with the structural city environment. Such interaction leads to the production of regional level outcomes. For the case of the generation of knowledge spillovers, local openness might be a particularly strong driver of impactful economic behavior if open populations live in, and interact with, a structural city environment that is described as favorable in the economics literature – for example Jacobs' density and diversity focus in terms of the structural city environment. Putting it simply, if *particularly* agentic populations are situated in, and benefit from, *particularly* stimulating structural city environments (e.g., urban density and diversity), then the city life of these people, in the Jacobs' sense, will be enhanced, resulting in more high impact economic outcomes. The latent dispositions in the local population become salient and expressed into actual behavioral outcomes via a stimulating environment. Such a 'contextual triggering' of psychological dispositions (Shanahan and Hofer, 2005) has been shown in various types of behavioral outcomes in psychology.

Based on the above argument, our second proposition is as follows. The most successful cities are characterized by a specific people-environment interaction. In particular, on the one hand, people in the city are assumed to be open to new experiences, and hence their interaction with each other are expected to be *more effective* for knowledge exchange and learning. On the

other hand, there is urban density in the city that facilitates a higher *frequency* of interactions and hence further learning opportunities for such open people. Moreover, there is diversity of industries and activities in the city that nurture the *generation* of new and novel ideas and knowledge and hence increase the learning opportunities and the extent of knowledge spillovers even further. In other words, those cities in which open people (high local openness) live, and interact with, a stimulating structural city environment that connects these people (via urban density) and facilitates the production and flow of ideas and knowledge (via diversity of local industries) achieves the strongest knowledge spillovers along with particular types of economic activity, such as entrepreneurship. This should be particularly true for economic activities conducive to growth (e.g., quality entrepreneurship), due to the peculiar novelty involved in such activities. Therefore, our second hypothesis is as follows:

Hypothesis 2: A favorable structural city environment can moderate (strengthen) the positive effect of local openness on entrepreneurship quality of cities.

Figure 1 conceptually depicts our propositions about direct effect of local openness on entrepreneurship of cities (H1) as well as the people-city interaction effect on entrepreneurship of cities (H2).

[Figure 1 about here]

3. METHODOLOGY

3.1. Dataset

We constructed our final dataset by combining three types of data sources. First, a unique macro-psychological dataset in order to obtain the Big Five personality traits variables (including Openness). This dataset comes from the Gosling-Potter Internet Project (GPIP) that has collected individual level Big Five personality traits among US residents between the period 2000 to 2015 (Rentfrow et al., 2008). The database consists of millions of survey respondents who are located in different MSAs (cities) in the United States, which has been successfully used in a number of regional studies recently (e.g., Götz et al, 2020; Obschonka et al, 2015; Stuetzer et al, 2018). We will explain this database and its construction more in detail in the 'explanatory variable' section. The second source is a newly developed dataset that captures the quality entrepreneurship for the majority of the US cities (Guzman and Stern, 2015; 2020). We will explain this dataset more in detail in the 'dependent variables' section. And third, we used a variety of publicly available data sources from US Census Bureau statistics in order to

obtain and construct our remaining two explanatory variables (diversity and density), along with a wide range of our control variables (will be explained in details below). Most of the variables were originally available at the zip code level. We combined and aggregated all the variables up to the level of Metropolitan Statistical Areas (MSAs), which are commonly perceived as 'cities' in the US. We chose the MSA as our spatial unit of analysis because they are functional regions consisting of an urban core and adjacent hinterland with strong economic and social ties. MSAs represent a standard set of spatial entities, which show pronounced heterogeneity in innovations (Boschma et al., 2015) as well as macro-psychological characteristics (Obschonka et al., 2015). Following previous studies (e.g. Porter 2003; Delgado et al, 2016), we focus on traded industries, which are geographically concentrated industries (versus local industries that are geographically dispersed)[10]. The reason for such choice is that the underlying theory of our paper is about economies of agglomeration, which take place in geographically concentrated industries. The final dataset contains 362 MSAs in the US ranging between the period of 2010 to 2015 for most variables (and 2000 to 2015 for personality trait variables).

3.2. Dependent Variable

Our dependent variable is *Quality Entrepreneurship*, which captures high growth potential entrepreneurship in a given city. Although identifying and operationalizing high growth 'established' firms is fairly common in the literature (Delmar et al., 2003), there is much less consensus about capturing the high growth potential of new firms. Following Guzman and Stern (2015; 2020), we call such high growth potential for new firms the quality entrepreneurship and measure it by the Regional Entrepreneurship Cohort Potential Index (RECPI). The RECPI is a comprehensive measure of the 'potential' of a region (or city) given the 'intrinsic' quality of its firms at birth. Using RECPI, the quality entrepreneurship measure is calculated as follows:

$$Quality\ Entrepreneurship_{r,t} = Quantity\ Entrepreneurship_{r,t} \times Quality\ Index_{r,t}$$

Where,

$$Quality\ Index_{r,t} = \frac{1}{N_{r,t}} \sum_{i \in \{I_{r,t}\}} \theta_{i,r,t} \quad (1)$$

Where *Quantity Entrepreneurship* is measured as the number of startups per MSA *r* averaged over the period *t* = 2010 to 2015, $N_{r,t}$ is the number of firms per MSA r year t and $\{I_{r,t}\}$

[10] In our dataset, 81% of new firms belong to traded industries and the rest (19%) belong to 'local' industries.

represents the set of all firms i in MSA r and year t. The $\theta_{i,r,t}$ is estimated for firm i in MSA r in year t with startup characteristics $H_{i,r,t}$ (e.g., whether the firm is organized in order to facilitate equity financing or whether the firm seeks IP protection), and growth outcome $g_{i,r,t+s}$ (e.g., achieving an IPO or high value acquisition within six years of founding) as follows:

$$\theta_{i,r,t} = P\left(g_{i,r,t+s} \middle| H_{i,r,t}\right) = f(\alpha + \beta H_{i,r,t}) \quad (2)$$

We used the average value of quality entrepreneurship over the period 2010 to 2015. Moreover, we used log transformation of the dependent variable in our analysis, because it was highly skewed in its original forms.

3.3. Explanatory Variable

Our explanatory variable is local *Openness* of city populations, measured as the average openness score of individuals residing in MSA r in year t (t = 2000 to 2015). This individual level data comes from a unique large-scale personality dataset, the Gosling-Potter Internet Project (GPIP) (Gosling et al., 2004; Rentfrow et al., 2008). This ongoing project has been collecting personality data since 2000 via a noncommercial, advertisement-free Internet website that can be reached via several channels (e.g., search engines, unsolicited links on other websites). Participants are given feedback via customized personality evaluations. Participants are asked to fill out a personality test, with additional items on the location of the respondents (e.g., respondent's current and past zip code). Personality scores are assessed by means of the 44-item Big Five Inventory (BFI) (John and Srivastava, 1999), a widely used and well validated personality instrument that measures the Big Five personality traits of openness, conscientiousness, extraversion, agreeableness, and neuroticism with an item Likert scale of 1 to 5. Openness is measured with 10 items (assessing curiosity, imagination, artistic interest, wide scope of interests, excitement, and unconventionality; sample item: "*I see myself as someone that is curious about many different things*", 1 = strongly disagree to 5 = strongly agree). Using the 2,515,072 respondents from this dataset and the location information of respondents based on their zip codes, we then aggregated the individual trait scores to the spatial level MSA (city) in order to obtain the local openness scores[11]. Previous studies showed that this dataset is generally representative for regions within the US (Rentfrow et al., 2008), including cities (Obschonka et al., 2015; Stuetzer et al., 2018). This, together with other

[11] We were able to identify 37,814 unique zip codes that can be assigned to counties in the US. Aggregating such zip code level data into MSA-level leaves us with 362 MSAs which covers the majority of MSAs in the US.

growing evidence speaks for the validity and robustness of such regional traits scores based on large scale online personality tests that were collected over several years (e.g., Ebert et al., 2019; Jokela et al., 2015; Rentfrow et al., 2016)[12].

3.4. Moderator Variables

We have two main moderator variables, i.e. density and diversity in cities. These two variables capture the 'structural city environment' aspect of Jacobs' approach in our conceptual model (Figure 1). The Jacobs' diversity is mainly about the variety of activities that the city pursues (Glaeser et al., 1992). It has been conventionally captured by industry diversity within a region or city, which in turn is measured by pure (overall) diversity measures such as inverse Hirschman–Hefindahl index (Glaeser et al., 1992; Obschonka et al., 2015; Stuetzer et al., 2018). However, recent measurement advancements split the pure diversity into within-sectors diversity versus between-sectors diversity (Frenken et al., 2007). It is further argued and empirically shown that Jacobs' diversity is best captured by within-sectors diversity (or so-called Related Variety) because such diversity allows for better Jacobian knowledge spillover (Frenken et al., 2007; Tavassoli and Carbonara, 2014; Tavassoli and Jienwatcharamongkhol, 2016). This is because a city with within-sector diversity has, for example, several 5-digit industry classes (allowing for variety) that share the same 2-digit industry class (allowing for relatedness)[13]. Then, the more sectors at the 5-digit class within each 2-digit class in a city, the higher the value of diversity driven knowledge spillover in that city[14]. Following this logic, we operationalize our diversity measure as the so-called Related Variety of sectors in MSA *r* in year *t* as follows:

$$Diversity_{rt} = \sum_{g=1}^{G} Pg_{rt} Hg_{rt} \tag{3}$$

Where:

$$Hg_{rt} = \sum_{i \epsilon Sg} \frac{Pi_{rt}}{Pg_{rt}} \, log_2\left(\frac{1}{Pi_{rt}/Pg_{rt}}\right)$$

[12] Note that research indicates that such regional personality differences exhibit substantial stability over time, hence collecting the survey respondents during 2000 to 2015 should not create inconsistency in measurement of local openness (Elleman et al., 2018).

[13] In such a city, industries show some degree of similarities, because all sectors (e.g., sub-branches in chemicals) will share some technology and product characteristics at the same 2-digit class (e.g., chemicals). But at the same time, these industries show some degree of dissimilarities with each other, because these sectors differ at the 5-digit level (hence allowing for between-industry spillovers and learning).

[14] We would like to acknowledge that unlike the related variety approach, another approach shows that manufacturing and service industries may be part of the same cluster (Delgado et al, 2016).

Where, Pi_{rt} is the employment share in five-digit NACE code for MSA r in year t, Pg_{rt} is the employment share in two-digit NACE code for MSA r in year t, and G is the maximum number of two-digit sectors in MSA r and year t.

The second moderator variable is the *Urban Density*. We capture it in two ways, as illustrated in Figure 1. First, it is captured as the population density, measured by the total population in the MSA *r* in year *t* divided by the square kilometers of the MSA *r*. This is a more conventional measure of urban density. Second, we used street network density as another way to capture urban density. This is well in line with Jacobs' original writings, where she also emphasized the importance of connectivity between street blocks in order to enhance interaction between people. The density of such connectivity (instead of pure population density) can be an alternative density measure, facilitating knowledge spillovers among people, because it takes into account the actual physical layout of city streets. Following Roche (2019), we used street blocks' connectivity, measured as the total miles of streets oriented toward both car and pedestrian travel (multimodal)[15]. For both of our moderator variables (and control variables), we used their averaged values over the period 2005 to 2010.

Finally, we used the two-way and three-way interactions between the main explanatory variable (local openness) and the two moderators in order to test our second hypothesis. We will particularly emphasize the results of the three-way interaction, because it enables a test of our second hypothesis about the 'interaction' of people (local openness) and structural city environment (urban density and industry diversity). In order to deal with potential biases that outliers may cause in our subsequent analysis, we Winsorize the top and bottom 5 % of data points in our dependent variables. We also mean-centered our explanatory and moderator variables in order to ensure that multicollinearity does arise in our interaction term models.

3.5. Control Variables

We include a set of control variables typically used in regional entrepreneurship studies. The majority of the respective data comes from the ACS (American Community Survey), unless otherwise stated. The first variable is the extent of *Human Capital* in a given region. Human capital is typically measured in terms of educational attainments (e.g. Qian & Acs, 2013). We used the share of the adult population in the region with a bachelor's degree or higher. Second, we also control for *Demographic* composition of the regions, measured by the share of the population between 25 and 44 years old per MSA per year (Stuetzer et al., 2018). Third, we

[15] We are thankful to Maria Roche who shared this street connectivity measure with us.

control for two variables that capture the local economic conditions, i.e. *Unemployment* rate and the *Median Income* of households per MSA per year (Rodríguez-Pose and Hardy, 2015; Obschonka et al., 2019). Fourth, there is a longstanding debate about the effect of specialization versus diversity in the literature. Therefore, we control for the extent to which MSAs are specialized in terms of their industrial sector compositions. We calculate the specialization index as follows: $Specialization_{r,t} = (1/2)\sum|S_{jr} - S_j|100$, where S_{jr} is the fraction of employees in industry *j* in MSA *r*, S_j is the fraction of employees in industry j in the entire US. This measure indicates the extent to which a local economy in a given MSA *r* deviates from the composition of the national economy[16]. Fifth, based on the Knowledge Spillover Theory of Entrepreneurship (KSTE), the usual and standard sources of knowledge generation and spillovers that can create entrepreneurial opportunities are university and corporate R&D investments (Audretsch and Lehman, 2005; Acs et al., 2009). Therefore, we control for the regional *University R&D* and *Corporate R&D* investments separately. Sixth, we control for the macro-psychological personality, which are basically the Big Five personalities traits aggregated at the level of MSAs (except the *Openness* which is our explanatory variable). They are *Agreeableness*, *Conscientiousness*, *Neuroticism*, and *Extraversion.* Recent regional entrepreneurship literature shows that such macro-psychological traits are an important predictor of entrepreneurial activities (Obschonka et al., 2015; Stuetzer et al., 2018). Seventh, we isolate the effect of *Ethnic Diversity*, because in those cities with high concertation of open people, there might be high ethnic diversity of people too – which might drive our results. In order to capture the ethnic diversity, we use an entropy measure of ethnic diversity, following previous studies (e.g. Lee et al, 2017). Finally, in order to capture the community traits, as an additional collective city traits, we added *Social Membership* variable, which is the number of memberships in social clubs including (a) civic organizations; (b) bowling centers; (c) golf clubs; (d) fitness centers; (e) sports organizations; (f) religious organizations; (g) political organizations; (h) labor organizations; (i) business organizations; and (j) professional organizations (Rupasingha et al., 2006). The list of all variables and their definitions are presented in Table 1.

[Table 1 about here]

[16] An alternative way to capture specialization is though the Location Quotient (LQ) index, which originally gives specialization per industry per region per year, which then one needs to aggregate all industries into the level of MSAs. Results remain the same if we use such LQ measure.

Descriptive statistics and correlation matrix are presented in Table 2. The dependent variable *Quality Entrepreneurship* has positive and moderate correlations with the main explanatory variables *Openness* as well as the two moderator variables *Diversity* and *Density*. Moreover, the explanatory and moderator variables do not show particularly high correlations with control variables, which indicates that multicollinearity should not be severe in our subsequent regression analysis. Moreover, the average Variance Inflation Factor (VIF) value is never above 2.8 in any of our models, hence further indicating that multicollinearity should not be serious in our models.

[Table 2 about here]

Figures 2 shows the distribution of our dependent variable quality entrepreneurship as well as explanatory variables (openness) and moderator variables (density and diversity) across MSAs in the US. The distribution and concertation of quality entrepreneurship follow similar patterns with the distributions of openness, diversity and density in many MSAs. The notable concentrations are in MSAs in east and west coasts.

[Figure 2 about here]

4. RESULTS

4.1. Main Effects

Tables 3A and 3B report our regression analysis results using *Population Density* and *Street Density* as two alternative measures of urban density, respectively. The dependent variable in all models is *Quality Entrepreneurship*. There are several important findings. First, the level of regional *Openness* of cities positively and statistically predicts the quality entrepreneurship (model 3a.1; model 3a.4; model 3b.1; model 3b.4). In terms of effect magnitude, if openness in a given city is increased by 1 unit, then the quality entrepreneurship is increased by about 10 percentage point, *ceteris paribus*. This confirms our hypothesis 1.

Second, as expected based on Jacobs' theorizing and in line with the previous literature, *Density* (both population based and street based density measures) has a positive direct effect on the quality entrepreneurship (model 3a.2; model 3a.4; model 3b.2; model 3b.4). *Diversity* also has the similar positive direct effect on quality entrepreneurship (model 3a.3; model 3a.4; model 3b.3; model 3b.4).

Third, most of the two-way interactions are positive however statistically insignificant (model 3a.6; model 3a.7; model 3b.5; model 3b.6; model 3b.7). An exception here is the

interaction effect of *Openness-Diversity* which is statistically significant (model 3a.5). This suggests that two-way interactions have weak explanatory power to explain the variation of quality entrepreneurship.

Fourth, the three-way interaction of *Openness-Density-Diversity* are positive and significant in explaining the quality entrepreneurship (model 3a.8; model 3b.8). In order to have an accurate statement about the effect of such three-way interaction, we will provide several plots and related tests and discussions for the marginal effects in the following section. This will pave the way for testing our hypothesis 2.

[Table 3a about here]

[Table 3b about here]

4.2. Interaction Effects

In order to further shed light on the three-way interaction effect of *Openness-Density-Diversity* on entrepreneurship, we provided the predicted marginal effect plots in Figures 3. Our main explanatory variable, *Openness*, is depicted in the x-axis, and we illustrate the three-way interactions by inserting density and diversity as the two moderators. The combination of 'low' and 'high' levels of density and diversity creates four types of cities, i.e. Low Density Low Diversity (LD-LD), Low Density High Diversity (LD-HD), High Density Low Diversity (HD-LD), and High Density High Diversity (HD-HD). As we are interested in the moderating effect of favorable versus unfavorable structural city environments on the openness-entrepreneurship relationship, we will focus and depict the first and last types in our marginal plots, as the operationalization of unfavorable and favorable city environments, respectively (based on our conceptual model in Figure 1). Moreover, Figures 3 has parts A and B, in which Part A corresponds to models where urban density is measured by population density (Table 3A) and Part B corresponds to models where density is measured by street density (Table 3B)[17].

Hypothesis 2 posits that a favorable structural city environment can moderate the positive effect of openness on entrepreneurship. In Figure 3, the red curve denotes a city type that has a favorable structural city environment for entrepreneurship, i.e. the city has High Density and High Diversity (HD-HD city). On the other hand, the blue curve denotes a city type that has Low Density and Low Diversity (LD-LD city). Such a city does not offer a favorable structural city environment for entrepreneurship. Now let us compare the moderating effect of these two

[17] In alternative empirical settings, employing Density or Diversity in x-axis would reveal qualitatively similar results about the three-way interaction effects. Nevertheless, we prefer to use Openness in the x-axis as it is our explanatory variable.

city types on the openness-entrepreneurship relationship. In the HD-HD city, increasing openness by one unit corresponds to an increase in quality entrepreneurship by (0.8 - 0.4) × 100 = 40% if urban density is captured by population density (Figure 3A), and (0.6 - 0.3) × 100 = 30% if urban density is captured by street density (Figure 3B). On the other hand, in the LD-LD city, the equivalent increase in quality entrepreneurship is (0.20 - 0.15) × 100 = 5% if urban density is captured by population density (Figure 3A), and it is (0.30 - 0.20) × 100 = 10% if urban density is captured by street density (Figure 3B). Therefore, the moderating effect of HD-HD city is 20% to 35% more than the base line LD-LD (depending whether urban density is measured by population or street network density). The above interpretation of the magnitude of the moderating effect is statistically significant, based on the pairwise comparisons of the average marginal effect for the two city classes, reported in the Table 4. This confirms our hypothesis 2.

There is an additional important empirical findings worthy of note. Consider the red HD-HD curve. The very left end of this curve corresponds to cities that have the lowest openness value (LO-HD-HD cities), while the very right end of it corresponds to cities that have the highest openness value (HO-HD-HD cities). Then the HO-HD-HD cities will have more quality entrepreneurship (i.e. high potential startups) than the LO-HD-HD cities by (1 - 0) × 100 = 100% (twice), if urban density is captured by population density (Figure 3A), and by (0.75 - 0.05) × 100 = 70% if urban density is captured by street density (Figure 3B), everything else equal. This shows the *additionality* of openness for quality entrepreneurship of cities that *already* have favorable structural city environments (i.e. the cities are already highly dense and diverse). In other words, comparing two MSAs with similar favorable city environment, the one that has higher level of openness seems to outperform the other one in terms of producing quality entrepreneurship. Such outperformance is statistically significant, based on the pairwise comparisons of the average marginal effect for the four city classes, reported in Table 4. This finding shows the importance of considering all three elements of openness-density-diversity in the people-city environment interactions for achieving the highest performance of cities in terms of quantity entrepreneurship. The top 10 cities that are HO-HD-HD are reported in the Appendix A. Examples of such cities are San Francisco and New York.

[Figure 3 about here]

[Table 4 about here]

4.3. Other Results about Control Variables

A particularly interesting result among the control variables is about *Specialization*, because this variable is argued to be an alternative way of capturing knowledge spillover in cities (Glaeser et al, 1992). The variable shows a negative effect on quality entrepreneurship in our data. This is in line with the earlier prediction (Duranton and Puga, 2000) and empirical evidence (Feldman and Audretsch, 1999; Duranton and Puga, 2001) that while specialization can increase the efficiency and hence labor productivity, it might be even harmful for new knowledge creation, creativity, innovation and high-quality entrepreneurship. This is because specialization can create 'lock-in', hence stopping the generation of new and novel ideas. Moreover, we also used two-way and three-way interaction terms of specialization (instead of diversity) with density and openness. The results of such interaction exercises are either non-significant or negatively significant (which are available upon request). This shows that the openness effect is neither enhancing nor interacting *any* type of agglomeration and knowledge externalities, rather it exclusively works for Jacobian externalities.

4.4. Robustness Checks

We have conducted several robustness checks. First, for the dependent variable, we alternatively used *Quantity Entrepreneurship*, measured by the startup rate in a given MSA, as a conventional measure of entrepreneurship. We do so in order to compare our quality entrepreneurship results with this often used measure of entrepreneurship in previous studies. Result of such robustness check is reported in the Appendix B. The results in terms of statistical significance largely remained the same in compare with quality entrepreneurship in Table 3. This is not surprising as quantity and quality entrepreneurship are highly correlated (0.7 correlation coefficient). In terms of the magnitude of the effect based on standardized coefficients, it is interesting to note that the effect of openness on quality entrepreneurship is slightly higher than its effect on quantity entrepreneurship (compare standardized coefficients in model 3a.4 and model B1.4)[18]. Moreover, a favorable structural city environment (i.e. high density and diversity) strengthens the local openness effect on quantity entrepreneurship by 15% (it was 35% in the case of quality entrepreneurship). We interpret these results as in line with our proposition that quality entrepreneurship represents a more accurate indicator of knowledge spillovers than quantity entrepreneurship.

[18] Such a greater effect of openness on quality entrepreneurship in comparison to quantity entrepreneurship is statistically significant based on Seemingly Unrelated Estimation.

Second, a related concept to our *interaction tendency* concept in this paper is Richard Florida's concept of *tolerance* or *openness to difference*, which is typically captured by the spatial concentration of bohemians and/or homosexuals, but also people who work in creative industries (Florida, 2002). There are some positive correlation between our people openness measure and Florida's measures. In particular, the correlation coefficient between people openness and Creative Class, Bohemian, and Homosexuals are 0.13, 0.16, and 0.15 respectively. Nevertheless, Florida's measures can be perceived as 'indirect' measures of openness as opposed to our 'direct' measure of openness (based on physiological traits). Therefore, we expect a weak association with Florida's indirect measure of openness with entrepreneurial outcomes of cities (if any). We replaced our openness measure with three Florida's measures, i.e. (i) share of bohemian, (ii) share of homosexuals, and (iii) share of people working in creative industries, and then re-ran our regression analysis for quality entrepreneurship. Results are reported in Appendix C. As expected, there is barely any significant effect of the indirect measure of openness on quality entrepreneurship of cities (neither direct effect nor three-way interaction effect). Such a lack of finding any robust result using the indirect measure of openness reinforces our choice of employing the direct measure of openness in studying the entrepreneurial performance of cities.

Third, there might be confounding factors for our main argument, particularly the interaction between local openness, urban density and industry diversity. To begin with, instead of people's openness to capture local openness, we used ethnic diversity as an alternative indicator of local openness in a city. We re-tested our H2 (interaction hypothesis) using this alternative measure. The result is reported in the Appendix D (Table D1, Model D1.1). Unlike people openness, ethnic diversity does not interact with density and industry to positively affect quality entrepreneurship. This suggests that empirically speaking, even though there might be other good proxies for local openness (e.g. ethnic diversity), nevertheless, it seems the best way to capture the interaction effect between local (cities) openness and cities structural environment is the psychological openness of people in cities. Moreover, instead of industry diversity, we used patent per capita as an alternative way to capture the "production and flow of knowledge". In doing so, we re-tested our interaction hypothesis (H2) twice as follows: (a) *Openness* $_X$ *Patent* $_X$ *Density* and (b) *Ethnic Diversity* $_X$ *Patent* $_X$ *Density*. The results of such alternative specifications and tests are reported in Appendix D, Table D1, Model D1.2 and D1.3, respectively. Patent seems to interact with density and openness (or ethnic diversity) to positively affect quality entrepreneurship. However, such interaction is fairly weaker in compare with having industry diversity in the interaction models (our original specification).

This is because even though patent per capita can facilitate the production and flow of ideas and knowledge, as you rightfully noted, however it is mainly about production and flow of technological knowledge. The industry diversity, instead, can capture a larger set of production and flow of knowledge, according to Jacobs herself.

Fourth, previous studies suggest that manufacturing and service sectors might show different patterns when it comes to knowledge spillovers (Kaiser, 2002). Therefore, we re-calculate quality entrepreneurship of cities using manufacturing and service firms separately. In our sample, 37% of firms in traded industries belong to service sector, while 44% belong to manufacturing sector (the rest of the firms did not report their sectors)[19]. Then we re-ran our regression models. The result of such robustness check is reported in the Appendix E. The results show that the effect of openness (both direct effect and interaction effect) on quality entrepreneurship is fairly similar in manufacturing and service sectors, albeit a slightly stronger effect can be observed in the manufacturing sector.

Fifth, endogeneity may arise as people with open personalities migrate to entrepreneurial MSAs. Entrepreneurial regions might attract open people, because they are more likely to meet their personal preferences for entrepreneurial activities and performance. Although we cannot rule out such possibility completely, nevertheless we think this issue should not be substantial in our study. In order to account for such endogeneity issue at least partially, we follow previous research (e.g. Stuetzer et al., 2018) and compute regional openness based on the respondents' residences in their youth (instead of current) zip code. Calculating local openness based on 'youth zip code' implies that we captured local openness of a given city presumably *before* any occupational and migration choices were made by its residents. The results of such robustness check is very similar to the main results. They are available upon request. Nevertheless, we are cautious about any causal conclusions and our results should be interpreted as preliminary.

5. DISCUSSION

5.1. Summary of purpose and results

The purpose of this paper was twofold. First, we develop a conceptual model about the role of people in fostering local knowledge spillovers by integrating (i) a personality perspective and the spatial clustering of individual personality traits (openness as indicator of agency) as well as (ii) the person-environment interactions within the Jacobs' knowledge spillover context.

[19] Our sample somewhat over represents manufacturing over service in the US (Delgado and Mills, 2020), nevertheless, since our main analysis is at the MSA-level, it should not affect our core findings.

Second, we moved beyond the traditional human capital approach and measured and investigated the 'people-focus' in Jacobs' thinking more directly than in previous research. To this end, we analyzed data collected from millions of people concerning their personality structure. The results show that, first, the dispositional agentic tendency of local populations (i.e. local openness) is positively associated with quality entrepreneurship. Second, we found important interaction effects between local openness and the structural city environment. On the one hand, a favorable structural city environment (i.e. high density and diversity) strengthens the openness effect on quality entrepreneurship by up to 35%. On the other hand, local openness has a clear additionality for quality entrepreneurship of those cities that already have a favorable structural city environment. Such cities can further enhance their quality entrepreneurship up to two times, by having more open people. Taken together, these results support and extend Jacobs' original view that knowledge spillovers and economic performance not only require agentic populations as a necessary condition, but are *considerably amplified* with increased psychological population agency in local populations embedded in, and interacting with, a favorable structural city environment.

5.2. Implication for research

As interest and concern about entrepreneurship has exploded in the literature, so too has the role of learning knowledge spillovers. Because of spillovers and externalities, investments in knowledge and research can have a leveraged impact in generating entrepreneurship, innovation, and economic growth. The extant literature has generally identified three key components driving the extent and magnitude of knowledge spillovers. The first is the knowledge source, most typically investments in knowledge by firms and universities (e.g. Audretsch and Lehmann, 2005). The second is the spatial structure and organization of economic activity, such as the degree to which it is agglomerated or characterized by density (e.g. Glaeser et al., 1992). The third involves the mechanism or conduit for the spillover of knowledge, such as entrepreneurship or labor mobility (e.g. Acs et al., 2009).

This paper has gone back to the roots, or the original insights of Jane Jacobs, who reminds us that there is a fourth key dimension shaping knowledge spillovers, which has generally been overlooked by the extant literature – people. Of course, people provide the vessel embodying human capital, which can serve as an important source of knowledge as well as key capacity for absorbing knowledge spillovers (Lucas, 1988; Qian and Acs, 2013; Qian et al., 2013). However, the emphasis in the human capital (externalities) literature is more on the capital and

less on the human, i.e. what matters is the degree of education and training, which translates into an equivalent of capital found in things rather than in people.

By contrast, inspired by Jacobs and a fundamental notion in the social sciences, namely *human heterogeneity* (Gelfand, 2019; Bettencourt et al, 2014), we emphasized a very different aspect of what it means to be human as well. People have numerous capacities, proclivities, capabilities and gifts in addition to the capital embodied in them in terms of education and training. We draw on one of those key aspects characterizing people – their propensity to be open to other people and to new ideas and experiences. Our empirical evidence provides compelling support that people matter in a way not reflected or captured by human capital, i.e. what makes people human – a dimension of their personality – is also conducive to knowledge spillovers. After all, for knowledge spillovers to occur efficiently, it is not only about having new knowledge (stemming from diversity) and frequent interfaces among people (stemming from density), but also the openness of those people to the ideas and possibilities inherent in those new ideas and human interactions.

Our study may stimulate further research on knowledge spillovers and economic performance that takes the people side more seriously – with a particular focus on person-environment interactions (e.g., how agentic dispositions may get expressed more strongly via a supportive context structure). This also concerns research that mostly looks at functional city infrastructure (e.g., local industry mix). One important way through which such structural factors stimulate the local economy is by providing an opportunity structure for local populations, and by triggering and harnessing agentic potentials in people. These agentic potentials in people show, however, a certain heterogeneity.

5.3. Implications for practice and public policy

With respect to the structural factors, our study underlines the practice and policy implications of seminal prior research on the Jacobs' approach highlighting the importance of density and diversity, e.g., for urban planning and industrial policy (Glaeser et al., 1992; Alexiou, 2006; Mohareb et al., 2016). However, our results also support the view that this alone would fall short as it does not *directly* address the human side of people. With our empirical focus on dispositional population agency (the local openness levels that represents a regional trait), we show that regions differ in this collective agentic potential, which should be considered in public policies (e.g., psychological population agency itself is a regional competitive advantage, Saxenian, 1996; Kenney, 2000). It is also important to note that while personality traits show considerable stability, both at the individual level (Caspi et al., 2005) and across regions

(Elleman et al., 2018), they also exhibit plasticity, i.e. a person's personality traits can change over time (Caspi et al., 2005; Roberts et al., 2017). From this perspective, public policy aiming to stimulate local knowledge spillovers and economic vitality (e.g., quality entrepreneurship) should not only focus on the structural environment, and with respect to people, on human and social capital factors, but also proactively take into account the local psychological tendencies, such as openness of people (Huggins and Thompson, 2019; Shane, 2003).

Such policy making could develop instruments to enhance the openness and agentic capacities of local populations, for example by promoting intellectual and cultural growth in people (Zimmermann and Neyer, 2013), by overcoming a general resistance to change (Oreg, 2003) and by enabling people *to embrace* new ideas, and *diversity* of ideas (and associated uncertainty), as something positive and an opportunity rather than a threat (Tasselli et al., 2018). Moreover, from personality psychology we know that openness shows a normative age trend over the lifespan with, on average, higher values in young age (adolescence and young adulthood) and decreasing values in mid and old age. Hence, policies that harness the agentic appetite and potential of young people (e.g., young students) might be a particularly effective way to stimulate knowledge spillovers. Such policies may aim to stimulate the young people to interact within, and benefit from, a favorable city environment that brings them together (density) and offers new ideas and learning possibilities (diversity). This could help explain why universities as such are often seen as important drivers of knowledge spillovers, entrepreneurship and innovation in a region (Audretsch and Lehmann, 2005). They essentially *concentrate* (physically and virtually via digital technologies) agentic people with an appetite and capacity to enhanced knowledge spillovers, and add *diversity* by providing a stimulating opportunity structure and structural city environment (e.g., new ideas and knowledge, education, experiential learning, and various learning technologies). Finally, increasing psychological agency and openness in a region may also contribute to better economic resilience during major macroeconomic crises as indicated by recent research (Garretsen et al., 2020).

There are also important implications for addressing the growing spatial divide and polarization in the United States and elsewhere (cf. Dijkstra et al, 2020). The coveted human qualities reflected by openness, along with the city structural characteristics of density and diversity do not fall like manna from heaven on high-performing cities and regions. Rather, they may reflect underlying long-term policy and institutional strategies. As Walshok and Shragge (2013) and Saxenien (2007) make clear, entrepreneurs surely do not randomly fall into their spatial location, but rather carefully chose where to locate, work and live, on the basis of

a broad spectrum of considerations, such as where the money is (VCs, for instance), and where the good local school are. Policies in less entrepreneurial cities and regions, as well as at the national level, could mitigate such spatial disparities through strategies to attract people who are more open in terms of their personality to their city or region and foster openness among the existing inhabitants.

5.4. Limitation and future research avenues

Our study has limitations. First, while it is the first study to introduce a person-context perspective with a personality focus to the literature on knowledge spillovers, our analyses cannot make strictly causal claims, given the correlational nature of the data. Nevertheless, we performed several robustness checks to rule out alternative explanations.

Second, our empirical context is based on US cities and our results might be US-specific. Recent evidence indeed suggests that there might be systematic differences between countries in what is universally assumed to be a favorable structural city environment. For example, in an international comparison of fourteen countries, Fritsch and Wyrwich (2020) found that spatial concentration (density) of innovative activities in large cities is only prevalent in the US and South Korea. Therefore, our findings need to be tested elsewhere in order to allow for generalizability.

Third, we advocate the idea that open people interact and exchange ideas better with each other than non-open people due to their psychological tendencies and that is how local openness facilities knowledge exchange. Other alternative mechanisms for how open people can facilitate knowledge exchange may exist. For example, open people may facilitate inter-firm linkages. As we cannot observe the firm and institutions in which each individual work in a given city, we suggest that these alternative mechanisms can be subject of future studies.

Fourth, we used a very comprehensive measure of quality entrepreneurship, which has been recently been successfully used in major studies recently (Guzman & Stern, 2015; 2020; Fazio et al, 2020). It is a groundbreaking approach since it fills the void of assessing quality entrepreneurship by means of firm characteristics based on business registration data and predictive modeling linking these firm characteristics to future firm growth. Nevertheless, future research could test our model using other measures of quality entrepreneurship (e.g., the index used by Decker et al. (2016) (see also Henrekson & Sanandaji, 2020), or other quality variables such as growth of firms, innovation outputs of firms, and survival of firms.

In terms of further future research avenues, we hope to inspire more economic research taking into account human heterogeneity, not only with respect to the important factor of human

capital, but also with respect to psychological heterogeneity between people, and between regions. It is one of the fascinating findings from modern geographical psychology that regions (e.g., cities and even city districts) show spatial psychological variation which has important implications for the economic processes in the regions, including knowledge spillovers. Future research could provide a more nuanced picture on *how* local populations with their unique psychological makeup interact with a structural city environment. This can deliver important new insights relevant to urban planning, innovation and entrepreneurship policies, and last but not least for the well-being and thriving of local populations themselves. We therefore call upon future research to tackle what Jane Jacobs identified more than a generation ago about what may ultimately prove to be among the most salient ingredients shaping and driving the spillover of knowledge – the very complex nature of people and their behaviors.

6. CONCLUSIONS

While our analyses echo a large and compelling body of literature confirming the central proposition of Jane Jacobs about what makes cities successful – that the extent of density and diversity matters greatly in shaping economic vitality (e.g., quality entrepreneurship) exhibited by a place, our study also adds to Jacobs' concept and the existing research inspired by her by shedding new light on the human side of people. Although prior studies have often generally operationalized Jacobs' ideas in terms of local mix of industries, our central finding is that the psychological characteristics of the people themselves matter in shaping local economic vitality in two important ways. First, dispositional population agency enhances knowledge exchange and interactions between people, and thus knowledge spillovers leading to economic vitality. Second, a favorable structural city environment is therefore (more) effective in enhancing knowledge spillovers than other city environments because it also enables agentic populations to achieve particularly amplified knowledge exchange and interactions. In other words, urban diversity and density may operate as an 'external enabler', or catalyst, for agentic populations' dispositional capacity to contribute to knowledge spillovers. Our paper is thus an important reminder that it is not just firms and industries at a place that matter for knowledge spillovers but ultimately the people inhabiting that place – and people do differ. They differ from one another not just in terms of human capital but in their personalities too, which is a key but previously missing ingredient driving knowledge spillovers. Taken together, our results support the view that what may really matter is *how* people in cities unlock their agentic tendencies to help turn a favorable city environment as envisioned by Jacobs into concrete economic output.

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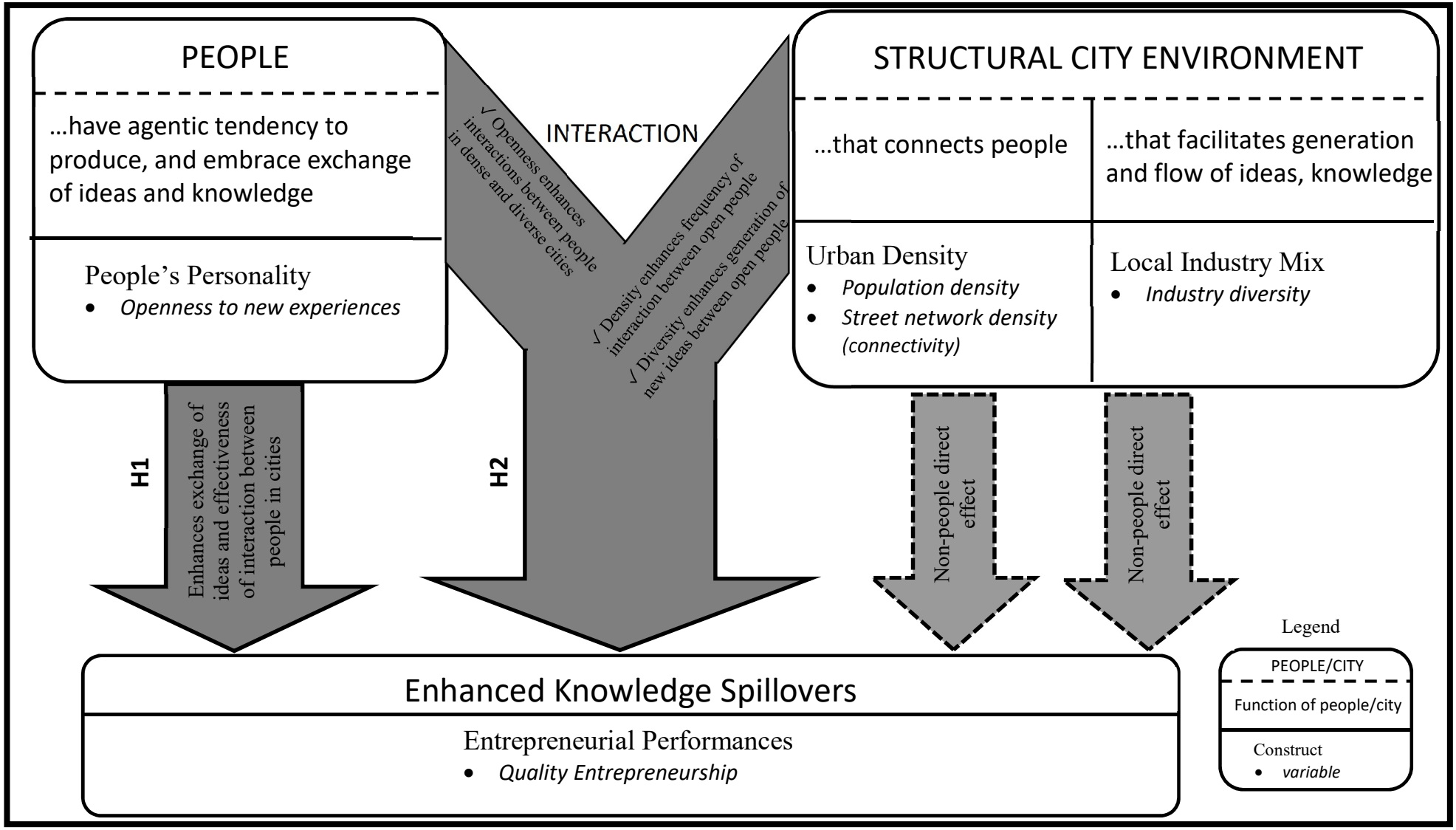
Figure 1 – Entrepreneurship in Cities: Agentic populations, structural city environment, and their interaction



Note: Solid arrows shows the scope of this study and proposed hypothesis. Dashed arrows are confirmed mechanism/relationship in previous studies.

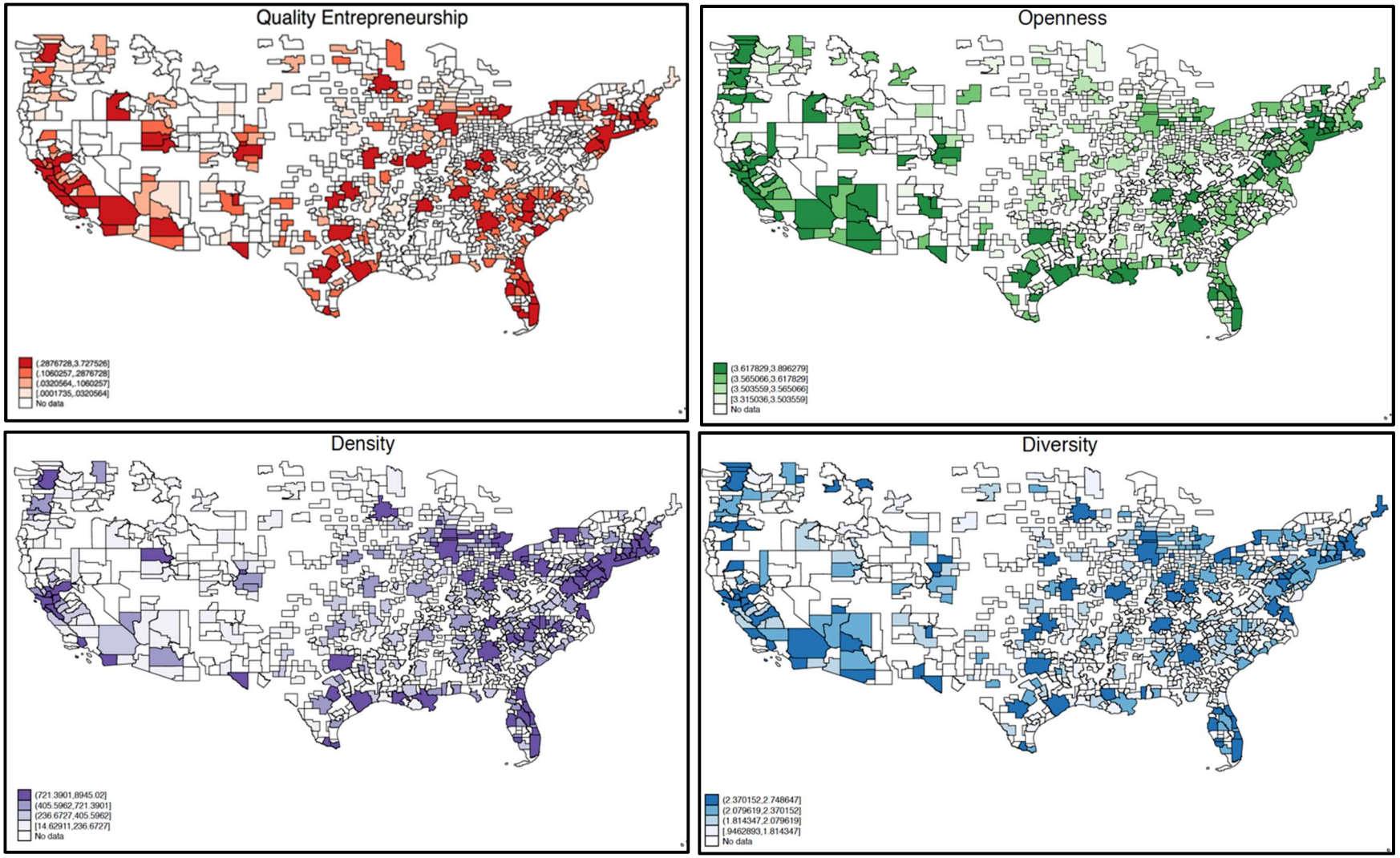
Table 1 - Variables definitions

Variable type	***Variable name***	***Measure***
Dependent	*Quality Entrepreneurship*	Quality-Adjusted Entrepreneurship measured by the RECPI Index (log), (2010-2015)
Explanatory	*Openness*	Average individuals' Openness score, as one of the Big 5 personality traits, per MSA (2000-2015)
Moderator 1	*Urban Density*	Captured in two ways: (1) Population density, measured as the number of individuals per square miles per MSA (log) (average 2010-2015), (2) Street Network Density, measured as the total miles of streets oriented toward both car and pedestrian travel (multimodal) per square miles per MSA (log) (average 2010-2015)
Moderator 2	*Industry Diversity*	The related industry diversity index of regions captured by Related Variety measure, per MSA (average 2010-2015)
Control 1	*Human Capital*	The percentage of population who have attained a bachelor's degree per MSA (average 2010-2015)
Control 2	*Median Income*	Median household income in the past 12 months (in 2012 inflation-adjusted) per MSA (log), (average 2010-2015)
Control 3	*Unemployment*	Unemployment rate measure as percentage of unemployed workers to the total work force per MSA per year (2010-2015)
Control 4	*Demographic*	The share of population who are between 25 and 44 years old per MSA (average 2010-2015)
Control 5	*Specialization*	Industry Specialization Index of regions per MSA, (average 2010-2015)
Control 6	*University R&D*	Amount of University R&D investment per MSA (log), (average 2010-2015)
Control 7	*Corporate R&D*	Amount of Corporate R&D investment per MSA (log), (average 2010-2015)
Control 8	*Agreeableness*	Average Agreeableness score, as one of the Big 5 personality traits, per MSA (2000-2015)
Control 9	*Conscientiousness*	Average Conscientiousness score, as one of the Big 5 personality traits, per MSA (2000-2015)
Control 10	*Neuroticism*	Average Neuroticism score, as one of the Big 5 personality traits, per MSA (2000-2015)
Control 11	*Extraversion*	Average Extraversion score, as one of the Big 5 personality traits, per MSA (2000-2015)
Control 12	*Social Membership*	The number of memberships in various social clubs, per MSA (2014)
Control 13	*Ethnic Diversity*	Ethnic Diversity Index captured by entropy measure, per MSA (2010)

Table 2 - Descriptive Statistics and Correlation Matrix

	Mean	S.D	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) Quality Entrepreneurship	0.27	0.30	1																	
(2) Openness	3.57	0.28	0.16	1																
(3) Density (population)	5.86	0.90	0.37	0.14	1															
(4) Density (street)	1.02	0.20	0.15	0.01	0.21	1														
(5) Diversity	2.06	0.35	0.24	0.14	0.05	0.27	1													
(6) Human Capital	23.56	6.88	0.36	0.20	0.22	-0.03	0.10	1												
(7) Median Income	10.79	0.16	0.41	0.02	0.21	0.26	0.04	0.61	1											
(8) Unemployment	8.87	2.61	-0.01	0.11	0.06	0.15	0.14	-0.48	-0.41	1										
(9) Demographics	25.54	2.14	0.44	0.00	0.19	-0.17	-0.20	0.11	0.27	-0.19	1									
(10) Specialization	22.91	7.24	-0.35	-0.04	-0.21	0.04	-0.51	-0.40	-0.23	0.20	0.00	1								
(11) University R&D	7.40	1.08	0.14	-0.06	0.27	0.64	0.05	-0.18	0.03	0.29	-0.04	0.13	1							
(12) Corporate R&D	8.69	1.52	0.16	-0.03	0.17	0.69	0.12	-0.18	0.12	0.38	-0.08	0.14	0.90	1						
(13) Agreeableness	3.77	0.28	0.01	0.10	-0.01	-0.16	-0.10	-0.02	-0.06	-0.06	0.06	-0.04	-0.02	-0.03	1					
(14) Conscientiousness	3.37	0.35	-0.02	-0.44	0.12	-0.07	-0.07	-0.05	-0.07	0.07	0.01	0.04	0.06	0.01	0.21	1				
(15) Neuroticism	2.82	0.32	-0.04	-0.04	-0.08	0.08	0.08	-0.02	0.03	-0.02	-0.05	-0.01	-0.01	0.00	-0.45	-0.16	1			
(16) Extraversion	3.38	0.34	0.09	0.17	-0.04	-0.09	-0.13	0.02	0.04	-0.09	0.05	0.01	-0.05	-0.07	0.44	-0.03	-0.49	1		
(17) Social Membership	2.38	2.44	0.23	0.21	0.12	-0.27	-0.23	0.28	0.31	-0.37	0.30	-0.15	-0.19	-0.32	0.13	-0.12	-0.14	0.22	1	
(18) Ethnic Diversity	1.66	0.10	-0.19	-0.13	0.02	-0.69	-0.36	0.06	-0.20	-0.45	0.16	-0.07	-0.48	-0.63	0.10	0.04	-0.05	0.11	0.41	1

Figure 2 - Quality Entrepreneurship, Openness, Diversity, and Density across MSAs in the US



Note: Quality Entrepreneurship is calculated by RECPI Index. Openness is the people openness to new experiences. Density is population density. Diversity is related industry diversity (see section 3.2 to 3.4 for exact definitions and formulations).

Table 3A - Effects of Openness on Quality Entrepreneurship: Main effect and its interaction effects with Density (population) and Diversity

	(3a.1)	(3a.2)	(3a.3)	(3a.4)	(3a.5)	(3a.6)	(3a.7)	(3a.8)
Openness	0.106**			0.094*	0.074+	0.096*	0.100*	0.081+
	(0.034)			(0.040)	(0.041)	(0.040)	(0.042)	(0.043)
	0.082			0.067	0.053	0.069	0.071	0.058
Density (population)		0.071***		0.083***	0.089***	0.078***	0.082***	0.082***
		(0.012)		(0.015)	(0.016)	(0.016)	(0.016)	(0.016)
		0.163		0.153	0.165	0.144	0.151	0.152
Diversity			0.141***	0.213***	0.217***	0.211***	0.213***	0.226***
			(0.036)	(0.043)	(0.042)	(0.043)	(0.043)	(0.043)
			0.131	0.163	0.165	0.161	0.163	0.172
Openness $_X$ Diversity					0.292*			0.465**
					(0.144)			(0.160)
					0.052			0.083
Diversity $_X$ Density						0.053		0.052
						(0.052)		(0.052)
						0.027		0.027
Openness $_X$ Density							0.022	-0.020
							(0.055)	(0.059)
							0.011	-0.010
Openness $_X$ Diversity $_X$ Density								0.505*
								(0.232)
								0.068
Human Capital	0.010***	0.009***	0.011***	0.009***	0.008***	0.009***	0.009***	0.009***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	0.203	0.175	0.215	0.168	0.161	0.172	0.169	0.167
Median Income	0.208**	0.169*	0.235**	0.290**	0.278**	0.289**	0.289**	0.278**
	(0.076)	(0.076)	(0.077)	(0.088)	(0.088)	(0.088)	(0.088)	(0.088)
	0.094	0.077	0.107	0.124	0.119	0.124	0.124	0.119
Unemployment	0.026***	0.021***	0.029***	0.023***	0.022***	0.023***	0.023***	0.023***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
	0.197	0.157	0.216	0.164	0.161	0.165	0.165	0.162
Demographics	0.062***	0.060***	0.063***	0.064***	0.064***	0.064***	0.064***	0.064***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
	0.392	0.377	0.399	0.396	0.395	0.395	0.396	0.394
Specialization	-0.014***	-0.012***	-0.010***	-0.009***	-0.009***	-0.009***	-0.009***	-0.009***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	-0.287	-0.251	-0.208	-0.168	-0.160	-0.170	-0.169	-0.165
University R&D	-0.014	-0.037+	-0.015	-0.016	-0.020	-0.016	-0.017	-0.017
	(0.019)	(0.019)	(0.019)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
	-0.041	-0.110	-0.045	-0.044	-0.055	-0.043	-0.046	-0.046
Corporate R&D	0.059***	0.055***	0.059***	0.042*	0.045*	0.041*	0.043*	0.042*
	(0.015)	(0.015)	(0.015)	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)
	0.244	0.228	0.246	0.158	0.170	0.153	0.160	0.156
Agreeableness	-0.077*	-0.059+	-0.051	-0.051	-0.050	-0.050	-0.050	-0.050
	(0.035)	(0.035)	(0.035)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
	-0.061	-0.046	-0.040	-0.039	-0.038	-0.038	-0.038	-0.038
Conscientiousness	0.068*	0.023	0.039	0.058+	0.052+	0.056+	0.059+	0.051
	(0.029)	(0.026)	(0.026)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
	0.065	0.022	0.037	0.054	0.048	0.052	0.055	0.047
Neuroticism	0.041	0.046	0.033	0.065+	0.066+	0.065+	0.066+	0.056
	(0.032)	(0.031)	(0.031)	(0.034)	(0.034)	(0.034)	(0.035)	(0.035)
	0.037	0.041	0.029	0.054	0.055	0.054	0.055	0.046
Extraversion	0.112***	0.129***	0.123***	0.132***	0.145***	0.128***	0.130***	0.125***
	(0.029)	(0.029)	(0.029)	(0.031)	(0.032)	(0.031)	(0.032)	(0.033)
	0.107	0.124	0.118	0.123	0.136	0.120	0.121	0.117
Social Membership	0.035***	0.032***	0.036***	0.035***	0.035***	0.034***	0.035***	0.033***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)
	0.193	0.176	0.201	0.190	0.190	0.184	0.189	0.182
Ethnic Diversity	-0.458***	-0.673***	-0.328**	-0.407**	-0.401**	-0.411**	-0.405**	-0.374**
	(0.113)	(0.116)	(0.120)	(0.132)	(0.131)	(0.132)	(0.132)	(0.132)
	-0.136	-0.201	-0.098	-0.119	-0.117	-0.120	-0.119	-0.110
Observations	362	362	362	362	362	362	362	362
Adjusted R-squared	0.491	0.503	0.494	0.528	0.530	0.528	0.528	0.532
AIC	118.1	94.60	112.1	107.5	105.2	108.4	109.3	104.4

For each variable the raw coefficient (β) is reported in the first row, and the standardized coefficient (b) is reported in the third row.
Robust standard errors in parentheses ()
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1
Density is measured by population density
Dependent variable: Quality Entrepreneurship measured by Regional Entrepreneurship Cohort Potential Index (RECPI)

Table 3B - Effects of Openness on Quality Entrepreneurship: Main effect and its interaction effects with Density (street network) and Diversity

	(3b.1)	(3b.2)	(3b.3)	(3b.4)	(3b.5)	(3b.6)	(3b.7)	(3b.8)
Openness	0.106**			0.092**	0.090**	0.092**	0.091**	0.056
	(0.034)			(0.034)	(0.034)	(0.034)	(0.035)	(0.036)
	0.082			0.071	0.070	0.071	0.070	0.044
Density (street network)		0.158*		0.142*	0.142*	0.140+	0.141*	0.142*
		(0.070)		(0.069)	(0.069)	(0.071)	(0.069)	(0.071)
		0.089		0.080	0.079	0.078	0.079	0.080
Diversity			0.141***	0.128***	0.135***	0.128***	0.127***	0.130***
			(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
			0.131	0.120	0.126	0.119	0.119	0.121
Openness $_X$ Diversity					0.136			0.250*
					(0.107)			(0.115)
					0.030			0.055
Diversity $_X$ Density						0.018		0.020
						(0.145)		(0.148)
						0.003		0.003
Openness $_X$ Density							0.058	0.089
							(0.187)	(0.196)
							0.007	0.011
Openness $_X$ Diversity $_X$ Density								2.096**
								(0.652)
								0.085
Human Capital	0.010***	0.011***	0.011***	0.010***	0.010***	0.010***	0.010***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	0.203	0.228	0.215	0.208	0.204	0.209	0.209	0.219
Median Income	0.208**	0.175*	0.235**	0.226**	0.229**	0.226**	0.227**	0.212**
	(0.076)	(0.077)	(0.077)	(0.077)	(0.077)	(0.077)	(0.077)	(0.077)
	0.094	0.080	0.107	0.103	0.104	0.103	0.103	0.096
Unemployment	0.026***	0.031***	0.029***	0.029***	0.029***	0.029***	0.029***	0.030***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
	0.197	0.233	0.216	0.216	0.217	0.216	0.217	0.223
Demographics	0.062***	0.065***	0.063***	0.064***	0.064***	0.064***	0.064***	0.064***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
	0.392	0.408	0.399	0.406	0.405	0.406	0.407	0.407
Specialization	-0.014***	-0.014***	-0.010***	-0.011***	-0.010***	-0.011***	-0.011***	-0.010***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	-0.287	-0.288	-0.208	-0.213	-0.211	-0.214	-0.213	-0.201
University R&D	-0.014	-0.025	-0.015	-0.022	-0.023	-0.022	-0.022	-0.026
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
	-0.041	-0.074	-0.045	-0.067	-0.068	-0.066	-0.066	-0.077
Corporate R&D	0.059***	0.053***	0.059***	0.056***	0.057***	0.056***	0.056***	0.055***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
	0.244	0.220	0.246	0.234	0.237	0.235	0.234	0.228
Agreeableness	-0.077*	-0.049	-0.051	-0.056	-0.056	-0.056	-0.056	-0.031
	(0.035)	(0.035)	(0.035)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
	-0.061	-0.039	-0.040	-0.044	-0.044	-0.044	-0.044	-0.025
Conscientiousness	0.068*	0.034	0.039	0.072*	0.073**	0.072*	0.072*	0.072*
	(0.029)	(0.026)	(0.026)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
	0.065	0.032	0.037	0.069	0.070	0.069	0.069	0.069
Neuroticism	0.041	0.037	0.033	0.041	0.043	0.042	0.042	0.038
	(0.032)	(0.032)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
	0.037	0.033	0.029	0.037	0.038	0.037	0.037	0.034
Extraversion	0.112***	0.118***	0.123***	0.116***	0.121***	0.116***	0.116***	0.117***
	(0.029)	(0.029)	(0.029)	(0.029)	(0.030)	(0.029)	(0.029)	(0.029)
	0.107	0.113	0.118	0.111	0.116	0.111	0.111	0.112
Social Membership	0.035***	0.033***	0.036***	0.037***	0.038***	0.037***	0.037***	0.038***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
	0.193	0.181	0.201	0.206	0.208	0.206	0.206	0.209
Ethnic Diversity	-0.458***	-0.365**	-0.328**	-0.194	-0.190	-0.197	-0.199	-0.204
	(0.113)	(0.127)	(0.120)	(0.132)	(0.132)	(0.134)	(0.133)	(0.133)
	-0.136	-0.109	-0.098	-0.058	-0.057	-0.059	-0.059	-0.061
Observations	362	362	362	362	362	362	362	362
Adjusted R-squared	0.491	0.489	0.494	0.499	0.500	0.499	0.499	0.504
AIC	118.1	122.5	112.1	104.3	104.6	106.3	106.2	99.60

For each variable the raw coefficient (β) is reported in the first row, and the standardized coefficient (b) is reported in the third row.
Robust standard errors in parentheses ()
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1
Density is measured by street network density (connectivity)
Dependent variable: Quality Entrepreneurship measured by Regional Entrepreneurship Cohort Potential Index (RECPI)

Figure 3 - Interaction plots for Quality Entrepreneurship

Figure 3A- Three-way interaction of Openness-Density-Diversity: Density as Population Density

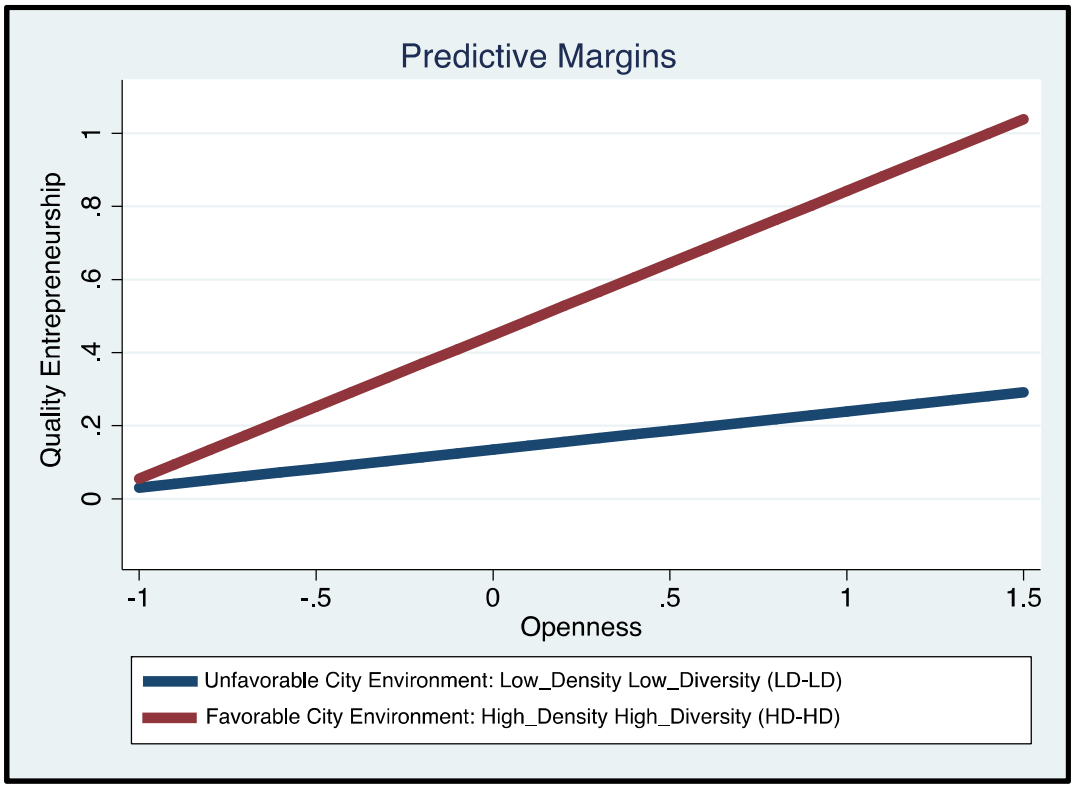
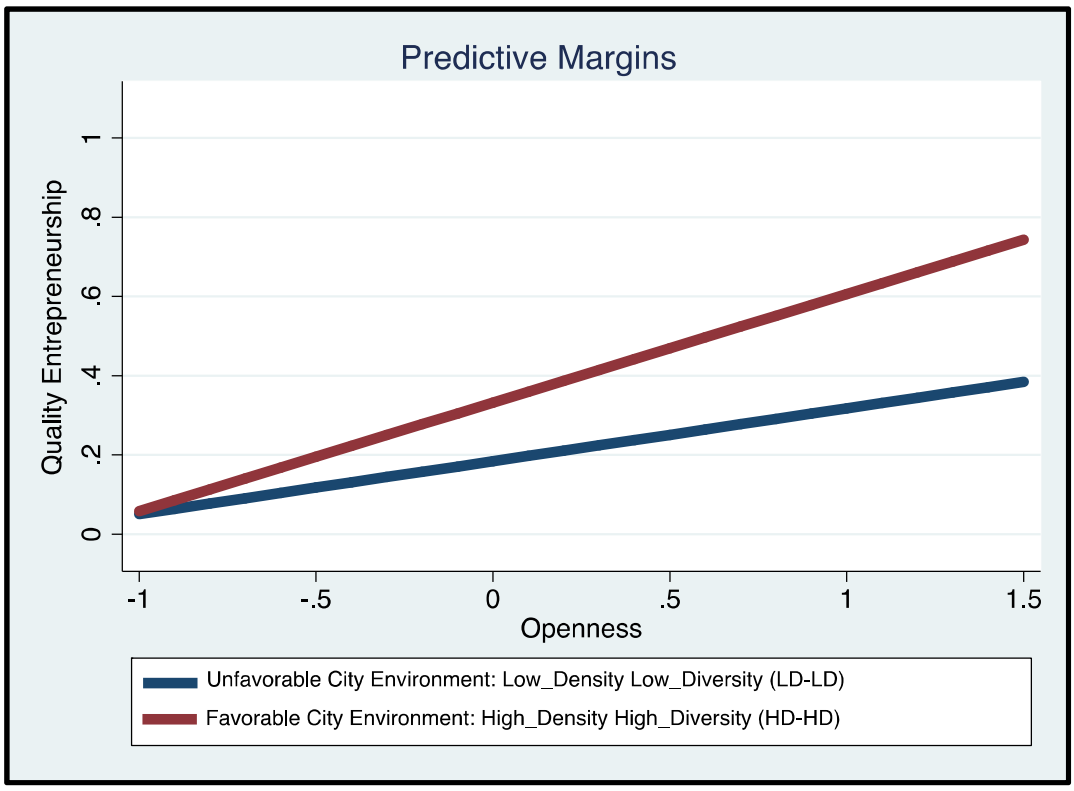


Figure 3B- Three-way interaction of Openness-Density-Diversity: Density as Street Network Density



Note: Openness is 'mean centered', so the value zero means the average value for Openness. The term 'High' refers to one standard deviation above the mean and 'Low' refers to one standard deviation below the mean.

Table 4 - Pairwise comparisons of average marginal effect for various city types

			Contrast dy/dx	Delta-method SE	t	P>|t|
Quality Entrepreneurship, Urban Density as Population Density						
High_Density High_Diversity	vs	Low_Density Low_Diversity	-0.606	0.149	-4.08	0.000
Quality Entrepreneurship, Urban Density as Street Density						
High_Density High_Diversity	vs	Low_Density Low_Diversity	-0.488	0.109	-4.47	0.000

Note: There are two city types in the table, based on the level of their density and diversity (see Figure 3A and 3B). A significant p-value shows that the two respective city types are statistically different from each other.

Appendix A: US cities with a combination of agentic populations (high openness) and a stimulating structural city environment (high density, high diversity)

Table A1- Quantity and Quality Entrepreneurship of US cities (top 10) scoring 'High' in Openness, Density, and Diversity simultaneously

MSA (city) name	Quantity Entrepreneurship	Quality Entrepreneurship
San Francisco-Oakland-Fremont, CA	11.20 (#1)	1.90 (#1)
New York-Long Island, NY	11.20 (#1)	1.90 (#1)
Los Angeles-Long Beach-Santa Ana, CA	11.20 (#1)	1.90 (#1)
Dallas-Fort Worth-Arlington, TX	11.20 (#1)	1.90 (#1)
Miami-Fort Lauderdale-Pompano Beach, FL	11.20 (#1)	1.90 (#1)
San Jose-Sunnyvale-Santa Clara, CA	10.74 (#3)	1.90 (#1)
Austin-Round Rock-San Marcos, TX	10.60 (#5)	1.90 (#1)
Riverside-San Bernardino-Ontario, CA	11.10 (#2)	1.84 (#2)
Sacramento-Arden-Arcade-Roseville, CA	10.73 (#3)	1.51 (#4)
Tampa-St. Petersburg-Clearwater, FL	10.53 (#6)	1.38 (#5)

Notes: The table reports the annual average values for quantity and quality entrepreneurship over the period 2010 to 2015 in a given MSA for the top 10 cities in the US.

Such top 10 cities are picked as follows: first, we ranked all cities based on their quality entrepreneurship. Then we picked the top 10, which also satisfy the condition of scoring 'High' in all in Openness, Density, and Diversity simultaneously. The term 'High' in openness, diversity, and density in this table refers to 'one standard deviation above the mean' for a given variable.

The numbers in the parenthesis refer to the US ranking of a given MSA in terms of its quantity/quality entrepreneurship.

For the variable Density we used population density in this table. Using street network density reveals a similar table.

Appendix B: Robustness Check for Quantity Entrepreneurship

Table B1 - Main effect and its interaction effects with Density (population) and Diversity

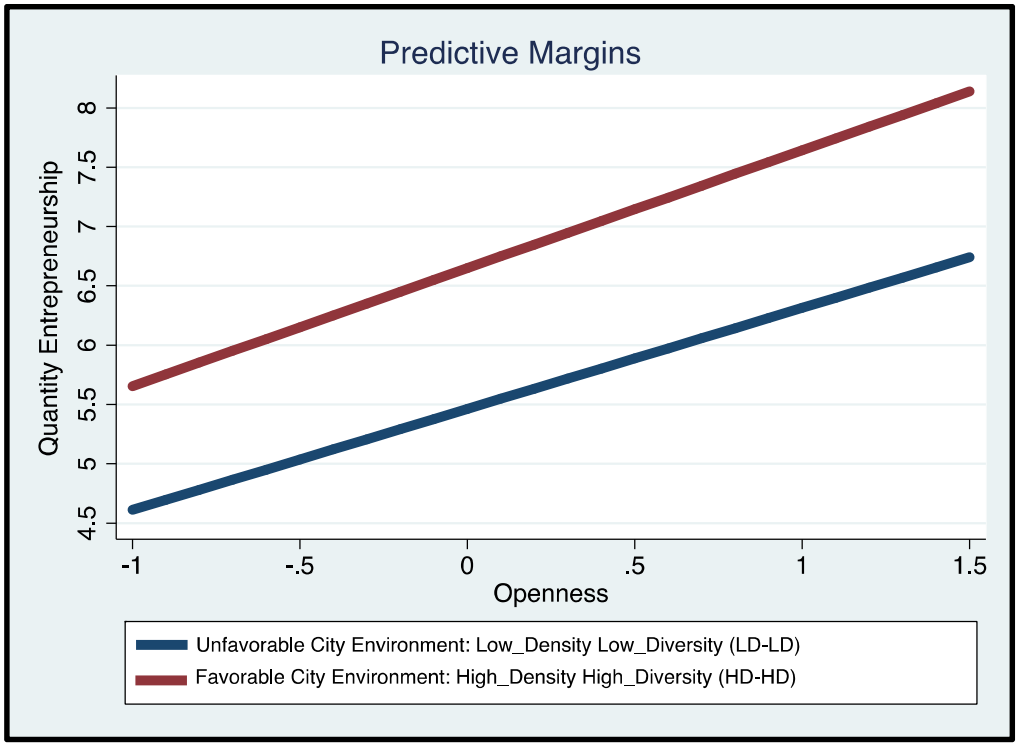
	(B1.1)	(B1.2)	(B1.3)	(B1.4)	(B1.5)	(B1.6)	(B1.7)	(B1.8)
Openness	0.486**			0.108**	0.517**	0.564**	0.513**	0.415*
	(0.187)			(0.185)	(0.190)	(0.185)	(0.196)	(0.183)
	0.091			0.576	0.097	0.105	0.096	0.079
Density (population)		0.410***		0.433***	0.453***	0.461***	0.443***	0.471***
		(0.072)		(0.072)	(0.073)	(0.075)	(0.073)	(0.074)
		0.194		0.205	0.214	0.218	0.209	0.244
Diversity			0.629**	0.559**	0.569**	0.571**	0.560**	0.422*
			(0.202)	(0.198)	(0.198)	(0.198)	(0.198)	(0.186)
			0.123	0.109	0.111	0.111	0.109	0.086
Openness x Diversity					0.879			1.048+
					(0.671)			(0.614)
					0.040			0.054
Diversity x Density						-0.312		-0.356+
						(0.240)		(0.199)
						-0.041		-0.061
Openness x Density							-0.243	-0.315
							(0.256)	(0.255)
							-0.030	-0.052
Openness x Diversity x Density								1.531*
								(0.780)
								0.082
Control variables	Included	Included	Included	Included	Included	Included	Included	Included
Observations	362	362	362	362	362	362	362	362
Adjusted R-squared	0.291	0.312	0.294	0.325	0.326	0.326	0.325	0.356
AIC	2826	2800	2823	2785	2785	2785	2786	3026

*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Density is measured as population density. Using street network density reveals similar results.

Dependent variable: Quantity Entrepreneurship measured by startup rates per MSAs.

Figure B1- Three-way interaction of Openness-Density-Diversity (Density as Population Density)



Note: Openness is 'mean centered', so the value zero means the average value for Openness. The term 'High' refers to one standard deviation above the mean and 'Low' refers to one standard deviation below the mean.

Appendix C: Robustness check for alternative Openness measure: Florida's (2002) indexes (Bohemian, Homosexual, Creative)

Table C1 - Effect of Bohemian index

	(C1.1)	(C1.2)	(C1.3)	(C1.4)	(C1.5)	(C1.6)	(C1.7)
Bohemian	0.052	0.036	0.057	0.050	0.069	0.045	0.061
	(0.050)	(0.049)	(0.049)	(0.049)	(0.048)	(0.050)	(0.051)
	0.025	0.017	0.027	0.024	0.033	0.022	0.029
Diversity			0.099**	0.102**	0.125***	0.097**	0.125***
			(0.037)	(0.037)	(0.037)	(0.037)	(0.037)
			0.087	0.090	0.110	0.085	0.110
Density			0.069***	0.064***	0.053***	0.067***	0.048***
			(0.012)	(0.013)	(0.013)	(0.013)	(0.013)
			0.151	0.141	0.116	0.147	0.106
Bohemian x Diversity				-0.193			-0.186
				(0.132)			(0.138)
				-0.033			-0.032
Diversity x Density					0.146***		0.145***
					(0.029)		(0.029)
					0.119		0.117
Bohemian x Density						-0.044	-0.023
						(0.052)	(0.056)
						-0.020	-0.010
Bohemian x Diversity x Density							-0.095
							(0.173)
							-0.014
Control variables	All Included except traits	All Included	All Included	All Included	All Included	All Included	All Included
Observations	362	362	362	362	362	362	362
Adjusted R-squared	0.490	0.498	0.516	0.517	0.528	0.516	0.527
AIC	332.3	320.5	282.5	282.3	258.6	283.7	262

Table C2 - Effect of Homosexual index

	(C2.1)	(C2.2)	(C2.3)	(C2.4)	(C2.5)	(C2.6)	(C2.7)
Homosexual	0.063+	0.056+	0.004	0.002	0.005	0.013	0.058
	(0.035)	(0.033)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
	0.045	0.044	0.003	0.001	0.004	0.010	0.041
Diversity			0.222***	0.221***	0.220***	0.222***	0.116**
			(0.043)	(0.043)	(0.043)	(0.043)	(0.036)
			0.169	0.168	0.168	0.170	0.102
Density			0.078***	0.079***	0.074***	0.079***	0.051***
			(0.015)	(0.015)	(0.016)	(0.015)	(0.013)
			0.144	0.146	0.136	0.146	0.113
Homosexual x Diversity				0.050			-0.002
				(0.110)			(0.095)
				0.011			-0.001
Diversity x Density					0.047		0.129***
					(0.052)		(0.029)
					0.024		0.105
Homosexual x Density						0.134**	0.128**
						(0.048)	(0.040)
						0.067	0.074
Homosexual xDiversityx Density							0.080
							(0.092)
							0.022
Control variables	All Included except traits	All Included	All Included	All Included	All Included	All Included	All Included
Observations	362	362	362	362	362	362	362
Adjusted R-squared	0.493	0.488	0.525	0.525	0.525	0.529	0.533
AIC	325.4	124.8	113.1	114.9	114.2	107.3	247.2

- The first model does not control for traits variables (extraversion, agreeableness, conscientiousness, and neuroticism). Other models include all control variables.
- For each variable the raw coefficient (β) is reported in the first row, and the standardized coefficient (b) is reported in the third row. Robust standard errors in parentheses ()
- *** p<0.001, ** p<0.01, * p<0.05, + p<0.1
- Density is measured as population density. Using street network density reveals similar results.
- Dependent variable: Quality Entrepreneurship measured by RECPI index.

Table C3 - Effect of Creative index

	(C3.1)	(C3.2)	(C3.3)	(C3.4)	(C3.5)	(C3.6)	(C3.7)
Creative	-0.054	-0.058	-0.027	-0.032	-0.026	-0.050	-0.047
	(0.036)	(0.036)	(0.035)	(0.035)	(0.035)	(0.036)	(0.036)
	-0.041	-0.045	-0.021	-0.024	-0.020	-0.039	-0.036
Diversity			0.222***	0.233***	0.221***	0.211***	0.218***
			(0.043)	(0.043)	(0.043)	(0.043)	(0.043)
			0.169	0.178	0.168	0.161	0.166
Density			0.076***	0.065***	0.072***	0.083***	0.068***
			(0.016)	(0.016)	(0.016)	(0.016)	(0.017)
			0.139	0.118	0.131	0.151	0.124
Creative x Diversity				-0.338**			-0.361**
				(0.108)			(0.112)
				-0.076			-0.082
Diversity x Density					0.046		0.057
					(0.052)		(0.052)
					0.023		0.029
Creative x Density						-0.138**	-0.094+
						(0.048)	(0.056)
						-0.073	-0.050
Creative x Diversity x Density							-0.302
							(0.210)
							-0.043
Control variables	All Included except traits	All Included	All Included	All Included	All Included	All Included	All Included
Observations	362	362	362	362	362	362	362
Adjusted R-squared	0.490	0.497	0.525	0.530	0.525	0.529	0.534
AIC	169.9	162.4	115.1	107.2	116.3	108.8	102.5

- The first model does not control for traits variables (extraversion, agreeableness, conscientiousness, and neuroticism). Other models include all control variables.
- For each variable the raw coefficient (β) is reported in the first row, and the standardized coefficient (b) is reported in the third row. Robust standard errors in parentheses ()
- *** p<0.001, ** p<0.01, * p<0.05, + p<0.1
- Density is measured as population density. Using street network density reveals similar results.
- Dependent variable: Quality Entrepreneurship measured by RECPI index.

Appendix D: Robustness check for Alternative measures for local Openness and Industry Diversity: Three-way interaction models

Table D1 - Alternative measures for openness and Industry Diversity

	(D1.1)	(D1.2)	(D1.3)
Ethnic diversity	-0.743***	0.841**	-0.460***
	(0.163)	(0.286)	(0.136)
Density	-0.029	-0.020	-0.429***
	(0.079)	(0.137)	(0.120)
Ethnic Diversity x Density	3.566***	-0.264	
	(0.537)	(1.015)	
Industry Diversity	0.205***		
	(0.046)		
Ethnic Diversity x Industry Diversity	-0.316		
	(0.457)		
Industry Diversity x Density	0.235		
	(0.231)		
Ethnic Diversity x Industry Diversity x Density	-1.344		
	(1.677)		
Patent		0.109***	0.109***
		(0.008)	(0.009)
Patent x Ethnic Diversity		-0.459***	
		(0.073)	
Patent x Density		-0.002	0.112***
		(0.032)	(0.026)
Ethnic Diversity x Patent x Density		0.771*	
		(0.253)	
Openness			-0.279**
			(0.100)
Openness x Density			-1.241*
			(0.577)
Openness x Patent			0.098***
			(0.024)
Openness x Patent x Density			0.263+
			(0.138)
Control variables	Included	Included	Included
Observations	362	362	362
Adjusted R-squared	0.534	0.614	0.600

Notes: The table reports various three-way interaction models. The Density is measured by street network density.

- In model D1.1, Ethnic Diversity is used instead of Openness.
- In Model D1.2, again Ethnic Diversity is used instead of Openness and also Patent is used instead of Industry Diversity.
- In Model D1.3, Patent is used instead of Industry Diversity.
- Dependent variable: Quality Entrepreneurship measured by Regional Entrepreneurship Cohort Potential Index (RECPI)

Appendix E: Manufacturing vs. Service sectors in calculating Quality Entrepreneurship

Table E1 – Manufacturing

	(E1.1)	(E1.2)	(E1.3)	(E1.4)	(E1.5)	(E1.6)	(E1.7)	(E1.8)
Openness	0.093***			0.098**	0.074*	0.098**	0.105**	0.078*
	(0.027)			(0.032)	(0.033)	(0.032)	(0.034)	(0.035)
	0.088			0.084	0.064	0.085	0.090	0.067
Density (population)		0.050***		0.062***	0.070***	0.060***	0.061***	0.064***
		(0.010)		(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
		0.142		0.140	0.158	0.135	0.138	0.145
Diversity			0.096***	0.163***	0.168***	0.163***	0.163***	0.185***
			(0.028)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
			0.109	0.150	0.155	0.150	0.150	0.170
Openness $_X$ Diversity					0.355**			0.579***
					(0.118)			(0.131)
					0.076			0.124
Diversity $_X$ Density						0.026		0.019
						(0.041)		(0.042)
						0.016		0.012
Openness $_X$ Density							0.027	-0.030
							(0.045)	(0.048)
							0.016	-0.018
Openness $_X$ Diversity $_X$ Density								0.672***
								(0.187)
								0.111
Control variables	Included	Included	Included	Included	Included	Included	Included	Included
Observations	362	362	362	362	362	362	362	362
Adjusted R-squared	0.420	0.427	0.420	0.455	0.459	0.454	0.454	0.465
AIC	-151.4	-165.4	-151.2	-95.20	-102.3	-93.60	-93.60	-111.2

Table E2 - Service

	(E2.1)	(E2.2)	(E2.3)	(E2.4)	(E2.5)	(E2.6)	(E2.7)	(E2.8)
Openness	0.094***			0.091**	0.073*	0.092**	0.097**	0.077*
	(0.024)			(0.028)	(0.029)	(0.028)	(0.030)	(0.030)
	0.097			0.086	0.069	0.087	0.092	0.073
Density (population)		0.050***		0.058***	0.064***	0.056***	0.057***	0.059***
		(0.009)		(0.011)	(0.011)	(0.011)	(0.011)	(0.012)
		0.153		0.144	0.158	0.138	0.141	0.147
Diversity			0.098***	0.161***	0.164***	0.160***	0.160***	0.177***
			(0.025)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
			0.122	0.162	0.166	0.161	0.162	0.178
Openness $_X$ Diversity					0.264*			0.436***
					(0.103)			(0.114)
					0.062			0.103
Diversity $_X$ Density						0.024		0.019
						(0.036)		(0.037)
						0.017		0.013
Openness $_X$ Density							0.022	-0.022
							(0.039)	(0.042)
							0.014	-0.014
Openness $_X$ Diversity $_X$ Density								0.511**
								(0.163)
								0.092
Control variables	Included	Included	Included	Included	Included	Included	Included	Included
Observations	362	362	362	362	362	362	362	362
Adjusted R-squared	0.467	0.474	0.467	0.504	0.507	0.504	0.504	0.511
AIC	-455.2	-472.3	-455.4	-383.6	-388.3	-382.1	-381.9	-393.9

- For each variable the raw coefficient (β) is reported in the first row, and the standardized coefficient (b) is reported in the third row. Robust standard errors in parentheses ()
- *** p<0.001, ** p<0.01, * p<0.05, + p<0.1
- Density is measured as population density. Using street network density reveals similar results.
- Dependent variable: Quality Entrepreneurship measured by RECPI index.