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## The regional dimension of knowledge transfers: a behavioral approach

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# 0612

**The Regional Dimension of  
Knowledge Transfers –  
A Behavioral Approach**

by

**Tom Broekel  
Martin Binder**

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# *The Regional Dimension of Knowledge Transfers - A Behavioral Approach*

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## Abstract

Innovations are inherently connected to knowledge transfers. The need of face-to-face contacts to transfer tacit knowledge is commonly argued to cause a regional dimension of innovative activities. The paper presents an alternative explanation based on a model of boundedly rational actors who search for knowledge. It is shown that a regional dimension exists in these processes that results from a regional bias in an actor's search activities. Social embeddedness, a shared regional identity and limited spatial mobility foster this bias. We argue that insights from research on these topics can help to define the geographic size of a region.

Keywords: Regional Economics, Innovation, Knowledge Transfers, Tacit Knowledge, Bounded Rationality

JEL-classification: D83, O31, R12, B52

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# 1 Introduction

Innovations play an eminent role as a driver for economic growth. They are usually depicted as increasing productivity and consumption possibilities and thus as welfare increasing for a society. This idea has been prominently defended by Schumpeter (1942, Chaps.7&8) and triggered a huge body of research on the conditions enabling innovativeness.<sup>1</sup> In its core, all innovative activity, understood as the trying out of a new opportunity or action (Witt, 1996, p.115), involves the generation and use of knowledge. For this reason, knowledge is often assumed to be the most valuable resource of a firm. Additionally, the creation of new knowledge is conceptualized as the recombination and exchange of existing knowledge (Teigland and Wasko, 2003, p.262).

With the division of labor in the field of innovative activities, the transfer of knowledge plays an important role (Backhaus and Seidel, 1998, p.254). The present paper wants to address the spatial dimension of knowledge transfers with special focus on the regional level. In innovation economics, this spatial dimension of knowledge transfers is explained with the occurrence of tacit knowledge that can only be transferred in personal face-to-face communication. However, this explanation has some shortcomings and is not entirely convincing.

Beside discussing these shortcomings, the present paper offers an alternative explanation based on a model of boundedly rational actors who search for and exchange knowledge. We choose an *individualistic perspective* to provide a sound behavioral micro-foundation for our approach. This foundation is grounded in the individuals' behavior, where agents do not perform exhaustive searches over a completely known (knowledge) search space. To the contrary, individuals heavily rely on heuristics that give *approximate* solutions to their problem at hand.

Translating such behavior into a spatial dimension, we argue that the individual behavior leads to a bias favoring a *regional* dimension of knowledge search and transfer processes. The virtue of this lies in providing a consistent micro-founded framework. There are two ways in which this translates to the aggregate level. First, the inherent spatiality of human action directly influences these heuristics. This 'search bias' is influenced by motivational factors as well. Second, an individual's social embeddedness is predominantly regionally oriented and thus indirectly biases knowledge transfer processes. Social embeddedness moreover influences the working of the heuristics, too. This also provides a justification why processes on the aggregate (social) level lead to the individuals' 'social bias'. This bias is also strengthened through a 'regional identity'. Thus, the framework proposed here allows us to coherently link important findings from the individual perspective with the social perspective regarding the spatiality of knowledge transfers, or in short, why spatial, especially regional, proximity matters.

The paper is organized as follows. After this brief introduction, the next section offers

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<sup>1</sup>This is not to say the innovations have only positive effects. We do not want to dwell on this issue here, however (cf. Witt, 1996, for an extensive treatment).

some remarks as to why tacit knowledge cannot adequately explain the regional boundedness of knowledge transfers. In section 3, we present a model of boundedly rational agents in the context of knowledge transfers. We then proceed to explain factors resulting from imperfect information and the model of bounded rationality of agents and their employment of heuristics in knowledge search and transfer. This is done from an individualistic perspective first, where heuristics and motivational factors are explained in the context of knowledge transfers. Then, an aggregate perspective is taken (section 4) and the effects of social embeddedness and networks are elucidated. Section 5 summarizes and discusses the findings. The factors mentioned explain why knowledge is spatially bounded. More precisely, our findings support strong regional influences on knowledge transfers. This support is used to tentatively define the concept of a region. Section 6 concludes.

## 2 Tacit Knowledge and Spatial Boundaries

### 2.1 Tacit Knowledge and Innovation Economies

In innovation economics, the spatial dimension has gained wide attention recently. While there are a number of very reasonable explanations for this (as e.g. Marshallian and Jacobian externalities), more and more economists build their line of argumentation on a specific pattern of interpersonal knowledge exchange, with tacit knowledge being at center stage.

Borrowing the concept from psychology, ‘tacit knowledge’ began its incredibly successful conquest through the models of innovation economists and even more through the studies of innovation geographers. Tacit knowledge has been introduced by Polanyi (1958) and was brought into the economic discussion by Teece (1981) and Nelson and Winter (1982). Since then, it became one of the most commonly accepted explanations why geographic distance matters for economic and especially innovative processes (see e.g. Cooke et al., 1997; Asheim, 1999; Encaoua et al., 2000; Edquist et al., 2001).

The argumentation for spatially bounded knowledge circles around the claim that tacit knowledge can only be transferred interpersonally by direct ‘face-to-face’ communication. Because face-to-face communication is a lot easier with a small geographic distance between the involved parties, tacit knowledge is more likely to be exchanged between persons that work or live within a limited geographic area (e.g. a region). Due to tacit knowledge’s complementarity to explicit knowledge (Cowan et al., 2000), there are not only ‘tacit’ knowledge flows affected, but also the transfer and diffusion of explicit knowledge. Since knowledge transfers are a basic requirement for innovation and economic processes, the latter are as much geographically bounded as the former. Thus, tacit knowledge locks economic and innovative activities into a tight geographic prison.

On a first glimpse, this argumentation is charming and explaining major findings in eco-

conomic geography: It is shown that there are geographical restrictions to cooperations (see e.g. e.g. Mansfield and Lee, 1996) and that knowledge diffuses not instantly across space (Jaffe and Trajtenberg, 1996; Peri, 2002). It is commonly argued that these observations can be explained by the tacit dimension of knowledge. However, as we show in the next subsection the definition of tacit knowledge and its application is connected to problems that blur the clarity of the above argumentation.

## 2.2 Some Remarks Concerning Tacit Knowledge

Polanyi has introduced tacit knowledge with a simple observation: “[W]e know more than we can tell” (Polanyi, 1966, p.4). With this notion he refers to those elements of knowledge that are ill-defined, un-articulable and of which persons are not even fully aware. This simply means that tacit knowledge defies expression and articulation. Therefore it cannot be codified as well. This seemingly simple definition is unfortunately not as explicit as to allow only one interpretation about what tacit knowledge is and how it is acquired.

In the context of knowledge transfers, two different interpretations of the concept of tacit knowledge are prominent. On the one hand, a *strict interpretation* only refers to tacit knowledge as those elements of knowledge that cannot be articulated and codified. On the other hand, there is a *loose interpretation* that allows for the articulation and codification of tacit knowledge. All knowledge that is not codified but which can in principle be articulated and codified is subsumed under the latter definition.

The strict interpretation allows to make two further distinctions relating to the possibility of ‘expressing’ tacit knowledge. On the one hand, it could be claimed that tacit knowledge cannot be meaningfully expressed in actions. On the other hand, it could be argued that tacit knowledge can be transferred via observational learning (i.e. via non-verbal expression). It is not clear which of both positions Polanyi held himself. We do not want to take up this discussion because both views cannot explain why tacit knowledge would be important for geographic proximity in knowledge transfers. Why is that? The interpretation that tacit knowledge cannot be expressed in any action simply means that tacit knowledge cannot be shared interpersonally (Witt et al., 2005). This seems to correspond best to Polanyi’s argument that one only fully understands a mathematical theory through its application (see Polanyi, 1966, p.25). Thus, each individual has to acquire tacit knowledge through his own activities. It cannot be transferred from another individual. If this interpretation is followed, tacit knowledge does not have any relevance for the geographic dimension of knowledge transfers. Nevertheless, due to its complementarity to explicit knowledge (Polanyi, 1966; Cowan and Foray, 1997) it is in all likelihood part of one’s absorptive capacity.<sup>1</sup> Only in this respect does it play a crucial role for knowledge transfers.

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<sup>1</sup>The notion of “absorptive capacity” was introduced by Cohen and Levinthal (1989, 1990). In the context of knowledge search processes, which are at the center of the present paper, the notion of absorptive capacity is not relevant.

Even if the second distinction (i.e. interpreting tacit knowledge as being transferable through observational learning) is chosen as definition of tacit knowledge, the spatial restriction of tacit knowledge transfers is not given *per se*. Here tacit knowledge is transferred via observational learning, that is, one actor observing the activities of another and ‘absorbing’ the tacit knowledge. This process is however not restricted to geographic proximity, because ‘face-to-face’ contact as observational activity is not geographically bounded. New information technologies, e.g. video conferences, cast doubt on the advantages of face-to-face contacts. We will take up this issue in more detail later, when discussing the loose interpretation of tacit knowledge.

Let us now discuss the loose interpretation of tacit knowledge. One has to be aware that it also does not allow the simple mechanism between tacit knowledge, face-to-face contacts and geographic proximity to work. This is due to the fact the ‘tacit’ knowledge can become codified. Therefore the ‘tacit’ knowledge transfer is no longer restricted to face-to-face contacts. By implication, the discussion why geographic proximity is advantageous for the exchange of ‘tacit’ knowledge changes to a discussion about the comparative advantages of face-to-face contacts in interpersonal knowledge transfers.

Saved codification costs are the main advantages of direct interpersonal (face-to-face) communication. Other advantages such as the possibility to communicate non-verbally (viz. by facial expression and gestures) or the possibility of direct feedback seem to have lost importance due to new sophisticated communication technologies. In particular, video conferences weaken the importance of geographic proximity for these features of face-to-face contacts. Thus, the loose interpretation of tacit knowledge needs to be flanked by a discussion about the role of face-to-face contacts in order to serve as an explanation for the importance of geographic proximity. For example Storper and Scott (1995) find that face-to-face contacts are more advantageous than indirect communication if the content’s complexity and uncertainty is high.

In this case, face-to-face contacts would only be restricted by spatial distance if the costs to overcome this distance are significant in relation to the gain from the contact. There has not been any empirical evidence that travel costs for knowledge exchanges are restricting face-to-face contacts. In fact, one survey found that *only* 4.4 percent of the West German manufacturing firms stated that the spatial distance between firm and external technology resource was too large for cooperation, compared to e.g. 46.1 percent that found transaction costs too high (Reinhard and Schmalholz, 1996, p.34).

It should have become clear that this argument is different from arguing that face-to-face contacts are *per definitionem* superior to other forms of knowledge exchange because they allow to exchange ‘tacit knowledge’.

Summarizing, we find that there is certainly a tacit dimension to knowledge and that it has economic relevance. Yet, the simple reference to tacit knowledge as an explanation for why geographic proximity is crucial for knowledge transfers has been shown to be problematic. These problems cannot be solved easily (if at all). Therefore, after this critical part, the remainder of

the paper presents behavioral and economic mechanisms that explain the spatial dimension of knowledge transfers.

## 3 The Spatial Dimension of Knowledge: A Behavioral Model

### 3.1 The Basic Search Process

In order to fulfill his research job, a potential inventor needs to ‘collect’ (search) knowledge from various sources before he can create something ‘new’ (see Feldman, 1994; Christensen et al., 2001). Thus, he needs to access not only internal knowledge but also external knowledge held by other members of the same knowledge base (Beise and Stahl, 1999; Zellner and Fornahl, 2002). External knowledge refers to knowledge that the agent does not possess, which is not within trivial reach (Arndt, 2000) and for which he does possess the corresponding absorptive capacity. *Intended* knowledge transfers are when actors actively seek knowledge (‘search’). Unintended knowledge transfers might be considered as an individual ‘stumbling upon’ knowledge, e.g. while visiting a trade fair, or listening to a presentation. In the present context, we concentrate on *intended* knowledge transfers because it is argued in the literature that they are more relevant for economic activities (Blume and Fromm, 2000; Breschi and Lissoni, 2001) than *unintended* knowledge transfers. Nevertheless, it seems plausible that the latter should be biased in a similar way as the former: Possibly, this is even more so because when consciously searching for knowledge, an agent might at least try to act according to economic rationality, while this is definitely not the case, when the transfer is unintentionally initiated.

When looking at intended knowledge transfer processes, knowledge about where to find the relevant knowledge is the necessary requirement. The direction and effort of search is highly affected by an actor’s knowledge about where he can find needed knowledge. Not all knowledge (especially uncodified knowledge) is easily accessible. Since large shares of knowledge are ‘stored’ within and managed by people, knowledge of where to find a piece of knowledge is often identical to knowing who is the relevant person to address (Lundvall, 1992). “Know-who involves information about who knows what and who knows what to do” (Johnson et al., 2002, p.251).

Although, in principle, such knowledge could be made explicit (i.e. it is not tacit) and be organized in databases, it tends to resist codification efforts (Lissoni, 2001). This is largely due to the fact that it is not always conscious in an actor’s mind and needs to be activated by triggering events. Thus, it is highly *context-* (Johnson et al., 2002) and, one may add, *situation-* dependent. This results from the fact that it is difficult to imagine *ex ante* all situations and whom to ask if relevant knowledge is missing. In their study, Anderson et al. (2001, p.149) confirmed “that recognition and assimilation of new, external information are more chaotic and



informal than one might expect”.

One cautionary remark seems in order before going into a detailed discussion of how a boundedly rational approach to decision making leads to ‘regional bias’: Of course, it could be argued that transaction costs or informational asymmetries lead to a differential favoring regional knowledge transfers. However, to the present authors knowledge, those empirical studies that deal with inhibiting factors of over-regional knowledge transfers (innovative activities) do not list any increased transaction costs (e.g. travel costs) as a limiting factor (Legler et al., 2001). There is only one study explicitly mentioning it but finding that it does not matter (Simmie, 1998, p.1285). In a way, our approach to bounded rationality is essentially about minimizing a boundedly rational agent’s transaction cost, subject however, not to a rigid minimization calculus but subject to ‘quick and dirty’ heuristics and decision procedures (see Williamson, 1986, p.110 for a similar view).

Concerning informational asymmetries, we want to make the case that although these asymmetries do exist, they only have a small explanatory role as opposed to the social and psychological factors. We present this in the subsequent sections. The same line of reasoning holds for the question of why not introducing an optimization calculus concerning knowledge transfers (for such considerations see Stigler, 1961; Kohn and Shavell, 1974; Anderson and Milson, 1989; Sargent, 1993). It seems impossible to calculate in advance benefits and (opportunity) costs associated with knowledge transfers and thus to optimize the transfers. This is due to the uncertainty and imperfect knowledge that is inherent in novelty and thus by implication in innovations, as being something that has not been tried before.<sup>2</sup>

To summarize: We have argued that the search for knowledge can be understood as a highly uncertain and unstructured process so that it is unlikely that potential innovators performing such a search would or even could really act according to an optimization calculus: A main restriction is the limited knowledge about the activities, foci and availability of external potential cooperation and knowledge sharing partners (see e.g. Reinhard and Schmalholz, 1996). It seems more appropriate to explain the search activities for knowledge as a process guided by principles of bounded rationality: Heuristics and biases underlie the agent’s activities and his search behavior might adapt over time, when the agent learns from previous search experience. In the following subsections, we will discuss the employed heuristics, the relevance of learning mechanisms and the underlying motivational factors of search behavior.

### 3.2 A Behavioral Model of Knowledge Transfer

In the following section we argue that social factors play a key role in influencing a region’s knowledge transfers. But these factors can only be coherently explained in a theoretical framework with a solid micro-foundation, i.e. a foundation that lies in individual behavior of the

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<sup>2</sup>We neglect the institutional dimension where norms play an important influencing part on individual behavior, reinforcing ‘regional bias’ even more (see e.g. Elster, 1979, on such mechanisms in general).

interacting agents.<sup>3</sup> As knowledge transfers play an important role in innovative activities, it can be surmised that an evolutionary approach toward explaining knowledge transfers is much better suited than a static one, focusing on processes and on learning (Cooke et al., 1997, p.476).

We want to put forward here a framework of boundedly rational actors who are influenced by heuristics, biases and norms, and who mostly show 'satisficing' behavior, as introduced by Herbert Simon (Simon, 1955, 1956, 1990). The idea behind bounded rationality is that humans are adaptive actors. They have evolved some mechanisms over time that allow for 'fast and frugal' (Gigerenzer et al., 1999) decision making in a variety of changing environments. This comes at the cost of solving problems only *approximately* (which is the "Principle of Bounded Rationality", Simon, 1990, p.6). Note that this does not mean that the approximate solutions have to be bad; they are just not optimal in the sense of a first-best-solution.

Human cognition is critically constrained by physiological and psychological limits (Simon, 1990, p.7). Therefore, cognitive activities such as decision making are not proceeding as assumed by 'economic rationality', i.e. individuals do not perform exhaustive searches over their opportunity space and then choose the best alternative. To economize on cognitive capacity and/or when confronted with imperfect information, individuals rely on heuristics, which are simple "rules of thumb, which fail to accommodate the full logic of a decision" (Conlisk, 1996, p.670). Thus, systematic errors ("biases") are made but solutions provided by heuristics are cheap and often adequate, and crucial to problem solving (e.g. Kahneman et al., 1982; Gigerenzer et al., 1999). Furthermore, this behavior implies learning when an alternative that has been formerly judged as adequately is improved upon by the agent or when environmental conditions change and the agent adapts his behavior.

Human approximate problem solving consists of different mechanisms, one of which is the 'satisficing' heuristic (Simon, 1990, pp.8-11). Let us turn to a short description of *Heuristic Searches*: Limits to our cognitive ability have led to search behavior that is very selective in huge search spaces. One so-called "weak method" of bounded rationality (Simon, 1990, pp.9-10) is 'satisficing'. When facing a task or problem, humans tend to construct an expectation of how a solution might reasonably be achieved. This expectation is, if possible, based on experience of similar past episodes. After having formed this expectation, which is the 'aspiration level', the agent proceeds to go over the search space (using other heuristics or methods) and halts the search as soon as a satisfactory solution is found. That means, the aspiration level forms the boundary which is satisfactory for the agent. In a dynamic setting, previously met aspiration levels can lead to an increase in an agent's future aspiration level for similar tasks, whereas the opposite holds when no satisfactory solution can be found (Simon, 1955, p.111). In the case of knowledge transfers, an agent might have come upon a problem which is similar to a previous problem. He then forms an expectation what the solution might look like based on the solution to the previous problem. Then he goes on to search and stops as soon as a solution is found that

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<sup>3</sup>A similar approach has been put forward by Pred (1967).

satisfies his aspiration level. Note again, that this solution would only be the optimal solution (in the sense of a maximization calculus) by chance. However, it is an approximately good solution for the agent.

When is such behavior advantageous? Obviously, such ‘satisficing’ behavior is helpful when the search space is huge or when the problem the agents faces is unfamiliarly structured or has no structure at all, or if search costs are high. Obviously, these conditions are readily fulfilled in innovative activities. Another case in point would be the incommensurability of alternatives, that is when there are multiple dimensions along which to judge the quality of the solution, or when facing uncertainty, etc. In such cases, a choice is satisfactory when the aspiration level is met for all dimensions of the problem (Simon, 1990, pp.9-10). Basically, the more complex the situation, the more likely that an agent will not show optimal behavior according to the standards of ‘economic rationality’.<sup>4</sup>

We will show later how boundedly rational behavior of agents results in situations where knowledge transfers are bounded by social and regional structures and thus favored over unbounded knowledge transfers, i.e. we give an explanation that enlarges the standard explanation of the tacit dimension of knowledge. Before that, it is in order to specify more precisely what heuristics an agent uses in the search process.

### 3.3 Heuristics Employed in the Search Process

As mentioned before, heuristics are employed to reduce the complexity of the task or to speed up decision making (Tversky and Kahneman, 1974). An important role in the case of knowledge transfers is played by the “availability heuristic” (Tversky and Kahneman, 1973). An actor makes use of this heuristic “whenever he estimates frequency or probability by the ease with which instances or associations could be brought to mind”<sup>5</sup> (Tversky and Kahneman, 1973, p.208). That means that an agent will turn to those points in his search space for a missing piece of knowledge that are in short associative distance, that come to his mind most easily when contemplating the problem. For example, he might remember occurrences of discussing similar problems with a colleague because something has only recently happened, etc. The availability heuristic is a reversal of the obvious fact from learning psychology that associative bonds in our memory are strengthened by repetition, i.e. strength of association is used as a basis for judging frequency (Tversky and Kahneman, 1973). But since availability is not only affected by frequency, biases arise. What are the factors determining availability? Timeliness (any events related to the problem at hand that have occurred only recently than past episodes),

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<sup>4</sup>We do not want to deny that simple decision problems are within the scope of an optimization calculus. With increasing uncertainty or complexity, however, humans can no longer apply such a calculus. It can be conjectured that humans maximize in certain stages of the decision process and do not maximize but satisfy in others (cf. Leibenstein, 1976, p.74)

<sup>5</sup>These heuristics have been empirically tested with judgments under uncertainty where probabilistic estimates had to be given, hence the definition’s reference to ‘estimates of frequency’.

salience (such as unique or special events), vividness (as vivid events are easier to imagine and call to mind) and affective congruence (events that are related in their affective components to the agent and his present emotional state) all influence whether something is recalled easily and thus comes to mind as ‘available’ when searching for knowledge (see Tversky and Kahneman, 1973, pp.227-30). Another important factor is ‘familiarity’ (Tversky and Kahneman, 1974, p.1127), i.e. facts come easily to mind if the actor is familiar with them. Thus, when thinking about the question who would be likely to hold the needed knowledge, it is very probable that some person comes to the actor’s mind that he is already familiar with. Generally, these five factors increase retrievability of information in the agent’s memory and can lead to bias in the knowledge search process.

When an actor is stumbling upon a knowledge gap (i.e. some knowledge is missing), he will first revert to his previously accumulated ‘know-who’ that is related to the content of the needed knowledge and that is brought up by the availability heuristic. In some cases, he has clear associations between a certain subject and persons that might possess the knowledge he is searching for.<sup>6</sup>

A similar rationale can be applied concerning the “representativeness heuristic” (Kahneman and Tversky, 1972, 1973). Here, probabilities are judged according to the representativeness with which one object *A* resembles another object *B*. That means that decisions are based on past experience and the similarity of the present problem (or solution) with problems (or solutions) encountered in the past. Without going into details, it seems clear that although such pattern recognition may be cognitively very frugal, it might easily lead to suboptimal decision making since mere similarity of problems need not imply similarity of solutions.

A third heuristic concerning search processes has been introduced by Gigerenzer et al. (1999, Chs.4&6) under the name ‘Take the Best Heuristic’. When faced with a decision between two (or more) alternatives, the decision maker relies on cues to predict which alternative scores higher concerning some relevant criteria. For example, to determine with this heuristic which city is bigger in size would be based on a cue such as ‘having a major league soccer team’. If one of the cities has one, it is likely to be bigger than the other city having no major league soccer team. The cue ‘having a major league soccer team’ has (empirically) a high validity in discriminating the bigger city. In the case of knowledge transfers, for example reputation can be a valid cue to determine which expert to ask concerning a specific search task and the quality of information received. The heuristic ‘Take the Best’ works on the principle that we have an order of cues concerning specific decision problems and can thus take the cue with the *highest validity* to reach a decision, i.e. we take the best piece of discriminatory knowledge we have, while we ignore all other -possibly relevant- knowledge. While cue orders can be ge-

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<sup>6</sup>Exemplarily, if he wants to reconfigure a machine such that it is able to conduct additional tasks, the first persons to ask are the machine’s producer or the maintenance engineer. Sometimes, the knowledge is even made explicit in the machine’s manual in form of a telephone hotline - or a little piece of paper taped to the machine (For help call ...), which he has seen numerous times when walking by.

netically fixed (mate choice in some animal species is an example, cf. Gigerenzer et al., 1999, p.80), most of them are learned by observation. Having successfully searched for knowledge at a university department previously could have led to establishing a high validity for the cue ‘knowledge comes from a university department’ and will lead to the decision maker using this cue (if it has the highest validity) as a first discriminating cue to solve the knowledge search problem. Thus, if deciding between two alternatives where to search for knowledge, in this case the decision maker would turn to the university department, based on the reasoning that previously, this solution to another search problem worked very well. If all alternatives would have a similar cue validity, another different cue (with the next highest validity) would be used to reach a decision. Gigerenzer et al. (1999, p.87) have shown that this very frugal heuristic (it searches only a very limited part of the possible search space) is surprisingly accurate even compared to multiple regression methods.

### 3.4 Motivational Factors

Beside the above-mentioned heuristics, motivational factors also play an important role in knowledge transfer activities. As has been shown by Ellsberg (1961), humans tend to show an aversion concerning ambiguity.<sup>7</sup> We tend to avoid situations which are ambiguous because of our *need for control* of a situation (cf. White, 1959; DeCharms, 1968).

Whether ambiguity aversion does indeed pertain not only to games of chance (the context in which it has been demonstrated) but also to judgment problems, where epistemic uncertainty is involved, is still matter of debate. Heath and Tversky (1991) argue that in the context of epistemic uncertainty, which is important our context, the idea of ambiguity aversion is misleading and should be replaced by the ‘competence hypothesis’<sup>8</sup>, which the authors empirically demonstrate to hold. The competence hypothesis states that decision makers favor situations in which their decision depends on their knowledge, i.e. they favor situations in which they are knowledgeable about the topic they place their bet on. Thus, they avoid those situations in which they are not knowledgeable. Stated casually, people tend to do what they know better.

Heath and Tversky (1991, p.7) make the case that there is a cognitive and a motivational explanation for this kind of behavior: Cognitively speaking, an actor might have learned over the course of his life that he performs comparatively better in situations that are known to him. The possibly more important (Heath and Tversky, 1991, p.22) explanation is motivational, however: With the outcome of the bet, there comes a ‘psychic pay off’ (satisfaction or embarrassment), depending on whether the agent is successful or not. However, following attribution theory (e.g. Hogg and Vaughan, 2002, Chap.3), an agent only receives credit for a right decision when

<sup>7</sup>We use this term deliberately broad in the sense of *vagueness* or *uncertainty*. It is used in the literature very ambiguously (see Bleaney and Humphrey, 2006, pp.257-8). For a survey of the literature on ambiguity aversion cf. Camerer and Weber (1992).

<sup>8</sup>This hypothesis would subsume the phenomena that have classically been called ambiguity aversion.

it is based on own skill. In a situation that is unknown to him, success would be a matter of chance and thus the agent could not get credit for knowledgeability. More precisely stated: Is the decision maker in a situation he does not understand, failure will be attributed to ignorance, whereas success would be attributed to chance. In a situation where he is knowledgeable, success would be attributed to his knowledge, whereas a failure could sometimes be attributed to chance (Heath and Tversky, 1991, p.8). From this point of view, seeking situations the decision maker understands is the preferred option.

Having explained the components of the boundedly rational agent model (heuristics and motivational factors), in the next subsection, we elaborate on how these mechanisms translate into a regional dimension of the knowledge search process.

### 3.5 Search Bias

We have shown that reference to the ‘tacit dimension’ of knowledge does not provide a sound explanation as to why innovation processes are affected by geographic distance. Nevertheless, we argue in the following that there is a spatial dimension of knowledge transfers (and innovation processes) that originates from the behavioral model introduced above. But before discussing the model’s components and their relationship to a spatial dimension of knowledge transfers, it is necessary to discuss the notion of ‘spatiality’ in more detail.

Human beings organize space hierarchically, both in cognition as well as in administration (Mark et al., 1999). For example, the most commonly used level is the national level (Freeman, 1987; Lundvall, 1992). Regional as well as a local levels are also meaningful geographic categories.

The ‘spatiality’ of knowledge transfers and the cognitive and administrative categorization of geographic space give rise to the question of which level captures this ‘spatiality’ best. In this paper we want to put forward arguments as to why the regional level captures large and significant parts of the spatial dimension of innovation processes. Therefore, not only do we present arguments for the spatial dimension of knowledge transfers, but also discuss in how far this dimension corresponds to the regional level.

In economics of innovation, the regional level was brought into consideration by Cooke (1992, 1996). But up to date regional economics lacks a commonly accepted definition of what a region is (Markusen, 1999; Doloreux and Parto, 2004). While the problem often is only discussed superficially in theoretical works, the availability of data often determines the chosen regional unit in empirical research. This unsatisfactory indefiniteness results from the context dependence of the regional approach. Jekel and Fromhold-Eisebith (2003), based on Massey (1999), even argue in favor of a *project* based regional perspective. Hereby, a region is a project of the socio-economic practice. It can be defined in space and time by the inherent spatiality of actions, by symbolic representation and collective assignment of meaning, as well as by the stability of institutional actions, to alternative projects.



In most situations, such project based understanding of regions conflicts with the classical cartographical picture of regions (Jekel and Fromhold-Eisebith, 2003). Due to the organization of data, it also withstands the common practice in empirical works. But even there, one has to check whether the investigated topic is best represented by the chosen regional unit.

To access the spatial range of innovation activities and gain insights into their regional dimension, we choose the *individualistic perspective* presented in the previous subsections to provide a sound behavioral micro-foundation. This foundation is grounded in the behavior of boundedly rational agents that do not perform exhaustive searches over a completely known (knowledge) search space. To the contrary, individuals heavily rely on heuristics that give *approximate* solutions to their problem at hand (Gigerenzer et al., 1999). Translating such behavior into a spatial dimension, we argue that the individual behavior leads to a bias favoring a *regional* dimension of knowledge search and transfer processes. This ‘regional bias’ in knowledge search processes is caused by two different mechanisms.

The first mechanism might be considered the ‘direct effects’ of the inherent spatiality of human action on a boundedly rational agent’s knowledge search processes. Heuristics as well as the motivational factors are directly biased by the inherent spatiality of an individual’s activities towards regional knowledge search (‘search bias’).

The second mechanism works rather ‘indirectly’ through the individual’s social embeddedness. The employed heuristics and motivational factors may not only cause an actor to seek for knowledge regionally, but also adjust his search focus towards his social networks. These social networks may be predominantly regionally oriented, which is sometimes also strengthened through a ‘regional identity’ (see next sections). This ‘social bias’ of social networks is not only caused by the inherent spatiality of human action, but also by the heuristics and motivational factors. These work similar for knowledge search as for adding new contacts to the individual’s social network.

For example, the availability heuristic brings to mind the factors which are familiar to the searching agent. A person who is known from mostly spatially bounded social contexts will come to mind more easily as the searched-for-expert than someone who is not known from such contexts. The reason is that the former can be imagined more vividly or might have been encountered in situations of affective congruence etc. Similarly, the familiarity (e.g. asking a friend, see Gross and McMullen, 1982) creates fewer psychological costs than asking a stranger.

A similar rationale applies to the representativeness heuristic: Here again, it is perceived representativeness but not objective congruence that leads to a decision. When applying the ‘Take the Best Heuristic’, the learned cue order might be also biased regionally, so that cue values are only known for knowledge sources in the social community. Then, those sources with known cue values are always preferred to these sources where no cue values are known, even if -objectively speaking- these external sources might provide a much better solution to the

search task. Here it becomes obvious that boundedly rational behavior can lead to results that are inferior compared to the economic calculus. However, it is necessary to be aware of the fact that there is a trade-off between frugality and accuracy in such knowledge search problems.

Social embeddedness moreover influences the working of the heuristics and the motivational factors as well. Thus, the ‘social bias’ in the social networks is in part caused by a regional focus of an individual’s search heuristics and motivation (‘search bias’). This strengthens the regional focus even more (see figure 1).

Obviously the processes on the individual as well as the aggregate (social) level are strongly interwoven. The conceptual distinction in ‘direct’ versus ‘indirect’ effect helps to analytically separate those processes which are working parallel in reality. Since the mechanisms at work are very similar, we here dwell only briefly on the heuristics and motivational factors’ effect on social networks, and rather concentrate on the ‘direct effect’.<sup>9</sup> The difference lies mostly in the content of the search process (New contacts for social members and new knowledge in the knowledge search process).

Agents are exposed to regional events more often due to the pure inherent spatiality of human life as well as their social interactions. For example having possibly studied in the region, knowing many local inhabitants from similar occupational backgrounds, reading local newspapers, in short, all those factors being also discussed under headings of regional embeddedness (see e.g. Fornahl, 2005), result in high timeliness, vividness and familiarity of those events. It thus can be conjectured that the availability heuristic will lead to comparatively higher search activities that are bounded spatially and especially regionally. Indeed, we can conclude that the availability heuristic can lead to this bias because of the ‘effectiveness of the search set’ (Tversky and Kahneman, 1974, p.1127) that an agent has created about his own well-known region, from which information can easily be retrieved.

The representativeness heuristic might play a part in increasing the ‘search bias’ because it allows for a self-augmenting process: If past knowledge transfers have mainly been regionally

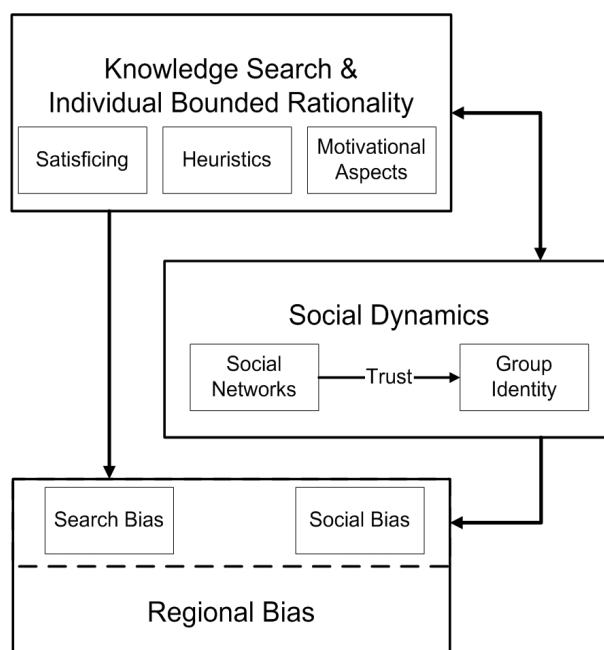


Figure 1: Influences on Knowledge Transfers

<sup>9</sup>Note however that the formation of social networks is directed to a larger extent by chance and occasions than knowledge search processes.



bounded then solutions to new problems might, even if falsely, be evaluated as being representative of previous regional knowledge transfers.

Similarly, the motivational factors provide an additional reason (beyond cognitive factors) for the regional boundedness of knowledge transfers. It seems obvious that agents are more knowledgeable in their own region. Of course, familiarity sets in weakly, when an agent moves to a new region. But continual exposure to local news, gossip and the increasing embeddedness are likely to create a regional bias for the new region over time. Thus, agents feel more in control when initiating a knowledge transfer in their familiar region. Staying in one's own region gives an actor a sense of control of his knowledge search task. While the task may be still unstructured, the search space is then sufficiently reduced and transformed into one which the actor is familiar with.

An important point about the paradigm of bounded rationality and adaptive behavior is that agents refine their behavior over time via learning processes.<sup>10</sup> We want to shortly discuss in this section how the previously mentioned heuristics are part of a dynamic learning process that is likely to lead to a path-dependency favoring regional knowledge transfer processes. As such, the mechanisms described so far are all part of a self-augmenting process in which regional actors increase their reliance on local knowledge sources over time.

Consider as an example the availability heuristic. Familiarity increases the availability of a certain information in memory. It is thus used more frequently and familiarity even increases. Furthermore, any transfer activities that might be successfully carried out will more easily be attributed to the agent's skill and are thus more rewarding. This feature tends to be reinforced over time as a self-reinforcing process as the boundedness to a region increases with successful knowledge search activities. The agent then gains more and more expertise of his region and thus the heuristics mentioned above will work and bring regional facts to mind more easily. The agent's effective search set will tend to be focused on his region.

Note that this dynamic is inherent in the nature of learning processes, where an increase in associative strength depends on the repeated pairing of stimuli: In learning psychology, this fact has been formalized in the Rescorla-Wagner Theory (Rescorla and Wagner, 1972). And as has been stated above, the stronger the associative strength, the more easily the learned fact is retrieved via the heuristics. That means, the more often an agent is positively reinforced by finding some satisfying information in his region, the more often in the future, he will resort to this strategy. In the following section, we will discuss how this can lead to a commonly shared *Weltanschauung* and even to "cognitive lock-in" (Grabher, 1993) on an aggregate level.

Summing up, the points mentioned in this section are the elements on an individual level that lead to what we want to name 'search bias'. That is to say that individual knowledge search is regionally bounded due to the 'direct effect' of the inherent spatiality of human action

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<sup>10</sup>What we have in mind here is providing the individualistic behavioral foundations for what Cooke et al. (1997, p.484) have called 'regional learning system'.

on an individual's search heuristics and motivational factors. It is very similar to the 'home bias' known from financial economics (cf. von Nitzsch and Stotz, 2005; Goldberg and von Nitzsch, 2001), where (due to similar reasons) investors prefer equity from their home countries or regions over foreign equity.<sup>11</sup>

As has been pointed out before, this 'direct effect' is similarly working on the individual's social embeddedness. It directs the search towards an individual's social network and also in parts causes the social networks to be regionally biased. This is has been considered as the 'indirect effect' which is presented in the following sections in more detail.

## 4 The Aggregate Perspective: Social Embeddedness

After having discussed the individual level in detail, we now proceed to a discussion of the aggregate (social) perspective. Our micro-foundation plays an explanatory role on a higher level, as it gives rise to the processes described in this section. While we have focused so far on cognitive processes in an individual, we now shift perspective to the collective processes that are triggered by individual behavior. The social embeddedness of an individual, we will argue, is also geographically bounded on a regional level and thus induces 'social bias'.

In addition, labor mobility adds to the 'regional bias' at the aggregate perspective.<sup>12</sup> The presented behavioral model certainly plays a role in spatially limiting labor mobility. However, these influences should be considered with caution due to many other factors that affect labor mobility. These make it difficult to estimate the role played by the heuristics and biases. Therefore, we will not dwell on the aspect of labor mobility in the present paper except for acknowledging for the fact that labor mobility is spatially bounded (Haas, 2000).

### 4.1 Networks, Ties and Social Embeddedness

One of the factors that can influence the outcome and processing of knowledge search and transfer processes is the embeddedness of individuals into a social context. Potential innovators, like most other persons, have a social as well as a work life. In both cases they interact with other persons. Thus, their interactions and knowledge exchanges are embedded into social networks that influence their behavior (Granovetter, 1985).

These social networks can be differentiated depending on the kinds of agents in the network. There are networks that are built for example around the family, friends and the workplace (see e.g. Birley, 1985). The intensity and frequency of interaction with the different contacts within the various networks naturally differs. Granovetter (1973) divides them into two groups:

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<sup>11</sup>As von Nitzsch and Stotz (2005) argue, rational actor models can only account for a small part of this bias so that psychological factors are likely to cause this bias.

<sup>12</sup>Restrictions in labor mobility are one natural aspect of the spatiality that is inherent in human action.

Contacts that are characterized by high frequency and intensity of interaction ('strong ties') and contacts which are less frequently and intensively activated ('weak ties'). In contrast to the many fairly loose connections to persons known to someone (weak ties), strong ties are those with family members, colleagues and friends. Nevertheless, both types are both relatively long lasting and voluntary (Granovetter, 1985).

Most of such social or informal networks are, in contrast to formal ones, not established by economic reasoning. Random occasions, shared career episodes or membership in the same clubs provide situations of inter-personal contact, which can result in the origin of a social network. The obtained information about each others' competencies and knowledge allows the actors to directly contact the person who holds the knowledge searched for (Zellner and Fornahl, 2002).

Such occasions often result from unintended inter-personal interaction, from a coincidental contact or from an intended interaction (Fornahl, 2005). Normally they are followed by other face-to-face encounters that can become regular and repeated events. The direct face-to-face interaction is the key not only for the establishment of networks but also for the maintenance of social networks (Zellner and Fornahl, 2002; Fornahl, 2005).

## 4.2 Regional Identity

Social networks are to some extent chosen as channels for knowledge search and transfer rather *unconsciously* via the heuristics discussed before. But the *conscious* search and transfer of knowledge is also restricted to social networks. This is caused by a shared and considerably strong group identification that motivates people to seek solutions or knowledge first within their community.

This identification is based on psychological community building processes. In social psychology, McMillan and Chavis (1986) base their definition of a psychological sense of community on four elements: 'membership', 'influence', 'integration and fulfillment of needs', and 'shared emotional connection'. Membership refers to the identification with a group or community. The feeling of being part of the community is crucial in this context. Influence describes the mutual influential relationship between the individual and the group. The integration and fulfillment of needs dimension accounts for the (positive) gain that the individual has from being part of the community. This is required for a positive feeling of togetherness existing in the community. Shared emotional connection allows for the emergence of a community spirit. It is argued that the more people interact in the community, the more intense ties between the members can develop. Furthermore, McMillan and Chavis (1986) suggest that shared needs, goals and beliefs serve as integrative force in the community building and maintenance process.

Obst et al. (2002) add as fifth dimension 'Conscious Identification'. In contrast to the membership notion by McMillan and Chavis (1986) which refers to a more latent 'feeling of belonging', conscious identification marks the state that an individual is strongly aware of his group

membership. Additionally, this membership is of strong value and emotional significance, resulting in a strong in-group identification (Hogg, 1992).

The identity of a community is its self-perception and the perception of the community by others (e.g. external audiences, see Romanelli and Khessina, 2005). An actor can share many different identities which result from different contexts and from a different weighing of the constituent parts that define a community.

Individuals who share such a group identity are *aware* of their membership. This causes a tendency to search *consciously* for the needed knowledge first among the members of the group.<sup>13</sup> This is due to the following reasons:

Firstly, when realizing an in-group solution, the actor profits from the better information about the other actors. Sharing the same identity acts as a cue to signal to the agent a common interest, background and shared competencies. This encompasses all aspects that define a member of the same community. Concerning the validity of this cue, one has to be aware that it is not necessarily the case, that everyone else really shares the stipulated competencies. Therefore, the search might not yield the desired result. However, usually the validity of the cue has to be reasonably accurate because otherwise there would not be a shared identity. This line of argument extends not only to the ‘Take the Best Heuristic’ mentioned before, where previous experience with the social community is likely to establish valid cues, e.g. reputation, to discriminate in favor of persons who are well-known to the searching agent and who are part of the social community.

Secondly, the agent can openly search for a solution without being concerned that the other will exploit him. A lesser likelihood of exploitation is related to the higher likelihood of reciprocation in knowledge exchange. In general, economic agents expect high levels of reciprocity for knowledge transfers (von Hippel, 1987; Teigland and Wasko, 2003). That means that knowledge is only exchanged if it is credibly signaled that (future) reciprocation will be obtained. This increases the cost of knowledge transfers making them more unlikely.

However, if two actors share the same group identity the searching actor can expect a comparatively higher likelihood of reciprocation. This is due to the higher levels of trust (Teigland and Wasko, 2003) among the members. Such an identity provides a credible signal (trustworthiness). This is not to say that knowledge exchange might also be associated with lower costs for the members of such a community as it could be argued that the expected level of reciprocation for a knowledge exchange is higher. Note again the important role of localized social interactions (e.g. gossip) for *governing* reciprocal interactions (Nooteboom, 2002).

The reciprocity argument is closely related to the shared interest of the knowledge searcher and the potential knowledge source in using this occasion to intensify their interactions. This will add to the further development of the group identity from which both gain in the future. The acquisition of knowledge also fosters the acquisition of identity (Szulanski, 2000). “Thus

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<sup>13</sup>Of course, this works also unconsciously.

identity, knowing, and social membership entail one another” (Lave and Wenger, 1991, p.53).

These two arguments can lead to a dynamic process that triggers and strengthens the development of a group identity. The intensity and frequency of the interaction processes determines the strength of the shared identity. These processes start if a specific issue or reason (serving as integrative force) gains enough importance for individuals from within a social community. Actors start to share experiences and attitudes. This increases the likelihood that they like each other “because they will understand each other better, and because liking someone who is similar is self-reinforcing as it ratifies one’s own qualities” (Pfeffer, 1985, p.69). The more knowledge about each other is exchanged, the more mutual openness and acceptance of control by others can develop. This is crucial for the build-up of trust (Nooteboom, 2002, 2004). Naturally, the growing trust adds to the self-reinforcement effect mentioned above. We will now discuss how social networks and group identities are biasing knowledge search processes towards a regional dimension.

### 4.3 Social Bias

Similar to the individual level and the ‘direct effect’ we are now going to discuss the ‘indirect effect’ by which the social networks and group identity add to the regional dimension of knowledge transfer processes.

Social networks are not directly linked to geographic proximity. But as we have argued in section 3.5 there are two effects that together constitute the ‘indirect effect’. Firstly, heuristics cause an actor to search for knowledge preferredly within his social network. Secondly, social networks are to some extent biased towards the region an actor lives and works in. Both mechanisms are briefly presented in this section.

As for the first effect: Due to heuristics (most importantly the familiarity and availability heuristics, see section 3.5) and motivational factors, actors tend to search for knowledge first within their social networks. This does not depend on the type of network contact (strong or weak tie). Strong ties are more likely to go along with a stronger emotional relationship, especially with mutual trust, that fosters the exchange of knowledge: As Schrader (1991) shows for friendship, strong ties are rather positively correlated with the likelihood of being asked for knowledge in the first place. While personal affinity does not affect the content of the knowledge exchange, it can rather lower the costs connected to informal information trading: In the case of intended knowledge transfers, Gross and McMullen (1982) argue that asking a friend for help creates fewer psychological costs than asking a stranger (this is an effect that familiarity breeds, see section 3.3). The duration of the relationship or friendship between two actors “may be significant for defining the network of personal contacts within which information is exchanged” (Schrader, 1991, p.168).

On the one hand, such strong ties reduce the transaction costs of knowledge transfers, but on the other hand, the likelihood that this type of connection serves as knowledge transfer

channel decreases with an increasing bond. This is classified as the ‘weakness of the strong ties’ (Grabher, 1993). The more knowledge is exchanged between the members of the network, the stronger their ties and the lower the transaction costs of the knowledge transfer. But the actors also become more and more homogeneous. “This can be an obstacle to creative development and, hence, the emergence of new mental models, the use or creation of new knowledge or a change in behavior is hampered” (Fornahl, 2005, p.172). The homogenization can cause cognitive ‘lock-ins’, a reduced flexibility and a bias toward the behavior present in the network (Grabher, 1993).

The opposite is true for weak ties. Their ‘strength’ results from connecting different networks and allowing diverse knowledge to be exchanged (Schrader, 1991; Reagans and Zuckerman, 2001). But this comes at higher transaction costs and emotional indisposition. Nevertheless, both types of contacts make up social networks and play an important role in knowledge transfer processes: “weak ties ... are here seen as indispensable to individuals’ opportunities and to their integration into communities; strong ties, breeding local cohesion lead to overall fragmentation” (Granovetter, 1973, p.1378).

The second effect is again caused in parts by the inherent spatiality of human action as well as by the heuristics and motivational factors. The heuristics and motivational factors clearly play a role in biasing social networks regionally. As we have argued in section 3.5, this is similar to the role they play in the knowledge search process as a whole. Group identification processes add to it as well. Therefore we are not going to discuss this in more detail here. Beside the effects of heuristics, motivational factors and group identification on social networks, two further influences increase that ‘social bias’ even more.

Firstly, in general, people interact socially stronger with persons spatially close to them. This is just a fact resulting from the inherent spatiality of action of human beings and the behavioral model described in the previous sections. As argued above, such social interactions represent potential ‘network establishment’ situations. So, just by the stronger social interaction on a local level the likelihood of social network establishment is increased. It has to be pointed out that this is especially true for the local or city-level.

Secondly, traveling costs time and brings stress or even disutility when a certain individual limit is exceeded. This holds especially for people who travel often, such as commuters (Evans and Werner, 2006). When the travel distance requires the use of an airplane ‘travel fatigue’ becomes an important stress factor reducing the individual’s performance (Waterhouse et al., 2004). Although traveling might be considered joyful to many individuals, if a certain individualistic frequency, duration and travel distance is exceeded it can become stressful and not desirable for the individuals. Together with certainly involved travel costs this limits the mobility of the actors significantly.

“Therefore, social networks will primarily connect individuals that live in close proximity to each other” (Sorenson, 2005, p.81). This is also confirmed by works of Strambach (1995)



and Singh (2005). This does not mean that social networks do not span across regions. We rather argue that social networks will likely consist of proportionately more contacts to persons that live in the same region.<sup>14</sup>

Social networks are to some extent chosen as channels for knowledge search and transfer rather *unconsciously* via the heuristics discussed before. But the *conscious* search and transfer of knowledge is also restricted to social networks. This is caused by a shared and considerably strong group identification that motivates people to seek solutions or knowledge first within their community. If this group identification builds around the individual's characteristics of geographic location, the knowledge search can be spatially bounded to a region.

The psychological sense of community (group identity) seems to be transferable to a geographical (regional) context. Important elements of the approach are also found in the 'regional identity' literature. While there is no unanimous definition of a 'regional identity', the constituents of such an identity are 'symbolic representation', 'collective assignment of meaning' and the 'stability of institutional actions' as well as the 'differentiation to alternative projects' (Jekel and Fromhold-Eisebith, 2003).

Therefore, we want to put forward the argument that both the concept of a group identity and a regional identity are overlapping and their respective constituents are very similar: The membership and shared emotional connection find their expression in the symbolic representation. The need for interactions and the finding of a common language is guaranteed by the stability of institutional actions allowing a collective assignment of meaning. In these collective learning and exchange processes the mutual influence between the individual members and the group is constituted. Thus, social interaction processes are the reason for its existence. The regional identity is a special case of such a community because all members are located within a geographically defined area, viz. a region. A regional identity is a phenomenon that is not too frequent and temporally limited. Empirically, such a collective identity has been observed for example as part of the 'Emilian model' in Italy (Cooke et al., 1997).

It can be concluded that regional identities (if existing with a significant strength in a region) bias the regional knowledge search agent to first look for a regional source and solution. This happens consciously as well as unconsciously depending on how aware an actor is about this identity and whether he wants to add to it or not. The regional bias plays an important role for innovativeness. However, this is not to say that regional bias cannot have negative effects as well: If regional interactions are too close, this can lead to lock-ins and reduce "cognitive distance" (Nooteboom, 1992, i.e. the actors' mind sets are so similar that no new impulses further innovativeness) too much so that innovative potentials are actually reduced.

The strong ingroup identification can lead to biased evaluations (Obst et al., 2002, p.122): The actor might tend to overestimate the quality and goodness of regional actors and their

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<sup>14</sup>Beside these aspects, regional proximity, of course, also matters for governance, e.g. where local gossip can act as a reputation mechanism (Nooteboom, 2002).

knowledge. This overestimation can drive him to accept higher costs or the agent does not even search for alternative sources in the first place. This augments the bias caused by the heuristics mentioned above: If the availability heuristic brings to mind local actors as experts for a knowledge search problem, the searching agent is unlikely to consider an extension of his search space beyond the regional context. Of course, the regional expert might offer a solution but there is no guarantee that it is the best solution. The problem lies in the fact that the searching agent might not even be aware of his limited search effort because due to the heuristic, it seems obvious to the agent that a satisfactory solution has been found.

Summing up, we find that the ‘indirect effect’ adds to the bias of knowledge search induced by the ‘direct effect’. Not only do the individual heuristics and motivational factors push an actor to search for knowledge regionally, social network and identity processes also foster this bias. Both processes are strongly interwoven so that the differentiation in a ‘direct’ and an ‘indirect effect’ should only be understood as a conceptual aid.

## 5 Summary and Discussion: Defining the Size of a Region

Much work has been done on regional economics and especially regional innovation economics. Yet, these works rely heavily on the assumption that there is a regional dimension to socio-economic processes. Even more, it is assumed that ordinary cartographic definitions of regions represent an adequate unit of investigation. By arguing for the importance of formal institutions, Cooke et al. (1997) provide a justification for such an approach. However, in innovation research formal institutions play a comparatively weak role as opposed to informal ones.

Another common approach is putting tacit knowledge at the center of innovation processes. Because tacit knowledge can only be transferred via face-to-face contacts, innovation processes are restricted to the spatial range of face-to-face interactions. Although this approach already builds upon (without naming it) a project or content based definition of a region (as postulated by Massey, 1999), it fails to provide empirical evidence for this claim. Yet, as we have shown in section 2, the use of this tacit dimension of knowledge does not seem to be in line with its psychological foundation. Thus, both commonly accepted approaches to a regional dimension of socio-economic processes are unsatisfactory.

The approach of the present paper of looking at the knowledge search process of a boundedly rational individual provides better and sounder evidence for a definition of a region with respect to innovation processes. It has been argued that a regional bias in the individual’s search for knowledge results from the employed heuristics and motivational factors as well as his social embeddedness. Beside the individual perspective, the investigation of an agent’s social embeddedness allows to gain insights on his knowledge search and transfer channels: As for the individual perspective taken before, persons that live in the same region are likely to be



overrepresented in an individual's social networks. This causes a regional bias of his knowledge in- and outflows. Here, research on the (geographic) composition and spatial range of social networks can provide helpful insights.

Although there is clear theoretical evidence for this regional bias and by this for a regional dimension of knowledge transfer processes, appropriate empirical research regarding this issue is missing. Therefore no insights on the geographic size or the adequateness of some existing spatial aggregation levels can be derived. Nevertheless, it seems reasonable to assume that these effects are strongest within the daily movement radius of an individual. Thus, findings from mobility research might provide insights into the daily travel behavior and the stimuli individuals are regularly exposed to. As a first approximation of this movement radius, we could use the average distance between working place and living place of skilled employees. For West German academics this is about 19 kilometers (Buchel et al., 2002).

Empirical research on social networks and on geographic identity building and its geographic range should help to define the geographic size of regions in this context. It has to be pointed out that the similarity between the regional identity approach and the innovative milieu concept seems to support the transferability of insights between both literature strands (see e.g. Koschatzky, 2002).

In addition to these effects, and as we have hinted at before, the regional dimension of labor and graduate mobility constitutes a closely related factor that underpins a regional dimension of knowledge transfers. On the one hand, it is to some extent an outcome of the other processes. On the other hand, it accounts for the embodied knowledge transfer, a role that is strongly emphasized in innovation research. Because of these two reasons and the measurability of the processes, research on labor mobility is extremely valuable for a supportive argument concerning the spatial definition of a region. Thus, the results from labor mobility research that take the specifics of the regional project into account can serve as first basis for establishing meaningful regional boundaries. For Germany, an important threshold that can be called regional boundary is represented by the size of the German labor market regions (see Legler et al., 2001). Research on the mobility of university graduates which represent a specific sub-type of embodied knowledge transfer (relevant for innovations) puts forward a distance of 50 km as a crucial threshold.

In summary, we have provided arguments for the importance of a regional dimension in innovation processes and hereby strong theoretical support for a regional perspective on innovation processes. It is clear that geographical space is organized hierarchically along several different dimensions (e.g. in cognitive or administrative practice; Mark et al., 1999). The argument of the present paper has been that a behavioral approach to knowledge transfers leads to the establishment of an additional strong regional category that organizes information.

Lacking empirical evidence from psychology on individual knowledge search processes as well as on the geographic range of social networks and regional identities, an approximation

of the spatial size of meaningful regions relies on results from mobility and labor mobility research. From this we find labor market regions as units of investigation as a best approximation. Nevertheless, it has to be pointed out that such labor market regions should be based upon the regional labor markets of the relevant group of employees for innovation processes. Thus, the specific labor markets for engineers and scientific staff can be considered as fitting to the presented theoretical framework best.

## 6 Conclusion

Innovations have been recognized as an important driver of economic growth. The generation of innovations is inevitably connected to the transfer of knowledge. The present paper has addressed the spatial dimension of knowledge transfers with special focus on the regional level. Usually, in innovation economics, this spatial dimension of knowledge transfers is explained with the occurrence of tacit knowledge. Some shortcomings associated with this explanation gave the motivation to provide an alternative approach based on a model of boundedly rational actors that search for and exchange knowledge. Such a behavioral model provides a sound justification as to why spatial proximity matters in knowledge transfers.

Starting from an individual's perspective, the paper has shown how his knowledge search processes are biased toward regionally available knowledge ('search bias'). This is due to the employed heuristics and motivational factors driving the search. In addition to that, an agent's social embeddedness also fosters the overrepresentation of regional actors in his set of potential knowledge sources ('social bias'). This can be even consciously enhanced by a shared regional identity.

Unfortunately, empirical findings on the spatial range of social networks, regional identities and individual knowledge search processes are missing that could confirm the considerations. Our framework can serve as a theoretical starting point to fill this lacuna.

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