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Openness values and regional innovation: a set-analysis

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Abstract

Statistical studies evidence that openness values matter for regional innovation but not how they matter. A qualitative comparative analysis (QCA) study of 108 North–West European regions identifies four cross-case mechanisms that explain regional innovation: the diversity, cosmopolitan environment, technology transfer and creativity mechanisms. Only in technology transfer do openness values not play a role. This evidences that openness values connect diverse local and non-local social spaces to local and non-local physical places to unlock a larger potential for more dynamic innovation. QCA understands causality as configurational and identifies mechanisms rather than net effects, which answers how-questions better than statistical methods do. The focus on mechanisms highlights how innovation connects interactions between agents in social space to physical place, which makes an empirical contribution to the relational economic geography literature.

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1. Introduction

How do openness values, such as tolerance, matter for regional innovation? Statistical research corroborates the hypothesis that openness values allow knowledge and ideas to travel between different communities and thus encourage innovation (Gambardella et al., 2009; Haisch and Klöpper, 2014; Weckroth and Kemppainen, 2016; Florida et al., 2017) but does not answer the question how they do so. Moreover, the literature also explains regional innovation without the help of openness values. This paper addresses the how-question as follow. First, it conceptualises regional innovation from a relational perspective. Second, it performs an empirical analysis on 108 NUTS two-regions in North–West Europe. Third, it elaborates the empirical findings into an answer to the how-question. From a relational perspective, innovation follows from knowledge creation between individuals (Cohendet, 2014; Rutten, 2017). Knowledge creation in this paper is conceptualised as analytical (science) and synthetic (application) knowledge creation. Also economic diversity suggests knowledge creation across diverse economic activities. Openness values are conceptualised as tolerance and as modernisation values. Tolerance in combination with socio-cultural diversity allows

regional innovation to benefit from a diverse pool of knowledge and ideas in society. Modernisation values in combination with personal freedom allow self-expression, which individuals use to seek new knowledge and ideas. Empirically this paper performs a qualitative comparative analysis (QCA) study on 108 regions. QCA is ideal to answer how-questions because it identifies multiple mechanisms explaining regional innovation that may or may not include openness values (Ragin, 2008). This QCA study identifies four such mechanisms explaining regional innovation: the diversity, technology-transfer, cosmopolitan-environment, and creativity mechanisms. Only in the technology-transfer mechanism do openness values not play a role.

The paper makes a 3-fold contribution to the literature: a systematic account of the role of openness values in the explanation of regional innovation, focusing this explanation on the micro-level interactions emphasised by the relational economic geography literature, and introducing QCA as a method for comparative analysis in economic geography. In the next two sections, regional innovation and the role of openness values are conceptualised from a relational perspective. Next, set-analysis, of which QCA is an example, is introduced to familiarise readers with this method. The causal conditions (analytical knowledge creation, synthetic knowledge creation, economic diversity, melting pot and self-expression) are conceptualised in the following section. The empirical section identifies how they are set-analytically connected to regional innovation. The final section develops the empirical outcomes into an explanation of regional innovation around the above four mechanisms.

2. Conceptualising regional innovation

Innovation as firms developing new technologies, products and services critically depends on firms having access to a diverse pool of global and local knowledge. That is, firms engage in networking to tap into diverse knowledge pools to fuel their innovation process (Lester and Piore, 2004; Ibert, 2007; Crevoisier and Jeannerat, 2009; Fitjar and Rodriguez-Pose, 2011). This identifies an important issue in the economic geography literature: innovation as a process of knowledge creation happens in social spaces (such as networks and communities) that are not necessarily territorialised. At least, according to the relational approach to economic geography. The relational approach focuses on agents and their relationships, that is, on micro-level interactions, and sees individuals as the principal agents of knowledge creation (Bathelt and Glückler, 2003; Lester and Piore, 2004; Cohendet, 2014). A relational approach to regional innovation thus explains how and why knowledge creation connects social space to physical place (Ibert, 2007; Moodysson and Jonsson, 2007). The relational approach criticises the territorial innovation models (TIMs) literature which defines geographical space as bounded territory and explains regional innovation as the outcome of knowledge creation between geographically concentrated and interconnected firms. This literature correctly argues that 'soft factors', such as social capital, trust and shared norms and values, encourage interaction between agents. However, it unhelpfully stylises soft factors into territorial artifacts while they are better understood as characteristics of social spaces (Hassink and Klaerding, 2012; Howells, 2012; Rutten, 2017).

The TIM literature traces its origins to Marshall's (1920, original 1890) industrial districts and includes among others, clusters (Asheim et al., 2006), learning regions (Morgan, 1997), innovative milieus (Crevoisier, 2004) and regional innovation systems

(Gregersen and Johnson, 1997). Strong conceptual overlaps exist between all TIMs (Moulaert and Sekia, 2003). While this literature is sensitive to density as driver of interconnections and knowledge creation between firms, it is ultimately the connections and not density that matters. TIMs are argued to apply equally to urban, central regions and rural, peripheral regions. Nowadays, the TIM literature is largely obsolete because knowledge creation is no longer territorialised in the way it may have been in the 1990s. Globalisation has dispersed knowledge-creation networks and innovation requires the combination of local and global knowledge (Moodysson and Jonsson, 2007; Lorentzen, 2008; Fitjar and Rodriguez-Pose, 2011). However, regional concentrations of interconnected, knowledge-creating firms are still a valid explanation of regional innovation. The relational approach to economic geography also differs from the institutional and evolutionary approaches. Focusing on micro-level interactions turns institutions and evolution into background factors; they are not an immediate concern for a relational approach (Bathelt and Glückler, 2003; Hassink et al., 2014). From a relational perspective, the importance of physical place lies in the access it provides to local and global knowledge (Gertler and Levitte, 2005; Shearmur, 2011; Howells, 2012). Providing such access depends on three intertwined elements: connectivity, diversity and coordination.

Connectivity of physical places enables interaction between local and non-local individuals. These interactions do not play out on the level of a region but on the smaller scale of research centres, science parks, campuses, office buildings, conference venues and cultural amenities. This is where physical place and social space connect through permanent and temporary co-presence of individuals (Rutten, 2017). Easy access to these places greatly reduces the effort required for face-to-face interactions. Even if technology-mediated communication enables spatially stretched knowledge creation, face-to-face communication still offers a premium because of the tacitness of knowledge. This tacitness is not so much cognitive as social in nature; that is, knowledge (creation) is inseparably connected to the norms, values, habits, etc. of the social context from which it originates. Consequently, knowledge creation requires some degree of socialisation for which (temporary) co-presence is extremely valuable (Gertler, 2003; Morgan, 2004; Moodysson and Jonsson, 2007; Cohendet, 2014). Density matters greatly in this context. Regions that host multiple easy-to-access venues where locals and non-locals exchange knowledge make a region a more valuable hub in the global knowledge network (Shearmur, 2012; Storper, 2013; Florida et al., 2017). Furthermore, connectivity is closely related to buzz: 'an unplanned contact system and a form of accidental knowledge creation among individuals who happen to be in the same … place' (Rutten, 2017, 165) (Bathelt et al., 2004; Shearmur, 2012; Grabher and Ibert, 2013). That is, connectivity is a double-edged sword that encourages both purposive and serendipitous knowledge creation.

Diversity and its connection to knowledge creation pertains to two very different mechanisms: economic diversity and socio-cultural diversity. The former is well-understood in the economic geography literature, the latter much less. Diversity contributes to knowledge creation because it enables the exchange of knowledge, practices and ideas between different (professional and social) communities in the same place (region). That is, diversity triggers all sorts of intended and unintended knowledge exchanges and spillovers that contribute to knowledge creation. With regard to economic diversity, the literature disagrees whether related diversity (Storper, 2013), unrelated diversity (Florida, 2017) or both (Boschma et al., 2017) are the 'root cause' of

innovation. On the level of knowledge creation between individuals, this is largely irrelevant because the opportunity to connect to many different others is what matters. The discussion on socio-cultural diversity goes back to Jacobs' (1961) argument that the diversity of cities depends directly or indirectly on diverse city commerce.

> Whenever we find variety ... [of commerce] we are apt to find ... a good many other kinds of diversity also, including variety of cultural opportunities, variety of scenes, and great variety in its population and other users. This is more than coincidence. The same physical and economic conditions that generate diverse commerce are intimately related to the production, or the presence, of other kinds of city variety (Jacobs, 1961, 148).

Although in its core an economic argument, Jacobs emphatically blurs the distinction between economic and socio-cultural diversity and connects this blurring to micro-level creativity and entrepreneurship (Desrochers and Leppälä, 2011). Jacobs' work lies at the basis of a literature that connects socio-cultural diversity to creativity.

The most vocal exponent of this literature is Florida (2002). He argues that knowledge workers (the creative class) thrive in socio-culturally diverse places because such environments expose them to different knowledge and ideas. Florida defines socio-cultural diversity as ethnic diversity (or melting pot) and as the presence of non-conventional lifestyles (or bohemianism). He further argues that diversity goes hand in hand with tolerance, otherwise diversity would not exist and that tolerance goes hand-in-hand with the exchange of knowledge and ideas across diverse communities. Problematically, this argument conflates diversity and tolerance. Moreover, critics argue that socio-cultural diversity is a function of urbanisation and that human capital rather than lifestyle drives creativity (Glaeser, 2005). Another exponent of this literature is Grandadam et al. (2013), who argue that creativity follows from repeated exchanges between a variety of heterogeneous communities. The meeting places of these communities (Grandadam et al., 2013) conceptualise as the 'middle ground' between individuals and their communities (underground) and the upper ground of, e.g., firms, research centres and cultural amenities. Contrary to Florida (2002), this argument only requires communities to be diverse and tolerant and not whole regions (see also Desrochers, 2001). Several empirical studies corroborate the above relationship between socio-cultural diversity and creativity (Gambardella et al., 2009; Rutten and Gelissen, 2010; Haisch and Klöpper, 2014; Spencer, 2015; Weckroth and Kemppainen, 2016). Ibert and Müller (2015) connect socio-cultural diversity to knowledge creation with the concept of 'relational distance' which 'assesses the extent of cultural diversity within social relations and the effects of cultural differences on innovative outcomes' (p. 182). Individuals belonging to multiple cohesive groups facilitate the recombination of resources because they have access to and familiarity with resources in both groups (p. 183). Socio-cultural proximity combined with geographical proximity may thus encourage regional knowledge creation (p. 192). On the other hand, the literature on related and unrelated economic diversity (Boschma et al., 2017) makes no connection to socio-cultural diversity; in fact, Storper (2013) is highly critical of the role of socio-cultural diversity. Nor do other explanations of regional innovation, such as the TIM literature (see above), explicitly connect to socio-cultural diversity.

Coordination between local and non-local individuals and their communities explains knowledge creation through various mechanisms. Among others, the economic geography literature suggests institutional thickness (Gertler, 2010), untraded

interdependencies (Storper, 1997) and regional social capital (Malecki, 2012). Ultimately, all these mechanisms have in common that they emphasise shared norms, values, customs, habits, routines, trust and other forms of relational proximity as a 'glue and lubricant' (Malecki, 2012) in relationships. That is, these mechanisms provide an informal, efficient and effective way to bring individuals together (glue) and to encourage them to create knowledge (lubricant). While some accounts suggest coordination mechanisms as territorial artifacts (most notably the TIM literature), they are more accurately seen as characteristics of social space. The importance of these coordination mechanisms for knowledge creation lies in the fact that they are informal; they hold together and bridge between social spaces that themselves have no formal hierarchy (Lester and Piore, 2004; Cohendet, 2014; Rutten, 2017).

The above discussion of connectivity, diversity and coordination reflects the multitude of explanations of regional innovation in the economic geography literature. Explanations that partially overlap and partially conflict. Most disagreement exists on the role of socio-cultural diversity. Rather than trying to develop a blanket explanation for regional innovation, or to sort out 'right' from 'wrong' explanations, it may be worth considering that regional innovation can be explained in different ways. Furthermore, negative dynamics of diversity and the above coordination mechanisms must also be considered. Norms, values, etc. may encourage inward-looking behaviour (Malecki, 2012) and Audretsch et al. (2018) suggest that, in the absence of trust, socio-cultural diversity may even be detrimental for innovation. What is missing from all explanations of regional innovation is an explicit connection to openness values. Or in the case of Florida, openness values (tolerance) are conflated with socio-cultural diversity. But openness values may be an important part of a relational explanation of regional innovation because they instil in individuals an attitude that embraces 'newness'.

3. Openness values and knowledge creation

The focus on tolerance in relation to creativity and innovation in the economic geography literature connects to a broader sociological literature on culture and economic development. This literature argues that 'economic development is associated with shifts away from absolute norms and values towards values that are increasingly rational, tolerant, trusting and participatory' (Inglehart and Baker, 2000, 19); otherwise known as the 'modernisation theory' (Inglehart, 1997; Landes, 2000). Traditional values pertain to, among others, rejecting gender equality and non-conventional lifestyles, being suspicious of foreigners and other cultures, believing religion is important, nationalism, putting family before personal achievement and favouring strong leaders (Inglehart and Baker, 2000, 26–27). Modernisation values emphasise the opposite. These and other items form an empirically validated scale from traditional values to modernisation values. This means that a person does not have to (dis)agree on all items to be (mostly) a traditional or modernisation values person. The more one does, the closer one gets to the ideal type. The strong correlation between modernisation values and economic development does not identify the direction of the causality; which probably works both ways. On the micro-level of individual interactions, modernisation values encourage individuals to engage in the exchange of knowledge and ideas across diverse communities.

The discussion on tolerance in economic geography connects to the modernisation theory in that tolerance is a modernisation value. But it makes sense to discuss tolerance and modernisation values separately because modernisation values specifically address motivational drivers of individuals while tolerance reflects appreciation of socio-cultural diversity. This appreciation makes individuals open to new knowledge and ideas but does not necessarily motivate them to become creative. Moreover, the exchange of knowledge and ideas across communities only happens when both sides are tolerant. Modernisation values do not require this reciprocity. That is, modernisation values and tolerance are both openness values; they contribute to the same outcome (knowledge creation) but do so in different ways. In economic geography, tolerance reflects an open mind towards diversity which encourages knowledge creation for two reasons:

> First, creativity and innovation is a product of the spatial concentration of a skilled 'creative class' … that today are highly mobile and feel especially drawn to culturally diverse and tolerant places. And second, tolerant and diverse communities usually indicate open and weak social structures where new ideas can flourish, people have low entry barriers to interact and learn from each other (Audretsch et al., 2018, 75).

Note that the second reason also captures the relationship between modernisation values and knowledge creation (Baker, 1997). However, empirical evidence connecting tolerance to knowledge creation is mixed. This leads Audretsch et al. (2018) to be sceptical of the 'effect' of tolerance on knowledge creation. Another way to interpret the mixed evidence is to argue as follows: Whether the presence of tolerance contributes to the presence of knowledge creation is contingent on the presence or absence of other conditions. It is not unreasonable to assume that the same goes for modernisation values (Granato et al., 1996; Inglehart and Baker, 2000). The other conditions to consider, of course, are knowledge creation and economic diversity (see above). According to the TIM and economic diversity literatures, these conditions are sufficient to explain regional innovation. If so, it does not necessarily follow that the openness values argument is false. Regional innovation may also be explained by openness values.

4. Introducing set analysis

A traditional approach to studying the relationship between openness values and regional innovation would be to include one or more openness values variables in a statistical analysis. Any net effect of these variables on regional innovation that survives after other independent and control variables are added is then taken as evidence of a causal effect of openness values on regional innovation. However, this does not actually answer the how-question because statistical techniques, powerful as they may be, have some important limitations:

– They do not distinguish between differences in kind and differences in degree. London and North-Brabant (the Dutch Eindhoven region) have a small difference in regional innovation. A similar small difference exists between Austrian Tyrol and Italian South-Tyrol. The former difference is trivial since both are very strong

innovators while the difference between Tyrol and South-Tyrol is the difference between a strong and a moderate innovator (Hollanders and Es-Skandi, 2017).
– They inflate causal effects by attributing the same analytical value to cases where openness values and regional innovation are both present (X, Y-cases) and cases where cause and outcome are both absent ($\sim X$, $\sim Y$-cases). Both cases contribute equally to the correlation coefficient but it is clear that $\sim X$, $\sim Y$-cases, such as Central Romania (Hollanders and Es-Skandi, 2017), tell us nothing about how openness values contribute regional innovation.
– They return probabilities that apply to a whole population. For example, a correlation coefficient may suggest that a 0.3-change in openness values produces the same amount of change in regional innovation in London, Central Romania and Tyrol. But that is questionable because these are all qualitatively different regions.

Of course, these and other issues can be addressed by introducing more control variables and using more sophisticated techniques. But that does not quite do the job. Statistical techniques assume causal symmetry (see above) but mechanisms connecting the presence of a cause to the presence of an outcome may be different from those that connect the absence of a cause to the absence of an outcome, because such regions are qualitatively different (London vs. Central Romania). Statistical techniques assume unifinal causality, i.e. one correlation coefficient applies to the whole population. But this conflicts with the fact that, e.g. London and North-Brabant have become very strong innovators for very different reasons and that Tyrol and South-Tyrol, although socio-economically very similar, qualitatively differ on regional innovation. That is, multiple paths may lead to the same outcome (equifinal causality) and whether an independent variable contributes to the outcome is contingent on other variables (conjunctional causality). Equifinal and conjunctional causality suggest that causes sometimes combine to produce outcomes and sometimes they do not, depending on the presence or absence of other causes (Goertz and Mahoney, 2012; Schneider and Wagemann, 2012; Ragin, 2014). While capturing all that in split-samples, bootstraps, jack-knifes, Hayes techniques, etc. is not impossible, it also makes the analysis very complicated and difficult to interpret. Such techniques remove the analysis ever more from cases (context) to focus on correlations between variables which then, in a sense, become vacuous (Abott, 1998; Boudon, 1998). Statistical analysis is a powerful tool to identify if causes matter for an outcome, but much less helpful when trying to explain how they do. A how-question requires complexity and context, which in traditional qualitative techniques often compromise generalisability. The 'comparative method' (QCA) is a middle-ground between the analytical precision of variable-based methods and the ability to deal with context and complexity of case-based methods, based on set-theory, formal logic and Boolean algebra (Ragin, 2008, 2014; Goertz and Mahoney, 2012). QCA was designed for mid-size Ns, 10–50 cases, but works with larger Ns as well.

Statements of sufficiency (and necessity) reflect causal mechanisms because they connect the presence of a (configuration of) condition(s) (i.e., a cause) to an outcome. However, no matter how many cases display both cause and outcome (X, Y-cases), a statement of sufficiency is violated by cases that combine the presence of X and the absence of Y (X, $\sim Y$-cases). As social reality is complex and measurement errors unavoidable, set-analysis allows for a number of such inconsistent cases before a statement of sufficiency is negated. As long as the consistency of a subset-relationship is

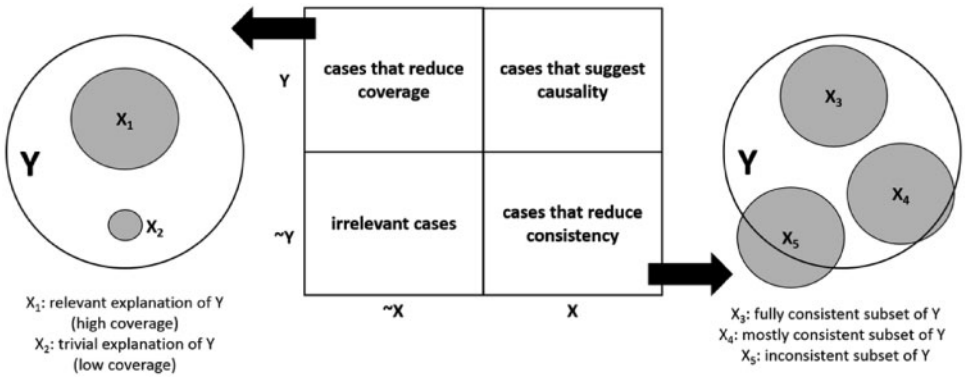

Figure 1. Subset relationships for sufficiency.

$\geq$0.85 it may be accepted as a sufficient condition. $\sim X$, Y-cases are inconsequential for a statement of sufficiency as other causes than X may explain the outcome (equifinality). Only when the number of X, Y-cases is very small relative to the number of $\sim X$, Y-cases is a statement of sufficiency compromised on the grounds that X is a trivial explanation for Y. In such an instance the coverage (the proportion of Y-cases covered by X-cases) will be very low (Figure 1). Consistency and coverage thus answer probabilistic criticisms against deterministic causality. Consistency allows for measurement error and unsystematic factors while coverage relinquishes the claim of universal applicability. $\sim X$, $\sim Y$-cases are set-theoretically irrelevant as they say nothing about how the presence of X contributes to the presence of Y. In sum, the goal of set-analysis 'is not to explain variation but to account for differences among instances of a certain outcome' (Ragin, 2014, 167).

A key difference between set-analysis (case-based) and correlational (variable-based) research is the use of control variables. Adding a 'control variable' to a configuration of conditions that is already a consistent subset of the outcome simply creates two new subsets, i.e. [configuration * control] and [configuration * ~control]. By definition, these new subsets will also be consistent subsets of the outcome, i.e. the control condition is logically redundant. Both new configurations will have fewer cases than the initial one, meaning their coverages will be lower. Because the new configurations are longer, i.e. more complex and more precise, their consistencies will be higher. In sum, set-analysis balances parsimony (few conditions, higher coverage, lower consistency) and complexity (more conditions, lower coverage, higher consistency), rather than controls net effects. That is, 'statistical methods bias researchers towards seeing causes as competitors in the struggle for net effects. [Set-analysis] favours the development of conjunctional arguments' (Ragin, 2014, 120).

5. Constructing sets

The literature identifies different kinds of knowledge creation that may have a different relationship to openness values. Among others, Asheim and Coenen (2005) distinguish between analytical and synthetic knowledge creation where the former focuses on science (high-tech) and the latter on application and engineering (Fitjar and Rodriguez-

Pose, 2013). To conceptualise an ideal-typical analytical knowledge-creating region one may plausibly argue that such a region would invest in technology development (R&D-expenditure), succeeds in doing so (patent applications) and employs many people (human resources) in science and technology occupations (Gambardella et al., 2009; Rutten and Gelissen, 2010). That is, analytical knowledge-creating regions are the intersection of the sets of R&D-expenditure regions, patent-applications regions and human-resources-in-science-and-technology regions.[1] Synthetic knowledge-creating regions, according to Asheim and Coenen (2005), are strong in the creation of applied knowledge, incremental innovations using existing knowledge and interactive learning with customers and suppliers. Consequently, the set of synthetic knowledge-creating regions is the intersection of these three sets. An important characteristic of regional innovation is that it depends on both local and global knowledge. The difficulty is to capture local and global knowledge creation in indicators. Statistical research suggests, for example, social capital as indicator for local interactions (Beugelsdijk and Van Schaik, 2005) and flight connections (Annoni et al., 2016) or hotel accommodation (Gambardella et al., 2009) for global connections. However, membership of political, religious, cultural, etc. organisations does not cause innovation, nor do airline passengers and hotel guests. A set-relationship between these indicators and regional innovation is causally uninterpretable. Set-theoretically this is unproblematic because all innovation regions will have local and global interactions, i.e. there is no difference in kind across cases on these indicators, meaning they add nothing to the empirical analysis.

The presence of related and unrelated diversity suggests all sorts of intended and unintended knowledge spillovers between diverse economic activities, which contributes to knowledge creation (Boschma et al., 2017). This suggests two things: first, knowledge in this case pertains to economic activities and not to more general knowledge and ideas in society. Second, knowledge and ideas flow through both formal (e.g., buyer–supplier relationships) and informal (e.g., buzz) relationships (Bathelt et al., 2004; Ibert, 2007). Because measuring the actual relationships is not possible, the presence of economic diversity is used as a proxy suggesting that more economic diversity leads to the exchange of more knowledge and ideas. The condition economic diversity can then straightforwardly be measured as the presence of diverse economic activities.

Tolerance and socio-cultural diversity are intimately related but rather than implying tolerance from the presence of socio-cultural diversity (Florida, 2002), tolerance can be measured in terms of people's attitudes towards ethnic and religious minorities, gender equality and homosexuality. Socio-cultural diversity is most straightforwardly measured as the proportion of non-nationals but Florida (2002) also suggests the gay and bohemian indexes. The gay index can be dismissed because gays do not cause innovation (see above). The bohemian index is doubtful because it may simply be a product of density (Glaeser, 2005). Ethnic diversity is connected to density but the connection is less straightforward so that the presence of ethnic diversity may be a proxy for diversity of knowledge and ideas in society. However, unlike economic diversity, presence does not indicate exchange. That also requires the presence of

1 Analytical knowledge creation thus is a meta-set composed of three individual sets. Whether these individual sets are correlated is irrelevant. They are not indicators of latent variables but necessary parts of a meta-condition (Ragin, 2008, 2014).

tolerance. Therefore, melting pot, in this paper, is conceptualised as the intersection of the set of tolerant regions and the set of ethnically diverse regions.

Modernisation values are relevant for regional innovation in so far as they encourage individuals to exchange knowledge and ideas. The transformation of individual values from traditional to modern is called post-materialism. When economies develop, 'people increasingly emphasise post-materialist goals such as freedom and self-expression and the quality of life' (Inglehart and Abramson, 1999). In particular, freedom and self-expression are important because they emphasise personal achievement and hence link to knowledge exchange and creativity. A scale to measure post-materialism developed by Inglehart and Abramson (1999) asks respondents to identify their first and second priorities out of four aims for their country for the next the 10 years: (1) maintaining law and order, (2) giving people more say in important government decisions, (3) fighting rising prices, and (4) protecting freedom of speech. Individuals who prioritise 1 and 3 are materialists, those who prioritise 2 and 4 are post-materialists. Based on average individual scores, societies can rank anywhere between these two ends of the scale (Inglehart and Abramson, 1999). But to encourage knowledge-creation, individuals must not only be post-materialists, they must also have the freedom to pursue their own ambitions. The European Social Progress Index (Annoni and Dijkstra, 2016) measures 'freedom and choice', which allows to conceptualise the set of self-expression regions as the intersection of the set of post-materialist regions and the set of freedom-and-choice regions.

Conceptualising innovation as new technologies, products and services allows multiple indicators, such as firms with product and process innovations, regional exports of medium and high-tech manufacturing and sales of new-to-market and new-to-firm products. These indicators capture different kinds of innovative outputs, not a mechanism. Defining the set of regional innovation regions as the intersection of these sets may therefore be unnecessarily conservative, while their union may be unrealistically lenient. Therefore, the set of regional innovation regions is defined as the average of the two highest set-membership values. This procedure gives a realistic estimate of the average innovativeness of regions by eliminating their lowest score and moderating their highest (Schneider and Wagemann, 2012).

In sum, the empirical analysis is conducted over five conditions, 'analytical knowledge-creation', 'synthetic knowledge-creation', 'economic diversity', 'melting pot' and 'self-expression' on the outcome 'regional innovation' (Table 1). The 108 cases were selected as follows. North–West European EU regions (NUTS 2 Sweden, Denmark, Germany, Belgium, Netherlands and UK) are mostly (but not all) innovative and mostly differ in degree on institutional and economic development. They differ in kind on those factors from EU regions in Southern, Central and Eastern Europe. This effectively rules out institutional and economic development as explanations of regional innovation and contributes to the relational economic geography nature of this study by seeing these factors as context. More specifically, the Global Competitiveness Report 2015–2016 (Schwab, 2015) identifies Switzerland, Germany, the Netherlands, Finland, Sweden, the UK, Norway Denmark, Belgium and Luxembourg as the 10 most competitive European economies; i.e. their level of economic development differs qualitatively from other European countries. Elert et al. (2017) observe that Denmark, Sweden, Finland, the Netherlands, Germany, Ireland, Belgium and the UK score higher on both 'trust' and 'individualism' than other European countries; i.e. they differ qualitatively in terms of institutional development. Focusing only on countries that are

Table 1. Where the data come from

Conditions/outcome (basic mechanism)	Indicator (individual sets)	Source	Year	Region
Analytical knowledge	Patents per million inhabitants	Eurostat[a]	2011	NUTS 2
	R&D expenditure	Eurostat[a]	2011	NUTS 2
	Human resources in science and technology	Eurostat[a]	2011	NUTS 2
Synthetic knowledge	Non-R&D innovation expenditure	Regional Innovation Scoreboard[b]	2012	NUTS 1[c]; NUTS 2
	SMEs innovating in-house	Regional Innovation Scoreboard[b]	2012	NUTS 1[c]; NUTS 2
	Innovative SMEs collaborating with others	Regional Innovation Scoreboard[b]	2012	NUTS 1[c]; NUTS 2
Economic diversity	HHI[d] of employment per sector for: 1) agriculture, 2) industry, 3) construction, 4) wholesale, retail, trade, transport, 5) information and communication, 6) financial and insurance services, 7) real estate, 8) professional, scientific, technical, administrative, and 9) arts, entertainment, recreation	Eurostat[a]	Average 2010, 2011	NUTS 2
Melting pot	HHI[d] of nationalities in the population for: 1) EU, 2) other European, 3) Africa, 4) Caribbean, South and Central America, 5) North America, 6) Asia and 7) Oceania	Eurostat[a]	2011	NUTS 2
	Tolerance and inclusion (attitudes towards minorities and gender equality)	European Social Progress Index[e]	2015 (data 2012)	NUTS 2
Self-expression	Post-materialist values	European Values Studies[f]	2008	NUTS 2
	Personal freedom and choice	European Social Progress Index[e]	2015 (data 2012)	NUTS 2
Regional innovation	Firms with product and process innovations	Regional Innovation Scoreboard[b]	2017 (data 2015)	NUTS 1[g]; NUTS 2
	Exports of medium- and high-tech manufacturing	Regional Innovation Scoreboard[b]	2017 (data 2015)	NUTS 1[g]; NUTS 2
	Sales of new to market and new to firm innovations	Regional Innovation Scoreboard[b]	2017 (data 2015)	NUTS 1[g]; NUTS 2

[a]Eurostat (http://ec.europa.eu/eurostat/data/databse).
[b]Regional Innovation Scoreboard 2017 (Hollanders and Es-Skandi, 2017).
[c]NUTS 1: Austria, Belgium, Bulgaria, France, Greece and UK.
[d]HHI, Herfindahl–Hirschman index.
[e]Social Progress Index 2016 (Annoni and Dijkstra, 2016).
[f]European Values Studies 2008 (GESIS, 2016).
[g]NUTS 1: Austria, Belgium, Bulgaria and France.

qualitatively different on both economic and institutional development, and eliminating Finland for missing data, identifies the above six countries.

Data are sourced from publicly available databases (Table 1). The raw data are converted into set-membership values using Ragin's method of direct calibration (Ragin, 2008). Using data for 249 EU NUTS 2-regions (nearly all of them), thresholds were set for full non-membership (the raw data value below which all regions are fully out of the set), full membership (the raw data value above which all regions are fully in the set) and the crossover point (the raw data value that distinguishes regions that are more out of than in the set from regions that are more in than out of the set, i.e. regions that are qualitatively different from one another). Based on these three values a logistic formula converts raw data into set-membership values. The values thus obtained were condensed into a six-value set-membership scale: 0 (fully out of the set), 0.2 (mostly out of the set), 0.4 (more out of than in the set), 0.6 (more in than out of the set), 0.8 (mostly in the set) and 1 (fully in the set). This procedure reduces relative differences between cases to semantically meaningful differences, which is important for causal interpretation of the empirical findings.

6. Empirical analysis and interpretation

The calibrated data were analyzed with the fsQCA 3.0-software (Ragin and Davey, 2017). The analysis of necessity (calculating superset relationships) for the presence of regional innovation did not identify any necessary conditions, however, the absence of self-expression and the absence of melting pot are necessary conditions for the absence of regional innovation (consistency 0.929293, coverage 0.673993 and consistency 0.929293, coverage 0.603279, respectively). The fact that ~self-expression and ~melting pot are necessary for ~regional innovation means that openness values-regions can never be ~innovation regions. The relationship is not symmetrical as the presence of openness values is not necessary for the presence of regional innovation.[2] However, the finding underlines the importance of openness values for regional innovation.

The analysis of sufficiency (calculating subset-relationships) is based on the truth table. With five conditions the truth table in this study has $2^5 = 32$ rows that list all logically possible configurations of the presence and absence of these conditions. To determine whether truth-table rows were 'true' (i.e. a consistent subset of the outcome) or 'false,' strict consistency ($\geq$0.85) and frequency thresholds ($\geq$5 cases) were used in order to eliminate rows (configurations) that may be measurement errors or exceptions (Schneider and Wagemann, 2012). This resulted in eight true rows and one false row; the remaining 23 rows are 'logical remainders.' This is perfectly consistent with the notion of 'limited diversity' which means that variation in social reality is clustered in a limited number of logically possible configurations (Ragin, 2008). In the next step of the analysis, these nine configurations of five conditions each are 'minimised' into fewer and more parsimonious configurations based on Boolean algebra and formal logic. The truth-table analysis identified the following four equifinal configurations:

1. Economic diversity * melting pot.
2. Analytical knowledge * synthetic knowledge * economic diversity.

2 To be a member of the set of ~innovation regions it is necessary to be a member of the set of ~openness values regions, but ~openness values regions can be a member of the set of innovation regions because other conditions than openness values may (equifinally) explain innovation.

3. Analytical knowledge * synthetic knowledge * melting pot.
4. Analytical knowledge * economic diversity * self-expression.

The full empirical results are presented in Table 2.

The high consistencies (≥0.9) and PRI-values[3] (≥0.8) of the equifinal configurations confirm that they represent very strong (i.e. valid) set-relationships. The high solution coverage (0.8) evidences that the 'full model' is highly relevant. The high raw coverages of the equifinal configurations and the high solution consistency underline the strength of the model. Unique coverages are always (very) low (Schneider and Wagemann, 2012).

Plotting the configurations on a map (Figure 2) shows that many regions have membership in multiple or all configurations. This suggests that the mechanisms are complementary rather than competing explanations of regional innovation. Regions that have membership in all configurations include the capital city regions of Berlin, Amsterdam (North Holland), Copenhagen and Stockholm, but also traditional manufacturing regions such as Dutch Limburg, Cologne, Koblenz, Darmstadt and Rhinehessen Palatinate. The *diversity configuration* unsurprisingly covers urbanised regions or regions that are home to one or more larger cities, e.g. West Sweden (Göteborg) and Upper Bavaria (Munich). The *technology transfer configuration* covers technology regions such as North Brabant (Eindhoven), Utrecht and Upper Bavaria (Munich). Also these regions are mostly economically diverse, urbanised regions. The geography of the *cosmopolitan environment configuration* is interesting because it covers the 'obvious' cosmopolitan city regions such as Stockholm, Copenhagen, Hamburg, Berlin, Cologne and the Randstad conurbation (Amsterdam, Rotterdam, The Hague) but not London. It does cover regions adjacent to London as well as semi-urban regions such as East Middle Sweden (bordering Stockholm) and many German regions. This suggests that 'quality of life' is a crucial part of this configuration, which includes not only urban amenities, such as a cultural scene and socio-cultural diversity, but also, e.g., green spaces and affordable housing (Florida, 2002). The fact that not London but its surrounding regions have membership in this configuration suggest that the dynamics of the 'new urban crisis' (Florida, 2017) negatively affect the drivers behind regional innovation. The *creativity configuration* covers successful technology regions (e.g. North West and South Netherlands, South England, Flanders and West Germany), and also deindustrialisation and reconstruction regions (e.g. Yorkshire, East Germany). This suggests that creativity can drive regional innovation also after formerly dominant industries have disappeared, if they left behind a nucleus of technology development.

Based on theoretical and substantive knowledge, the four configurations can be developed into empirically corroborated causal mechanisms for regional innovation.

6.1. Configuration 1: The diversity-mechanism

Configuration 1 suggests a diversity mechanism where crossovers of knowledge, practices and ideas between economic sectors, groups in society and between economy and society produce regional innovation when these crossovers are supported by

3 Proportional reduction in inconsistency (PRI) expresses the skewness of a set-relationship. Uniformly low X-values (PRI < 0.75) make X a subset of Y by default and do not evidence causality.

Table 2. Solution

	CONFIGURATION 1 DIVERSITY	CONFIGURATION 2 TECHNOLOGY TRANSFER	CONFIGURATION 3 COSMOPOLITAN EVIRONMENT	CONFIGURATION 4 CREATIVITY
Analytical knowledge		●	●	●
Synthetic knowledge		●	●	
Economic diversity	●	●		●
Melting pot	●		●	
Self-expression				●
Consistency	0.944163	0.947369	0.962366	0.958333
PRI	0.845070	0.803922	0.887097	0.863636
Raw coverage	0.543860	0.526316	0.523392	0.605264
Unique coverage	0.061403	0.008772	0.099412	0.043859
Solution coverage	0.789474			
Solution consistency	0.944056			

● Condition present ⊗ Condition absent **[Blank]** Condition logically redundant

tolerance. This mechanism is corroborated in the economic geography literature by, among others, Jacobs (1961), Florida (2002, 2017), Storper (2013) and Boschma et al. (2017). Jacobs (1961) and in particular Florida (2002, 2017) emphasise socio-cultural diversity as a cause of regional innovation, while Storper (2013) and Boschma et al. (2017) emphasise (related and unrelated) economic diversity. This finding suggests that openness values allow diverse social spaces in society and the economy to exchange knowledge and ideas and that both diversities work together to produce innovations. Importantly, the literature emphasises local economic diversity and local socio-cultural diversity to encourage the exchange of knowledge and ideas between local social spaces. This is not to suggest that non-local social spaces are necessarily excluded but that the basic mechanism is local (Bathelt et al., 2004; Crevoisier and Jeannerat, 2009; Fitjar and Rodriguez-Pose, 2011; Shearmur, 2011). It implies that the diversity mechanism depends on diverse local social spaces meeting in local physical places, and that the involvement of non-local spaces is not very relevant (Grandadam et al., 2013; Florida, 2017). Given the involvement of both 'economy' and 'society' in this mechanism, the exchange of knowledge and ideas is most likely to happen in professional and semi-professional social spaces meeting in both 'formal' (office buildings, campuses) and 'informal' (cultural amenities) physical places. The exchanges will be mostly goal-directed, such as in the SME-design project of the Eindhoven region Chamber of Commerce that connected local manufacturing SMEs to local designers in order to improve functionality and aesthetics of the design of manufacturing products. As designers generally come from different socio-cultural social spaces than SME engineers and technicians, this project connected both economy and society (Rutten et al., 2011).

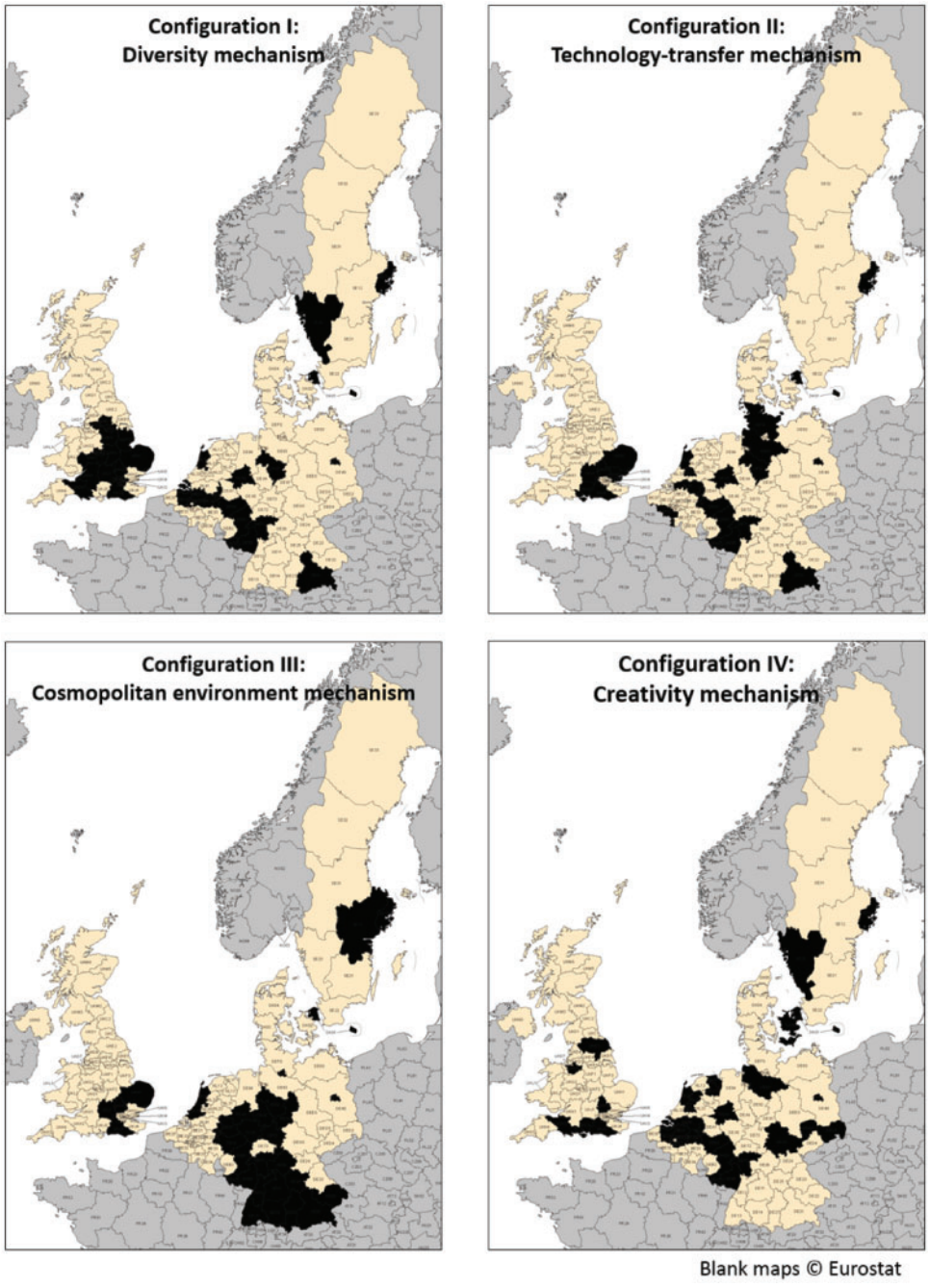

Figure 2. The geography of the configurations.

6.2. Configuration 2: The technology-transfer mechanism

Configuration 2 suggests a technology-transfer mechanism where regional innovation follows from mutual transfers of knowledge, practices and ideas between science (analytical knowledge creation), application (synthetic knowledge creation) and a diverse regional economy, and that openness values are logically redundant in this mechanism. The technology-transfer mechanism is at the heart of the TIM literature (Morgan, 1997; Moulaert and Sekia, 2003). It 'works' because economic diversity, on the one hand, produces both demand and opportunity for knowledge creation and, on the other hand, is able to absorb a wide variety of different kinds of knowledge. This suggests 'thick' connections and mutually reinforcing flows between science, application and the economy rather than a top-down mechanism of technology transfer (Morgan, 1997; Ibert, 2007; Lorentzen, 2008; Howells, 2012). The fact that openness values are logically redundant in this mechanism suggests that analytical and synthetic knowledge can be exchanged between scientists, technicians and engineers based on their cognitive proximity (Cohendet, 2014). Technology transfer is strongly connected to a physical research and technology infrastructure but the social spaces of scientists, technicians and engineers are largely global (Bathelt et al., 2004; Gertler and Levitte, 2005). Examples of the technology-transfer mechanism are ubiquitous in all kinds of technology districts and regional clusters. Staber and Sautter (2011) discuss technology transfer in the medical instruments and the clock-making clusters in South-West Germany and argue that 'shared understanding of basic industrial, technological, social and institutional features of a cluster' (p. 1350) plays a vital role in the 'cluster's evolving knowledge base and the way firms communicate knowledge to external audiences' (p. 1358). A counterfactual example of the technology-transfer mechanism comes from the North-East of England where deindustrialisation and globalisation have deteriorated regional R&D capacity to the extent 'that the potential for translating high-level knowledge and skills into new activities ... was lost' (Hudson, 2011, 1002).

6.3. Configuration 3: The cosmopolitan-environment mechanism

Configuration 3 suggests a cosmopolitan-environment mechanism where the interaction between analytical and synthetic knowledge creation and a diverse, tolerant and inclusive society produces regional innovation. The individuals involved in knowledge creation thrive in such open and diverse regional environments (Weckroth and Kemppainen, 2016). That is, the role of the melting-pot mechanism in this configuration is, on the one hand, to create an environment that (analytical and synthetic) knowledge workers find attractive. On the other hand, the melting-pot mechanism builds an environment where knowledge workers are exposed to a diversity of new ideas across diverse social spaces (Desrochers, 2001; Gertler and Levitte, 2005; Grandadam et al., 2013). Since the 'economy' is not part of the mechanism, but only local social spaces of knowledge workers, interaction may be mostly between semi- and non-professional social spaces and take place mostly in informal local places. That is, the exchange of knowledge and ideas may not necessarily be work-related or even goal-directed. An attractive physical local environment (both in terms of amenities and Jacobs' (1961) walkable neighbourhoods) is critical in this mechanism and openness values help to connect a diversity of social spaces to them. However, the cosmopolitan environment is attractive to non-local social spaces as well. Social spaces of knowledge workers are oftentimes global and connect to multiple physical places (Grandadam

et al., 2013; Haisch and Klöpper, 2014; Spencer, 2015). This makes cosmopolitan environments 'hotspots' of local and non-local exchange of knowledge and ideas. One example here is the diverse London music scene which connects to other creative industries and contributes to building an attractive environment for other knowledge workers (Watson, 2008).

6.4. Configuration 4: The creativity mechanism

Configuration 4 suggests a creativity mechanism where interaction between science (analytical knowledge), economic diversity (the crossover of knowledge, practices and ideas between economic sectors) and an open society (self-expression) triggers a creative process that produces regional innovation. This mechanism is corroborated, for example by Uzzi's (1997) discussion of regional innovation in the New York garment industry, which emphasises technological and design creativity and the openness of entrepreneurs for new ideas. In line with this example, the creativity mechanism may be mostly connected to professional and semi-professional social spaces. This mechanism is connected to local economic diversity, not to socio-cultural diversity. That is, social spaces may be connected to local physical places but depend on the access they provide to other local and non-local social spaces rather than on their amenities as such. Social depth of local social spaces may provide a 'safe' environment for creativity and experimentation (Uzzi, 1997; Bathelt et al., 2004) but these social spaces may still solicit important knowledge and ideas from non-local social spaces (Fitjar and Rodriguez-Pose, 2011; Hassink and Klaerding, 2012). Another example of the creativity mechanism is the Australian video-game industry. Firms in this industry geographically cluster in Brisbane and Melbourne to share knowledge and skilled labour but also connect to national and international networks and they serve global audiences (Darchen, 2016).

7. Discussion and conclusion

The above findings corroborate the notion that openness values encourage regional innovation by facilitating the exchange of knowledge and ideas across diverse communities in two ways. Tolerance, as part of the melting pot-mechanism, allows regional innovation to benefit from the diversity of knowledge and ideas in society. That is, tolerance encourages regional innovation indirectly by exposing knowledge workers to a larger and more diverse pool of knowledge and ideas. Self-expression encourages regional innovation more directly because it motivates knowledge workers to engage in the exchange of knowledge and ideas with a variety of partners. Since openness values pertain to social spaces rather than regions, openness values not only connect local social spaces (e.g. manufacturing SMEs and designers) but also local and global social spaces (e.g. global ties of local knowledge workers). Put differently, regions become better and more attractive entry points to local and global knowledge, the more, and the more diverse, social spaces connect to physical places within the region. The technology transfer-mechanism, which does not include openness values, corroborates this argument as follows. In this configuration, knowledge creation is confined to the social space of scientists, technicians and engineers suggesting that cognitive proximity is sufficient for knowledge creation. That, in turn, suggests that openness values contribute to a more dynamic regional innovation process because it

benefits from a more diverse pool of local and global knowledge. This explanation connects to two other micro-level explanations of innovation. Lester and Piore (2004) suggest that a diversity of inputs initially contributes to ambiguity but that ambiguity eventually produces more and better ideas. Similarly, Page (2008) suggests that the inclusion of many different perspectives and heuristics leads to the consideration of more potential solutions.

Although familiar at first sight, the four mechanisms challenge the regional innovation literature because they combine existing elements into new explanations. For example, the connection of socio-cultural and economic diversity and the fact that cosmopolitan environments are also found in non-urban regions sit uncomfortably with the core mechanisms hypothesised in the economic diversity and 'floridian' literatures. These literatures emphasise the importance of economic ties and urban environments, respectively. The four mechanisms thus (re-)structure the regional innovation literature and identify new research avenues. For example:

An important issue in this context is the connection of openness values, (socio-cultural and economic) diversity and regional innovation to density. Particularly the absence of London in all but one configuration, and Brussels in all, suggests that density is not uniformly beneficial for diversity and regional innovation. Most importantly, density has to be disentangled from diversity because the former is a territorial concept, the latter is relational. High density does not necessarily imply high diversity, nor are economic and socio-cultural diversity regions in this study always particularly dense regions (see above). Density is relevant for the present (micro-level) discussion in so far as it encourages connectivity (see above). However, micro-level connectivity may suffer from too much density, e.g. congestion and rising housing costs that drive middle-class knowledge workers out of cities; this, in turn, contributes to 'wrong' diversity (e.g. gated communities next to deprived communities). These are the negative dynamics of the 'new urban crisis' (Florida, 2017).

Another important find is that melting pot and self-expression do not appear as part of the same configuration. That is, socio-cultural diversity and tolerance may not encourage creativity in the way that Florida (2002) suggests. This does not mean that tolerance and socio-cultural diversity, on the one hand, and creativity and entrepreneurship, on the other hand, are always unrelated; however, melting pot and self-expression are part of different regional-innovation mechanisms. Melting pot allows innovation to benefit from the diversity of knowledge and ideas in the regional population, self-expression actively connects knowledge workers across different (related and unrelated) economic sectors. This corroborates Jacobs' (1961) original argument that economic diversity drives mixed usage of places and thus exposes people to 'urban diversity', rather than Florida's (2002) more direct connection between socio-cultural diversity and entrepreneurship.

The fact that the four mechanisms are complementary rather than competing explanations of regional innovation invites to elaborate the interaction between social space and physical place. Regions are home to multiple physical places and the four mechanisms connect different social spaces to different physical places. As argued, the technology-transfer mechanism connects social spaces of scientists, engineers and technicians to science parks, the cosmopolitan environment-mechanism connects social spaces of knowledge workers to cultural amenities. Regional innovation benefitting from diverse local and global knowledge may thus be related to a diversity of social spaces connecting to the same physical places, both intentionally and serendipitously

via buzz. This suggests a new research agenda on how social spaces and physical places connect. What kind of physical places are interesting for multiple social spaces? Are cultural amenities particularly relevant in this respect? Is it enough for a physical place to be populated with knowledge-creating social spaces (knowledge workers) or should they also be populated by non-professional social spaces? And does that suggest a relationship between, on the one hand, providing access to local and global knowledge and, on the other hand, being an inclusive, liveable and affordable region for a much broader population?

Finally, this paper makes an important empirical contribution to the largely conceptual relational economic geography literature. It develops the empirical findings into an empirically corroborated explanation of regional innovation as the interaction between social space and physical place. Herein, too, lies an important methodological contribution of this paper. It introduces set-analysis to economic geography. This allows going beyond net effects of individual variables to empirically studying configurations of conditions (causal mechanisms) in the form of generalisable cross-case patterns. The assumptions on the nature of causality underlying statistical research are rarely, if ever, questioned in economic geography and empirical rigour is too easily conflated with advanced statistical methods. This study explains that submerging cases in correlations and distributions are unhelpful to answering how-questions and introduces QCA as a rigorous method for qualitative cross-case analysis.

Supplementary material

Supplementary data for this paper are available at *Journal of Economic Geography* online.

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