Connecting Cognitive Diversity in Space: Towards a Geographic Theory of Creativity

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Introduction

It has become widely accepted that the 'knowledge-based economy' is now the standard perspective from which questions regarding regional economic development are mainly examined. This not only means seeking to understand the geographic patterns of knowledge and how it is applied for economic advantage, but crucially, why new knowledge tends to be developed more frequently in certain types of places.

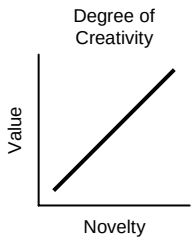
A commonly accepted and rudimentary definition of creativity is that it occurs when existing knowledge is recombined in novel and valuable ways (Jacobs 1969; Boden 1994; Weitzman 1998; Sternberg and Lubart 1999). Two possible reasons as to why some places display a greater propensity to producing creativity are: one that promotes the notion that certain people make places more creative; and a second that promotes the notion that certain places make people more creative (Florida 2002). In this sense, the first perspective would mean that some people are better at making new combinations of knowledge than others. Subsequently, such people tend to locate themselves in particular places thereby making such places more creative. Conversely, the second perspective would mean that certain places enable people to make more and better new combinations of knowledge thereby making people present in such locations more creative. While there is most likely some truth to both positions, the theory put forth in this paper supports the latter view. Underlying this position is the belief that creativity is a process primarily grounded in social activity, rather than one that is contained within the minds of certain individuals. There are two key reasons for this belief. The first is that access to a variety of knowledge is a prerequisite for making new combinations of knowledge. Thus learning, which is an inherently social process (Lundvall 1996; Wenger 2000), is a crucial dimension of creativity. The second is that the value of any new combination of knowledge is judged by collective agreement rather than the creator. With these two things in mind, the basic hypothesis of this paper is that the places that will generate the most creativity are the ones that offer the greatest

access to differentiated knowledge as well as be more likely to accept and value new combinations of knowledge.

This paper consists of two main sections. The first section builds in a systematic manner a theory as to why some places are sites of greater creativity than others. In this section a series of suppositions or 'stylized facts' are used to construct the argument. They are contained within series of sub-sections including: creativity, learning, networks, proximity, place, and motivation. The second section deals with the implications of the theory put forth in section one. The main contentions are that: first, creativity is more important to certain economic sectors than others; and second, that such sectors are more likely to be located in places described in the first section as being favourable to generating creativity.

Creativity

As was stated in the introduction, creativity occurs when value is derived from novel combinations of knowledge. A key implication of this is that existing knowledge is essentially the raw material of creativity. Furthermore, obtaining novel inputs (learning) is crucial to producing novel outputs (creativity).



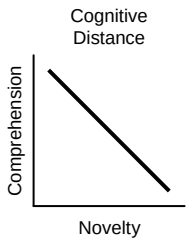
Supposition 1
Creativity occurs when existing knowledge is combined in new and valuable ways.

Not all novel combinations are however valued equally, as the greater the novelty, the greater the potential value. Things that are only slightly new will produce only marginal value, while things that are radically new have a much greater potential value. However, it is easier to produce the former and thus more likely that new combinations of knowledge will produce only a slight degree of novelty. Conversely, radically new knowledge is more difficult to produce and

thus a more rare occurrence. The specific reasons for this are elaborated on in the following sections.

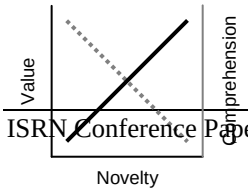
Learning

If knowledge is the raw material of creativity then acquiring knowledge, or learning, is an essential component of the process of generating new ideas. Learning involves not only acquiring new knowledge but also retaining it. In order to retain newly acquired knowledge it must be classified and integrated within the context of what is already known. Thus there is a 'path dependence' whereby new knowledge is added to old. Cohen and Levinthal (1990) refer to this as 'absorptive capacity' whereby individuals' as well as organizations' abilities to absorb new knowledge is dependent upon the "level of prior related knowledge". A key implication is that some knowledge is more difficult to learn if one does not already possess a significant amount of related knowledge.



Supposition 2
There is an inverse relationship between the novelty of acquired knowledge and the ability to comprehend it.

There is an inherent trade-off between the novelty of newly acquired knowledge and the ability to comprehend it. Knowledge that closely resembles what is already known is easier to understand and classify. Conversely, knowledge that does not closely resemble what is already known is more difficult to comprehend. This phenomenon is known as 'cognitive distance', which Nooteboom (2000) believes, "indicates that people do not just have different thoughts, but that they have different abilities of perception, interpretation and evaluation, and thereby see the world differently, as a function of their experience".



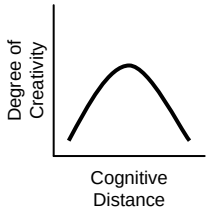
Supposition 3

The optimal value of acquired knowledge is a balance between novelty and comprehension.

So far the novelty of knowledge has been related to both its value, which shows a positive relationship, and the ability to comprehend it, which shows a negative relationship. Therefore a balance must exist between novelty, value and comprehension. Nooteboom (2001; pp) explains that,

> cognitive distance yields both an opportunity and a problem. The opportunity is that contact with others gives us an opportunity to escape from the myopia of our personal cognitive construction. A problem, however, is that the greater the distance, i.e. the less people share cognitive categories, the more difficult it is to cross it, i.e. to understand the actions and expressions of a partner. Thus there is some optimal cognitive distance: large enough for partners to tell each other something new, and small enough for comprehension.

While knowledge that is extremely novel has a high degree of theoretical value, its practical value is much less as it is difficult, if not impossible, to gain any utility from it. There is instead an optimal level of novelty that exists at the point where it does not exceed the absorptive capacity of the individual or organization.



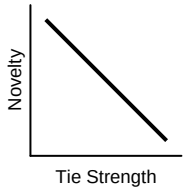
Supposition 4
Creativity, which depends on the ability to absorb, then recombine knowledge, is most likely when there is a moderate cognitive distance between two sets of knowledge.

The point at which the novelty of knowledge and the ability to comprehend it intersect identifies what knowledge is most beneficial to the process of creativity. As creativity involves generating new combinations of knowledge in valuable ways, spanning the greatest possible cognitive distance will deliver the most creative outcomes. There is a point at which cognitive distance becomes so great that the ability to connect knowledge diminishes. Individuals may have varying abilities and therefore some may be able to connect knowledge of greater cognitive

distance. This encapsulates the view of creativity as a personal trait. While this view is not contended here, it is also not the focus. The central issue for this paper is *access* to knowledge of varying degrees of cognitive distance. The greatest ability in the world to span cognitive distance will be wasted if access to knowledge is limited in scale and scope. Thus access to knowledge, mainly through social learning processes, is an essential component of creativity.

Networks

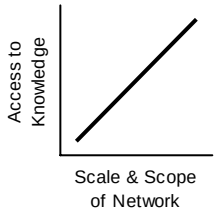
Learning occurs when two or more people connect and knowledge flows between them. The nature of the connection has a significant impact on the nature of the knowledge that is exchanged. Connections or 'ties' vary according to their 'strength'. The 'strength of ties' is determined most importantly by the amount of time and number of times the connection is made (Marsden and Campbell 1984). Additional components of tie strength include: emotional intensity, intimacy, and reciprocity. In terms of learning, because stronger ties involve more frequent interaction, knowledge flows are also more frequent. As knowledge flows are more frequent there is a greater amount of commonly shared knowledge. The aggregate effect is that within 'strong tie networks' common knowledge leads to common values and norms. Such networks, in conjunction with institutions that act to bound and reinforce common values and norms, provide the foundation for distinct cultures (Erickson 2001; Amin and Cohendet 2004).



Supposition 5
'Stronger ties' are more likely to be sources of redundant knowledge while 'weaker ties' are more likely to be sources of novel knowledge.

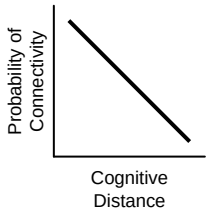
The more time two people spend interacting with one another the more they will learn from one another. Consequently the more they learn from one another the less there is to learn. Or in other words cognitive distance diminishes with increasing tie strength. The inverse implication, first articulated by Granovetter (1973), is that weaker ties are a better source of knowledge that is

novel. In other words, connections that are less frequent will be a more valuable source of knowledge because the knowledge obtained through such ties is more likely to be novel.



Supposition 6
An increase in the number of non-redundant weak ties will increase access to learning opportunities.

An important inference from Supposition 5 is that people who have a greater number of weak ties will have greater access to a variety of knowledge. One vital caveat is that weak tie relationships be non-redundant. What this means is that if multiple weak ties are subsequently strongly tied to one another the overall informational benefits are diminished. This is because each weak tie will bring the same set of knowledge on account that they belong to the same group as one another. In comparing the structure of networks Burt (1992) notes that, "everything else constant, a large, diverse network is the best guarantee of having a contact present where useful information is aired". According to Burt it is vital to avoid redundant ties, as they are inefficient to maintain. The reason is that developing ties in the first place requires time and effort. As time is finite people can only develop and maintain a certain number of ties with a certain amount of strength. It is better therefore, in terms of obtaining knowledge, to use one's social resources to develop non-redundant rather than redundant ties.



Supposition 7
The probability of a network connection forming is inversely related to cognitive distance.

There is an intrinsic contradiction with weaker ties being more valuable, which is that the weaker the tie the less likely they are to form in the first place. There is a well-established literature on the concept of 'homophily' that describes how people display a tendency to form

relationships with people who are similar to them. McPherson et al. (2001; pp) offer a précis of homophily and its implications with the following:

> Homophily is the principle that a contact between similar people occurs at a higher rate than among dissimilar people. The pervasive fact of homophily means that cultural behavioral, genetic, or material information that flows through networks will tend to be localized. Homophily implies that distance in terms of social characteristics translates into network distance, the number of relationships through which a piece of information must travel to connect two individuals. It also implies that any social entity that depends to a substantial degree on networks for its transmission will tend to be localized in social space and will obey certain fundamental dynamics as it interacts with other social entities in an ecology of social forms.

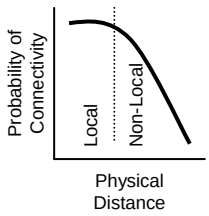
One of the implications of homophily is that it is a self-reinforcing cycle. As people who are similar tend to form relationships with other people who are similar to them they learn from one another and by doing so grow ever more similar. The problem with this is that if creativity depends on knowledge being brought together in novel ways then homophily is a constraint on creativity. The concept of homophily suggests that the formation of 'weak ties' or the 'bridging of structural holes' does not tend to occur naturally. Such connections must therefore involve instrumental action motivated by the understanding that combining differentiated knowledge in novel ways can produce something of value. Thus seeking out connections that provide novel rather than redundant information becomes a worthy goal.

Proximity

Previous to the invention of information and communications technologies (ICTs) the only way an interactive connection could be established was through direct face-to-face communication. Thus the probability of a connection forming between two people was wholly dependent on the participants' proximity to one another. The advent and improvement of ICTs had changed this paradigm so that it is now possible for a network connection to form regardless of proximity. This has led some (for example see Cairncross 1997) to question whether proximity now matters at all in terms of networks and knowledge flows. The most common defence of the

importance of proximity relates to the differences between tacit knowledge and codified knowledge. Gertler (2003) maintains that, "tacit knowledge does not travel easily…this is because its transmission is best shared through face-to-face interaction between partners who already share some basic similarities: the same language; common 'codes' of communication; shared conventions and norms; personal knowledge of each other based on a past history of successful collaboration or informal interaction". The rough translation of this statement into the language of 'tie strength' would be that tacit knowledge develops within 'strong tie networks' and their associated institutional contexts which, due to the necessity of frequent face-to-face contact, remain inherently local. The key implication is that knowledge cannot easily be transmitted over long distances because networks do not tend to form over long distances.

There is however some evidence that network connections can form over longer distances. Grotz and Braun (1997) examine the networks of German small and medium sized enterprises (SMEs) engaged in mechanical engineering. They find that the networks that the SMEs depended on for access to knowledge often tended to be non-local rather than local. One of the main reasons for this was that due to a high degree of specialization there were not very many local firms that had similar knowledge bases. It was more important to find firms with a shorter cognitive distance even if this meant a further physical distance. Britton (2004) finds similar patterns in the electronics industry in Toronto. The key implication from these works is that cognitive distance is not always related to physical distance. This is especially true with knowledge that is highly specialized.



Supposition 8
The probability of a network connection forming is higher if the dyads exist in the same region.

The clarification that needs to be made at this point is that knowledge flows are not directly constrained by distance. Knowledge flows are constrained by networks. It is networks that are

constrained by distance. The primary constraint on non-local relationships is not technological but temporal. First of all people tend to spend the majority of their time within one region. Secondly, they tend to spend much more time interacting with people face-to-face then via ICTs. Thirdly, most contact via ICTs acts to reinforce existing face-to-face relationships rather than supplant them (Wellman 1996). Fourth, face-to-face contact is a more efficient method of transmitting knowledge than using ICTs (Storper and Venables 2004). Therefore one hour of face-to-face contact is worth more in terms of strengthening a relationship than one hour of communicating via ICTs. For these reasons networks are more likely to form locally than non-locally as the majority of social interaction occurs face-to-face between people who inhabit the same locale. This does not mean that networks cannot form inter-regionally but rather that it is less likely.

The main factors given as to why networks tend to form intra-regionally can be overcome in the following ways. First, even though people tend to spend most of their time in one region they are not fixed to one locale. This means that by traveling outside of their region they can exchange knowledge face-to-face with people in other regions. Secondly, it is possible to spend more time interacting via ICTs than face-to-face (although this remains rare). Third, it is possible to establish connections via ICTs (although this too remains rare). Non-local networks can occur but they must overcome greater resistance. Zipf (1949) explains the preference for local over non-local connections as the "principle of least effort" whereby connections that are easiest will be the most common even if they are not the most desirable. The formation of inter-regional networks then must involve instrumental actions that seek out 'better' rather than 'easy' connections. This relates to Bathelt, Malmberg and Maskell's (2004) theory of 'global pipelines'. They explain that, "the establishment of a pipeline is a conscious attempt to overcome identified shortcomings in the local knowledge base and fulfill certain goals and expectations, actors are also prepared to make special efforts to bridge cognitive distance". Physical distance acts as a constraint on networks and knowledge flows by constraining the quantity and quality of social interaction. This in turn

increases cognitive distance. However, if effective ties can be created that span longer distances then cognitive distance can be reduced.

Therefore, the difficulty of overcoming physical distance in networks can be mitigated somewhat if there is less cognitive distance.

		Cognitive Distance		
Physical Distance		**Low**	**Medium**	**High**
	Local	High	Medium	Low
	Non-Local	Medium	Low	Very Low

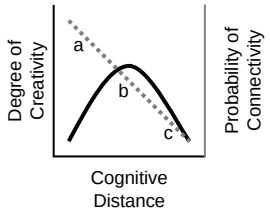
Supposition 9
The probability of a network connection forming (and knowledge flow occurring) is a function of cognitive distance *and* physical distance.

Following Zipf's (1949) 'principle of least effort' the probability of a network connection forming is a function of both cognitive distance and physical distance. The most likely connections are the ones between people who inhabit the same region and know many of the same things. This accounts for why most network connections are local but also why knowledge maintains a distinctly local characteristic as cognitive distance and physical proximity act to reinforce one another. As was stated in the previous section, inter-regional connections are possible but they depend upon instrumental action and a relatively low level of cognitive distance. Conversely, if a high degree of cognitive distance exists then connections are unlikely even if they are local.

Recalling *Supposition 4* that "creativity is most likely when there is a moderate cognitive distance between two sets of knowledge" it is the most probable location of moderately cognitively distant knowledge that is of greatest relevance to creativity. By following the stated principles above it can be supposed that moderately cognitively distant connections are more likely if it is local. This probability of type of connection however, is relatively moderate.

Supposition 10

The most important network connections in the process of creativity will be intra-regional weak ties.

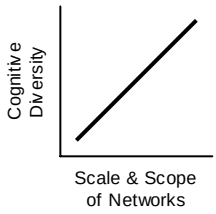


	Probability of connectivity	Cognitive distance	Degree of creativity	Source
a	High	Low	Low	Local/Non-local
b	Medium	Medium	High	Local
c	Low	High	Low	Non-local

Intra-regional ties are a more important source of creativity than inter-regional ties. There are three interrelated reasons for this. One is that the probability of making a connection is higher if it is local (Supposition 8). Secondly, knowledge that is moderately differentiated is more likely to be sourced locally (Supposition 9). Thirdly, knowledge that is of a moderate cognitive distance is most likely to contribute to a creative outcome (Supposition 4). The key implication of this is that if intra-regional networks matter to producing creativity then the composition of local networks also matters.

Place

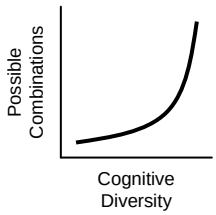
So far it has been contended that the most valuable knowledge for creativity is knowledge that is of moderate cognitive distance. Furthermore it is more likely that it is easier to obtain such knowledge if it exists locally. The missing dimension at this point is the *amount* of knowledge present locally that is of moderate cognitive distance. The amount of such knowledge will vary between regions according to the scale and scope of networks that are present locally.



Supposition 11

The presence of a greater number of networks leads to a greater degree of cognitive diversity.

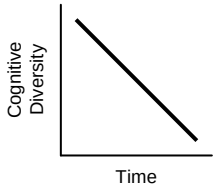
Typically the level of knowledge-intensity in a particular place is measured by the average level of educational attainment of the population, whether it be average number of years of schooling or the percentage of the population with a university degree. While this is important, it does not tell the whole story. It is not only the amount of knowledge that individuals hold but also the amount of cognitive distance between individuals that matters to the creative potential of a place. The aggregate amount of cognitive distance between individuals equals the amount of cognitive diversity (Milliken, Bartel and Kurtzberg 2003). As was stated in Suppositions 5-6, common knowledge is built around common ties that form networks. Therefore in order to have cognitive diversity there must be a variety of networks.



Supposition 12
The number of possible new combinations of knowledge (the creative potential) is exponentially related to the level of cognitive diversity.

The creative potential of a place is a function of the amount of possible new combinations of knowledge. As some places are more cognitively diverse than others they will have a potential creative advantage over places that are less diverse (before accounting for knowledge obtained from elsewhere). For instance, if only two distinct networks exist and they each have only 'one' piece of knowledge then there is only one possible combination. The number of combinations can grow in two ways: either more networks are added or more differentiated knowledge is added to the existing networks. In the first case, if there were now three networks and they each have only one 'piece' of knowledge then there are three possible combinations. If there are four networks the number of possible combinations grows to six and so on. The second way that the number of possible combinations can increase is if each network possesses a greater amount of differentiated knowledge or in other words there is a larger 'structural hole' between the two groups. For example if there are two networks and they each have two 'pieces' of differentiated knowledge

then there are four possible inter-network combinations. If each network held three 'pieces' of knowledge the number of possible inter-network combinations grows to eight. These two ways of expanding the possible number of combinations of knowledge are in no way mutually exclusive. If they occur simultaneously then the number of combinations grows at an even higher rate as the scale and scope of networks increases.



Supposition 13
Cognitive diversity decreases with time as networks intersect and knowledge is shared.

At the level of the individual it was stated in Supposition 5 that cognitive distance decreases with tie strength. That is to say that the more time two people spend together the more they learn from one another and consequently the cognitive distance between them shrinks. This principle is also applicable at an aggregate level. The more contact that occurs between networks the greater the knowledge flows, which over time leads to a decrease in cognitive distance. What this means in a regional context is that as local networks interact and learn from one another assimilation will occur and cognitive diversity will dissipate. Therefore in order to prevent an erosion of cognitive diversity there must be constant churn in the people and networks that are present locally. Practically this means constant inflows and outflows of people and the knowledge that they bring. For cognitive diversity to persist it needs to be constantly refreshed.

The overall message of this section is that places that contain a greater degree of cognitive diversity provide greater opportunities for creativity to occur. Such diversity is derived from having many non-redundant networks that are constantly being refreshed by people and ideas from outside the local area.

Motivation

Just because some environments have a greater potential for creativity does not necessarily mean that more creativity will occur. As was stated in Suppositions 8-9 network connections are normally formed according to the 'principle of least effort', which is a combination of low cognitive distance and low physical distance. Such network connections do not, however, tend to lead to creative outcomes because they are not likely to be sources of differentiated knowledge. Thus a greater effort has to be made in order to make connections that will bring valuable knowledge. The motivation to do so is closely associated with the very definition of creativity: that something valuable is being produced. The value of a creation is not determined by the creator, but rather by the members of the network(s) that the creator occupies. Thus creators must convince others that what they have created is of value. By doing so however, the creator is taking a risk as they are likely to be judged along with the creation itself.

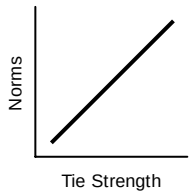
All creations are potentially disruptive as they may act to displace something that already exists and even possibly disrupt the current structure of the network itself. In writing about the effect of new technological innovations Schumpeter (1947) referred to this phenomenon as 'creative destruction'. The creator's network may decide that the destructive elements outweigh the potential benefits. The risk to the creator is that their standing within the network or their very inclusion in it may be in jeopardy as a result. This is important because networks are not only a source of knowledge they are also a crucial source of support (Pearlin 1989). The concept of 'social capital' has a plethora of definitions and meanings but in very general terms it refers to the resources that are gained from investing time and energy in building social relationships. Coleman (1988) identifies three forms of social capital:

a) obligations, expectations, and trustworthiness;

b) information channels; and,

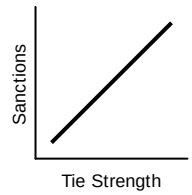
c) norms and effective sanctions.

Up to this point social relationships have been predominantly treated as information channels but in order to understand the motivation behind creativity it is essential to discuss Coleman's other dimensions of social capital as well. In particular, norms and sanctions play a significant role in the level of risk associated with creativity.



Supposition 14
As tie strength increases between two people the degree of shared values also increases.

The role of social norms is to act as a guide of behaviour for individuals confronted with choices that will have consequences for themselves and the group. Norms are established through frequent contact with others, which involves feedback on behaviour. Positive feedback is received when an individual's action conforms to the obligations and expectations of the group. Negative feedback in the form of sanctions is received when an individual's actions contradict the obligations and expectations of the group. Stronger connections between people lead to a stronger degree of reciprocity. As a result the norms that guide such reciprocity will also be stronger in terms of their specificity and importance.

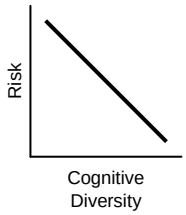


Supposition 15
Sanctions are more strictly and severely imposed when network ties are stronger.

While the value of weaker ties may be informational the value of stronger ties is derived from the support that is gained from them. As less time and energy is invested in weaker ties there is also less to be lost if they are damaged. There is also less likely to be a significant effect on other relationships if a weaker tie is disrupted. Stronger ties on the other hand require a greater

investment and so are more carefully guarded. Damage to a stronger tie will also more likely result in other stronger tie relationships being affected as reputation within the core network can be diminished. Thus sanctions associated with policing the norms between close relations are more severe.

As a person's time and energy are finite they have only so much to invest in forming relationships. This can involve investing a great deal in a small number of relationships, investing a small amount in a wide number of relationships, or some intermediate combination of these. As was established earlier, networks that lack scale and scope will be less diverse. They will also however be better sources of support. Thus within smaller and less diverse networks there will be stricter norms and more severe sanctions. The implication is that acts of creativity in such networks bring a greater degree of risk.



Supposition 16
The risks associated with acts of creativity are higher when cognitive diversity is lower.

By extrapolating the point that creativity is riskier within smaller and less diverse networks to entire places, a link can be made between the potential risks of creativity and the level of cognitive diversity present. If cognitive diversity is relatively low within a region, norms of behaviour will be more tightly defined and the sanctions that enforce them will be harsher. Conversely if a greater degree of cognitive diversity exists then norms will be broader and more pluralistic in nature. The severity of sanctions may not be as strongly affected by greater cognitive diversity but the likelihood of receiving them will be dampened. The implication is that acts of creativity involve less risk in places with a greater degree of cognitive diversity. The overall effect is that when diversity is low 'groupthink' tends to take hold whereby people are reluctant to voice any difference of opinion from that of the majority. Nemeth and Netmeth-

Brown (2003) note that dissent can be highly valuable in counteracting 'groupthink' and it is more likely to occur if there is a greater degree of cognitive diversity present.

Summary

The case built so far attempts to support the notion that more diverse places will likely be more creative places. This hypothesis rests on the idea that creativity is a social process that involves producing novel recombinations of knowledge. In order for this to occur previously disconnected networks need to link up and exchange knowledge. It is argued that places that contain a wider scope of networks will also have a greater number of possible new combinations of networks and subsequent combinations of knowledge. Furthermore, a lack of cognitive diversity can lead to 'groupthink' which stifles dissent and prevents new connections of knowledge and the expression of them.

While the first section of this paper has attempted to establish a theoretical connection between cognitive diversity and creativity it has not explored questions pertaining to why such a connection might matter in a wider sense. It is often assumed that more creativity is automatically a good thing for places especially in the context of regional economic development. The next section of this paper begins to examine these questions while identifying the nuances of the impacts of greater creativity from a geographic perspective.

Implications

> *The city has thus historically been the melting-pot of races, peoples, and cultures and a most favorable breeding ground of new biological and cultural hybrids. It has not only tolerated but rewarded individual differences. It has brought together people from the ends of the earth* ***because*** *they are different and thus useful to one another, rather than because they are homogeneous and like-minded.*
>
> (Wirth 1938; pp. 10)

So far a theoretical connection has been established between cognitive diversity and creativity. A further connection between creativity and economic activity is however less clear. Creativity does not affect all economic activity in an equal manner. Or conversely, not all economic activities rely on creativity to the same extent. One of the main qualitative determinants is the type of knowledge that underpins the products and processes within each economic sector. Asheim and Gertler (2005) provide a framework of industrial knowledge bases that is comprised of a spectrum between synthetic and analytic knowledge. They explain that synthetic knowledge, "prevails in industrial settings where innovation takes place through the application or novel recombination of existing knowledge", and conversely, "an analytic knowledge base dominates economic activities where scientific knowledge is highly important, and where knowledge creation is based on formal models, codified science and rational processes". An 'idealized' distinction between synthetic and analytic knowledge is elaborated on in Table 1. It is important to note that these types are meant to represent extreme ends of a spectrum with the understanding that all knowledge-bases exist somewhere in between.

Table 1 – Contrasting Synthetic Knowledge and Analytic Knowledge

Synthetic		**Analytic**
Tacit Synthetic knowledge tends to be tacit in nature, meaning that it is difficult to codify and is specific to its context. Thus it is more difficult to transmit over longer distances.	**Comprehension**	**Codified** Analytic knowledge is best transmitted via the use of formal models and equations. Thus it is more easily transmitted over longer distances.
Cultural Synthetic knowledge is derived from social interaction and mutually agreed norms and conventions.	**Source**	**Scientific** Analytic knowledge is derived from the scientific principles of observable and verifiable evidence.
Personal Synthetic knowledge is organized and understood according to what is already known. Thus the classification system is internal and personal. As what is already known varies between individuals the classification of synthetic knowledge is subjective and therefore dependent on individual beliefs and values.	**Classification**	**Universal** Analytic knowledge is organized around objective scientific criteria. Thus classification of knowledge is external and universal. Examples include such things as the periodic table of the elements and the human genome.
Evolutionary The learning of synthetic knowledge is disruptive in nature, meaning that as new knowledge is formed, knowledge classification systems are changed simultaneously. In other words, learning synthetic knowledge is selective and value-based. Thus values that provide the foundation for classification systems can change as new knowledge is added. The learning of synthetic knowledge is more reliant on weak-tie relationships as they are more likely sources of new knowledge.	**Learning**	**Expansionary** The learning of analytic knowledge is based on accumulating specific knowledge based around a certain type of scientific classification. It is often highly linear in terms of increasing complexity and specificity. Thus knowledge diffusion is very important especially via strong-tie networks or within specific communities of practice.
Creativity New synthetic knowledge is created when existing knowledge is combined in novel ways. Thus the resulting knowledge is derived by human creation.	**Novelty**	**Discovery** New analytic knowledge is the result of scientific discovery. It usually involves the initial human understanding of 'natural' phenomena.

The most important feature of table 1 is the bottom row concerning novelty which contends that new synthetic knowledge is the result of human creativity while new analytic knowledge is derived from scientific discovery. This distinction relies on the idea that synthetic knowledge is culturally-based rather than scientifically-based. Thus the classification of synthetic knowledge is highly subjective and contingent on personal beliefs and values while analytic knowledge is classified around scientific principles. As synthetic and analytic differ in their characteristics, so too do learning processes. In the literature learning is often conflated with novelty. Here they are separated in that learning refers to individuals obtaining knowledge that is already known by others while novelty refers to the development of knowledge that has previously been unknown to anyone. In this regard the learning of synthetic-based knowledge is an evolutionary process whereby new knowledge is classified according to what is already known by the individual. As synthetic-based knowledge is mainly obtained via social interaction, personal knowledge bases, values and classification systems will tend to closely resemble those of others within the same social networks. Therefore, contact with those outside of one's own core network is more likely to provide richer learning opportunities.

The learning of analytic knowledge differs in that it is expansionary rather than evolutionary. While both are path dependent, learning analytic-based knowledge requires one to follow more or less the same path from general and simple concepts to increasingly specific and complex concepts. Perhaps it for this reason that the presence of 'star scientists' are credited with being geographic cornerstones of analytic-based economic sectors as they are the ones developing the paths for others to follow (Asheim and Gertler 2005). Connections to the leading edge of scientific advancement are therefore vitally important. Thus learning analytic-based knowledge is more likely to occur via contact with others who have very similar knowledge sets. The implication is that stronger ties are more important than weaker ties for learning analytic-based knowledge.

The two contrasting learning systems are strongly linked with how new knowledge is produced. With analytic-based knowledge novelty comes from discovery while with synthetic-based knowledge new knowledge is derived from creativity. The key difference is that purely analytic-based knowledge exists but is not known before it is discovered while synthetic-based knowledge comes into existence at the time of creation. For example, sub-atomic particles (subject of analytic-based knowledge) have always existed but have not always been known to exist while great works of literature (subject of synthetic-based knowledge) only exist after they have been created. The key implication is that economic sectors that predominantly depend on synthetic-based knowledge also depend on creativity for progress and competitiveness.

The type of knowledge-base is not however the only factor that needs consideration as quantitative factors of knowledge intensity are also significant (Von Tunzelmann and Acha 2005). Economic sectors also vary according to the predominant type of work that is performed. The traditional distinction in this sense is blue collar/white collar. What is most important in this case is the degree to which work involves non-routine activities and frequent problem solving. Such activities can be considered 'knowledge intensive' while highly repetitive and mechanical work can be considered 'labour intensive'. Those engaged in activities that are knowledge intensive are also more likely to be engaged in activities that require developing new knowledge. In analytic-based sectors this would to a greater degree involve pursuing scientific discovery while in synthetic-based sectors this would more likely involve creativity.

The degree to which creativity is important to a particular economic sector can therefore be seen dependent upon two factors, one qualitative and one quantitative. The qualitative dynamic is the type of knowledge that the economic sector predominantly relies upon, spanning a spectrum from purely synthetic to purely analytic knowledge. The quantitative dynamic is the degree to which knowledge is important to the overall work function of the economic sector, or in other words, the overall knowledge intensity of the sector. The overall implication is that creativity is

most important to sectors that are both knowledge intensive and rely predominantly on a synthetic knowledge-base (See Figure 1).

Figure 1 – Economic Sector Factors of Creativity

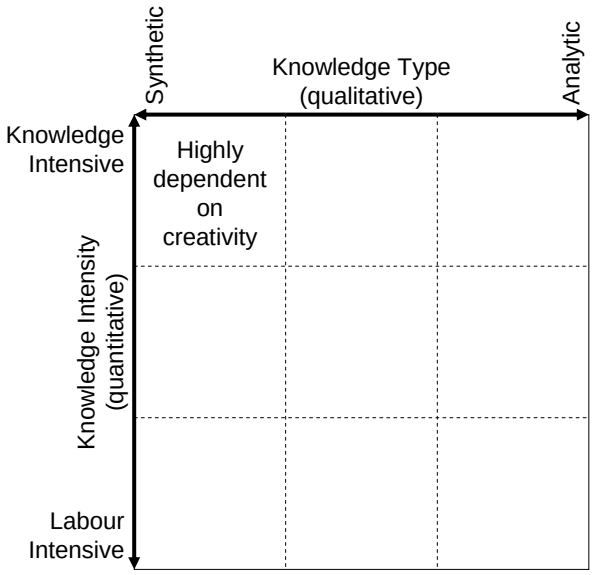


Figure 1 can be made operational by developing indicators of both knowledge type and knowledge intensity. Knowledge type can be measured according to the field of study of the post-secondary qualification holders within each industry. In this case certain fields of study are identified as being predominantly analytically-based and then expressed as a percentage of the total for each industry. This gives a relative measure of the way demand for certain types of knowledge varies between sectors on a national level. Relative knowledge intensity can be estimated using occupational data. Professional occupations are typically the most 'knowledge intensive' as they are characterized by non-routine and constantly adaptive work practices. Thus the knowledge intensity of an economic sector can be gauged by the percentage of the workforce that is

employed in professional occupations. Figure 2 shows the results for Canadian economic sectors (4 digit NAICS sectors).

Figure 2 – 4 Digit NAICS Sectors by Knowledge Type and Knowledge Intensity

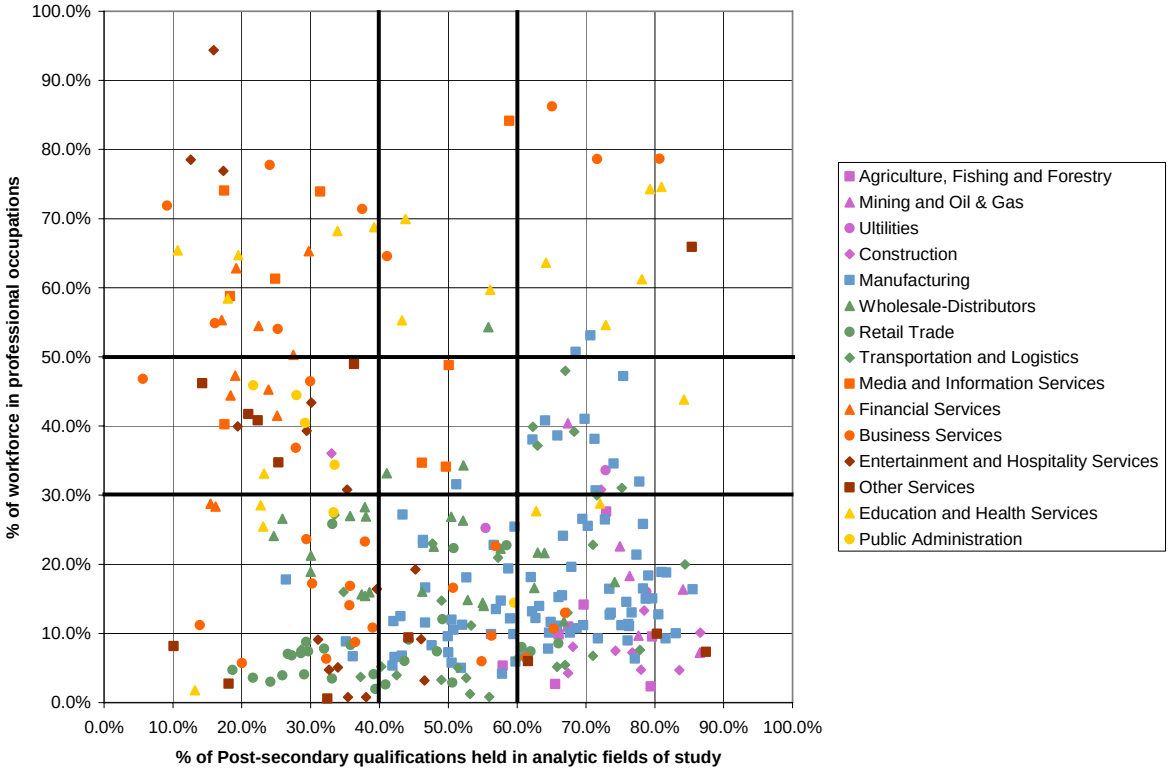


Figure 2 shows how the various 4 digits NAICS sectors (grouped by general economic activity) differ according to knowledge type and knowledge intensity. Darker lines have been added in order to more clearly demarcate groupings of industries. From this chart an interesting pattern emerges as particular groupings of sectors are found in each corner. Starting at the bottom left, which represents sectors that are more reliant on synthetic knowledge but are not very knowledge intensive, there are industries that are mainly non-basic services such as retail trade, hotels and restaurants. These sectors are known to tend to locate near markets. Sectors that have an analytic knowledge-base but are not highly knowledge intensive are found at the bottom right of the

graph. These sectors are predominantly concerned with natural resource extraction and related manufacturing. Examples include fishing, logging and mining as well as basic metal manufacturing and paper manufacturing. The location of such sectors is clearly dependent upon the location of the resources. The location dynamics of sectors that are less knowledge intensive seem to follow general economic geography principles that have been well established. Specifically, the location of industries is based on proximity to either resources or the market. What figure 2 is showing is that sectors with a synthetic knowledge-base tend to locate near markets while analytic sectors tend to locate near resources. This makes sense as knowledge of markets is primarily synthetic knowledge while the understanding of where resources can be found in greater abundance requires analytic-based knowledge.

The location dynamics for knowledge intensive sectors, however, appear to differ. Sectors that are highly knowledge-intensive and analytically-based can be found on the top-right corner of the graph. These sectors included such industries as ICT, biomedical, and general research and development services. A growing and very convincing literature that focuses on the location dynamics of such industries points to the importance of the presence of specific knowledge creating institutions, anchor firms, and 'star scientists' in attracting and developing further related economic activities (Zucker and Darby 1996; Feldman 2003). This follows the principles put forth in table 1 whereby the transfer of analytic-based knowledge tends to be based on stronger ties between parties that have a low level of cognitive distance between them. This would suggest that such industries may perform better in locations with a critical mass of closely related economic activities.

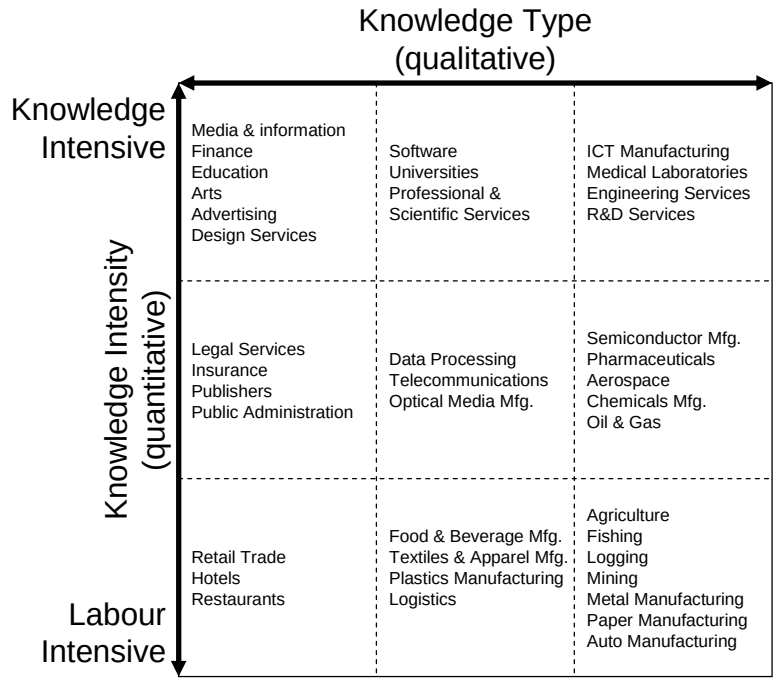
The upper-left grouping on the graph represents the sectors that have both a high reliance on synthetic knowledge and a high level of knowledge intensity. In the context of the first section of this paper, economic activities that rely on greater quantities of synthetic knowledge will also be heavily dependent on creativity. According to the criteria used in figure 2 these industries are concentrated in media and information, financial services, education, the arts, and certain

business services such as advertising and design. Such sectors tend to be found in higher concentrations in large urban areas. Such places also tend to be locations that contain a high level of cognitive diversity. The key question then becomes whether such industries are present where they are because of higher levels of cognitive diversity as the theory outlined in the first section of this paper suggests.

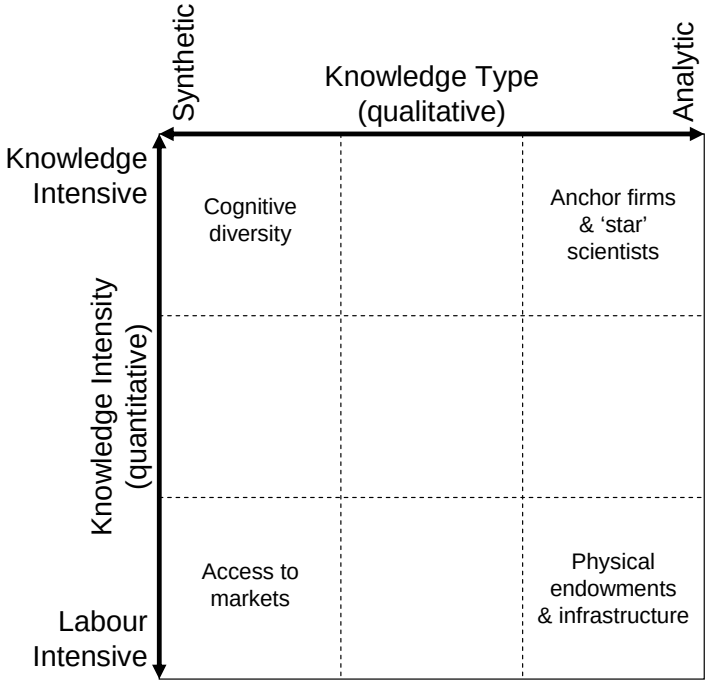
Conclusions

What this paper as attempted to do is, firstly, establish a theoretical connection between diversity and creativity from a geographical perspective, and secondly, identify more precisely how and why creativity matters to specific economic activities. As this paper is primarily intended to construct a geographic theory of creativity the next steps involve the testing of the key hypotheses put forth. The first broad question is whether cognitive diversity and creativity are related, especially in a geographic sense. A second question would involve attempting to uncover more specific details about the process of creativity itself and whether the characteristics of personal (including diversity of contacts) has an impact on creative ability. Finally, policy questions must be addressed in order to assess how any relevant findings can be used to improve the wellbeing of places and their inhabitants.

Appendix A – Selected Sectors by Relative Knowledge Intensity and Knowledge Type



Appendix B – Key Location Factors by Knowledge Intensity and Knowledge Type



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