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**Proximity and Innovation
Through an Accessibility to Knowledge Lens**

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Keywords:	knowledge diffusion, accessibility, geographical proximity, social proximity, networks

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Proximity and Innovation

Through an “Accessibility to Knowledge” Lens

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Abstract:

The aim of this paper is to improve our understanding of the spatial diffusion process of knowledge in terms of *accessibility*, and also to elaborate a new measurement and evaluation tools adapted to a concrete estimation of these phenomena.

This approach offers ways of giving an operational content to the concept of proximity. We enrich the “potential functions” used to measure geographical accessibility with the integration of the characteristics of knowledge diffusion, namely sources of externalities/knowledge, ways of transmission and absorptive capacity. We especially focus on the relational and strategic dimensions of proximity, using some developments from social networks analysis.

Such an approach leads to new empirical models for estimating the determinants of accessibility to knowledge.

Key words: knowledge diffusion, accessibility, geographical proximity, social proximity, networks

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JEL classifications: O3, R12, R58

Résumé :

Le but de cet article est à la fois d'améliorer notre compréhension des processus de diffusion spatiale des connaissances et d'élaborer de nouvelles mesures et outils d'évaluation adaptés à une estimation concrète de ces phénomènes en termes *d'accessibilité*.

L'approche en termes d'accessibilité aux connaissances ouvre la voie à une opérationnalisation du concept de proximité. Aux « fonctions de potentiel » utilisées pour mesurer la proximité géographique nous intégrons les caractéristiques de la diffusion des connaissances, à savoir les sources d'externalités/de connaissances ainsi que les moyens de transmission et la capacité d'absorption. En l'occurrence, nous mettons tout particulièrement l'accent sur les dimensions relationnelle et stratégique de la proximité en mobilisant certains développements de l'analyse des réseaux sociaux.

Une telle approche suggère de nouveaux modèles empiriques d'estimation des déterminants de l'accessibilité aux connaissances.

CRES-2006-0274.R1 (French abstract already provided)

Nähe und Innovation durch das Objektiv eines 'Zugangs zum Wissen'

Nadine MASSARD *and* Caroline MEHIER

Abstract:

Mit diesem Beitrag wird versucht, das Verständnis für den räumlichen Diffusionsprozess des Wissens im Hinblick auf den Zugang zu verbessern und neue

Mess- und Bewertungsinstrumente zu entwickeln, die sich für eine konkrete Schätzung dieser Phänomene eignen.

Dieser Ansatz bietet die Möglichkeit, dem Konzept der Nähe einen funktionalen Inhalt zu verleihen. Wir ergänzen die zur Messung des geografischen Zugangs verwendeten 'Potenzialfunktionen' durch die Integration der Merkmale der Wissensdiffusion, nämlich der Quellen von Externalitäten bzw. Wissen, der Übertragungswege sowie der Absorptionskapazität. Insbesondere konzentrieren wir uns auf die relationalen und strategischen Dimensionen der Nähe, wofür wir einige Entwicklungen aus der sozialen Netzwerkanalyse nutzen.

Ein solcher Ansatz führt zu neuen empirischen Modellen zur Schätzung der Determinanten eines Zugangs zum Wissen.

Key words:

Wissensdiffusion

Zugang

Geografische Nähe

Soziale Nähe

Netzwerke

JEL classifications: O3, R12, R58

Proximidad e innovación, vistas a través del objetivo de 'acceder al conocimiento'

Nadine MASSARD and Caroline MEHIER

Abstract:

El objetivo de este ensayo es conocer a fondo cuál es el proceso de divulgación espacial de los conocimientos en cuanto a la *accesibilidad*, y elaborar nuevas herramientas de medición y evaluación adaptadas para calcular concretamente estos fenómenos.

Este enfoque ofrece modos de aportar un contenido operativo al concepto de proximidad. Mejoramos las 'funciones potenciales' usadas para medir la accesibilidad geográfica con la integración de las características de la divulgación de conocimientos, es decir las fuentes de efectos

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3 externos/conocimientos, los modos de transmisión y la capacidad absorbente. Prestamos especial
4 atención a las dimensiones relacionales y estratégicas de proximidad usando algunos avances de los
5 análisis de las redes sociales.

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7 Esto nos lleva a nuevos modelos empíricos para calcular los determinantes del acceso al conocimiento.
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10 **Key words:**

11 Divulgación del conocimiento

12 Accesibilidad

13 Proximidad geográfica

14 Proximidad social

15 Redes
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20 **JEL classifications:** O3, R12, R58
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27 **I INTRODUCTION**
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30 It is now generally accepted that innovation has a strong locational component.
31 Geographical knowledge externalities are at the heart of an understanding of the role of
32 proximity in the innovation process. The association between externalities and proximity is
33 however, far from obvious and deserves specification.
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39 Various econometric studies on local externalities, assembled under the heading
40 “geography of innovation”¹, have been developed aiming at the empirical estimation of the
41 geographical dimension of technological externalities. A first assessment of the results
42 obtained can show that geographical proximity as such is rarely sufficient to allow firms to
43 benefit from knowledge spillovers. Firstly, innovation processes do not only involve local
44 knowledge transfers. They mix together local and global exchanges. The model based on the
45 strict dichotomy “tacit knowledge=local” and “codified knowledge=global” however, does
46 not appear satisfactory. Secondly, geographical proximity is not the only one to play a role.
47 Proximity effects can also pass through organisations or networks, so proximity can comprise
48 a relational dimension. Nevertheless, the exact role of each of these forms of proximity and
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3 the way they interact are not clear. Such ambiguities have given rise to theoretical returns
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5 aiming at highlighting the conditions under which knowledge (tacit or codified) can be
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7 exchanged at different geographical distances. The evolutionist literature, in particular, has
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9 focused on the “*local buzz-global pipeline*” issue. BATHELT *et al.* (2004, p. 38)² define the
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11 buzz as “*the information and communication ecology created by face-to-face contacts, co-*
12
13 *presence and co-location of people and firms within the same industry and place or region*”.
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15 Buzz does not require any particular investments. Actors continuously contribute to and
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17 benefit from the diffusion of information, gossip and news by just “*being there*” (GERTLER,
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19 1995). On the contrary, the term “*pipelines*” refers to the channels used in distant interactions.
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21 Here, the establishment of relations with new partners takes time and involves costs. The
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23 advantages of global pipelines are associated with the openness of clusters which can feed the
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25 local buzz and avoid the lock-in or over-embeddedness phenomena. Nevertheless, the debate
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27 is not closed because this approach leads to another dichotomy which is open to criticism:
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29 “*geographical proximity = buzz*” and “*relational proximity = global pipelines*”. AMIN and
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31 COHENDET (2005), by contrast, reconsider the local/global relation through a firm
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33 perspective and argue that buzz can take place at a great distance through virtual relations
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35 thanks to relational proximity. The corporate goal of “*being there*” is no longer a question of
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37 location, it is a question of mobilizing “*a network of both contiguous and non-contiguous*
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39 *relations of varying length, shape and duration, where knowing can involve all manner of*
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41 *spatial mobilizations*” (AMIN and COHENDET, 2005, p.465). According to this approach,
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43 relational proximity is what really matters.
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53 ASHEIM *et al.* (2006) also consider that face-to-face (thereafter F2F) and buzz should
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55 not be conflated. They argue that “*face-to-face primarily refers to the multidimensional*
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57 *aspects of communications that require physical contact. It covers deliberate knowledge*
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59 *exchange in mainly formal collaborations, (while) buzz refers to rumours, impressions,*
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3 *recommendations, trade folklore and strategic information (so to non deliberate knowledge*
4 *and information exchange propensities). Thus, it is predominantly about knowledge*
5 *spillovers” (ASHEIM et al., 2006, p.10). This allows them to distinguish between the relative*
6 *importance of F2F and buzz for industries drawing on different knowledge bases and to show*
7 *that the very spatial dimension of F2F as well as buzz can also vary according to this*
8 *knowledge base.*

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17 At this point, and in order to disentangle the main conceptual arguments, it is clear that
18 there is a lack of empirically sustained work on this topic. Most of the empirical studies in the
19 geography of innovation have focused on the “buzz” considered as non deliberate and
20 naturally emerging from the physical proximity over space. By contrast, very few elements
21 have been provided concerning the role of relational proximity especially in its deliberate
22 dimension in order to explain the geography of innovation³.

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32 In this paper our aim is to provide an alternative framework for the empirical study of
33 knowledge diffusion over space. We propose to shift from a knowledge externality framework
34 to an accessibility to knowledge one in order to take the micro-decision of actors
35 (development of effective interactions which requires costly efforts) and social networks into
36 account. That way, we go from a conception where the local environment is a source of
37 unsolicited externalities from which firms may benefit by localizing nearby, to a conception
38 of facilitated externalities arising from the actions of agents⁴. The Economics of Proximity
39 (PECQUEUR and ZIMMERMAN, 2004), provides an interesting framework for the
40 development of our perspective. The concern is an analysis of coordination by considering
41 “situated agents”, where situated means both where they are located in a geographical space
42 but also how they are embedded in a system of relations that conditions their innovative
43 activities. By using a multi-dimensional concept of proximity, including both geographical
44 and non-geographical embeddedness, it is possible to analyze the way by which situated

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3 agents access external knowledge. In this perspective⁵, in accordance with ANDERSSON and
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5 KARLSSON (2004, p. 283) “(...) *we claim that the concept of accessibility can be used to*
6
7 *provide meaningful and useful operationalization of proximity*” in the sense that it offers
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9 insights in the means of overcoming some of the difficulties we face when we try to measure
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11 knowledge externalities on one hand, and when we try to bridge the gaps between
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13 “proximities” on the other hand. Especially it will enable us to propose measurement tools
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15 that have two main advantages compared to the current methodology. Firstly, being “point-
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17 based” (actors-based) instead of “zone-based” (KWAN, 1998), these tools go beyond a strict
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19 local/global dichotomy and allow us to estimate the diversity of the spatial dynamics at play.
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21 Secondly, they permit us to assess the role of the different forms of proximity (geographical
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23 and relational) in order to give an empirical answer to the following question : is the effect of
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25 one form of proximity completely integrated into the other (the geographical proximity as a
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27 pure reflection of the relational one) or is it possible to distinguish these two effects
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29 (geographical proximity, as such, keeps a specific role once the effect of relational proximity
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31 is taken into account) ?
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39 The common approach to model and measure knowledge externalities has been to
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41 consider the stock of external knowledge as an augmenting variable of a knowledge
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43 production function (ANSELIN *et al.* 1997; AUTANT-BERNARD, 2001). As we will see in
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45 section II below, this literature shows many improvements during the last decade. Diverse and
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47 more flexible functional forms of the function are estimated, externalities are more and more
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49 finely modelled, and the improvement in the methodologies of estimation allows us to better
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51 take into account the data characteristics (notably, count data or/and panel data) and the
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53 environment characteristics (using techniques of spatial econometrics for instance to account
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55 for the spatial dependence or the spatial heterogeneity of the phenomena observed).
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60 Consequently, our objective is not to propose alternative methodologies but rather to pinpoint

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3 the necessary changes in the production function when switching from the externalities
4 perspective to the accessibility one.
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8 The paper proceeds as follows. In section 2, we analyze the grounds for the transition
9 from an issue of geographic knowledge externalities to one of the accessibility to knowledge.
10 Section 3 outlines the use of the traditional potential function as a way of measuring
11 geographical accessibility. It shows that, in order to improve our measurement of accessibility
12 to knowledge, the potential function must be enriched by taking the characteristics of
13 knowledge diffusion into account. In section 4, methodological proposals are presented for
14 the estimation of the role of accessibility to knowledge within knowledge production
15 functions. Conclusions are given in section 5.
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28 **II FROM EXTERNALITIES TO ACCESSIBILITY TO KNOWLEDGE**

29 *II.1 The Measurements of Knowledge Externalities and Their Limitations*

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31 Two questions remain subjects for discussion when it comes to assessing the spatial
32 effect of externalities. What is the spatial dimension of this diffusion? Does the conception of
33 externalities in the strict sense, that is to say free and unintentional diffusion, really allow us
34 to grasp the spatial dynamics of knowledge flows?
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42 The estimation of the knowledge production function is used to provide a measure for
43 these spillover phenomena (GRILICHES, 1979). As well as the variables characterising a
44 given firm (E_i) and the intra-firm research inputs (R_i), externalities are gauged according to
45 the external research stock (R_i^*) which itself represents the amount of research activities
46 carried out by the other firms, contributing to the production of internal innovations (I_i). The
47 elasticity of performance in terms of innovation towards an evolution of this stock (β_3)
48 measures the effects of this externality as intangible input for the corporation and ε_i is a
49 random disturbance.
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$$I_i = \alpha (E_i)^{\beta_1} (R_i)^{\beta_2} (R_i^*)^{\beta_3} \varepsilon_i \quad (1)$$

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3 Measuring the geographical dimension of knowledge externalities consists for the
4 main part in introducing the spatial dimension into the estimated knowledge production
5 function. Two methods are used.
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10 The first method, which was introduced by JAFFE (1989) and then elaborated upon by
11 ACS *et al.* (1992), consists of introducing a ‘coefficient of geographic coincidence’ into the
12 knowledge production function. The underlying assumption here is that if innovation grows
13 when the geographic coincidence between the research inputs is high, we may then believe
14 that the R&D efforts of some are reflected locally on the innovation of others, thus that
15 externalities are localized in the specific area.
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24 The second type of method implies the reversion to a definition of externalities as an
25 external stock of knowledge and testing the relevant geographic level for the constitution of
26 this external stock. In order to gauge spillovers at different geographic levels, ANSELIN *et al.*
27 (1997) include as explanatory variables the private (R) and public (U) research expenses
28 invested in the periphery of the metropolitan area (50 or 75 miles). The underlying
29 assumption being that if the estimated variables at the closest geographic level have a more
30 significant effect on the level of innovation, then a concentration or location of the
31 externalities may be inferred.
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43 The econometric studies concentrating on the demonstration of the existence of local
44 effects, which are carried out according to this “geography of innovation” trend, are not
45 without ambiguity. Several explanations to these ambiguous results may be suggested:
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50 - In these works, the geographical area within which the externalities phenomena
51 are studied is often predefined. If the local dimension exists however, it is far from exclusive.
52 Corporations from a same location are actually influenced simultaneously by local knowledge
53 flows and global flows.
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59 - Moreover, the mere observation of the externalities within the defined zones
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3 raises spatial autocorrelation issues since the knowledge flows cross the administrative
4 borders and the regions are consequently not independent. The use of spatial econometric
5 techniques enables us to measure the weight and geographical dimension of these
6 interdependences and to take them into account in the regressions. Let us note however, that
7 few authors in the geography of innovation use these techniques, except for ANSELIN *et al.*
8 (2000) and PARENT and RIOU (2005).
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17 - The diversity of the results obtained also indicates that having a much more
18 accurate understanding of the externalities, i.e. by better specifying the sources, ways and
19 conditions of transmission, is essential. The analysis of the nature of knowledge and the
20 distinction between tacit and codified knowledge constitute key arguments in the geography
21 of innovation by founding the significance of geographical proximity for the transmission of
22 knowledge (GERTLER, 2003). Some will note however, that knowledge is not tacit or
23 codified as such. This cannot be classed as an attribute of knowledge but is in fact largely due
24 to appropriation strategies developed by the actors around such knowledge (BRESCHI and
25 LISSONI, 2001). It might seem that knowledge flows actually measure an effort level
26 emanating from the players as they seek to develop interactions generating knowledge
27 transfers rather than “externalities” which could be seen as homogeneous flows evenly
28 covering localized corporations within a given zone. Consequently, geographical proximity as
29 such cannot be sufficient to benefit from technological spillovers; it has to be articulated with
30 relational proximity. Real interactions need to be developed and costly efforts expended.
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51 On the whole, most of the ambiguities observed concerning the measurement of the
52 geographical dimension of externalities, may therefore be explained by three main limits that
53 stand out from the measures carried out: an excessive local/global dichotomy (one would only
54 need to conclude on either the localized or global nature of the externalities), a lack of micro
55 foundations of the knowledge flows, some methodological difficulties due to spatial
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3 autocorrelation.
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6 In our opinion, addressing these limitations requires a change of approach towards
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8 fundamental questions. Indeed, the overall question of such a measurement is no longer: What
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10 geographical distance does knowledge spread to?, but, rather, Which strategies should be
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12 implemented to identify sources of externalities, construct means of transmission and build
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14 the necessary absorptive capacities in view of the fact that all of this implies costs?
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17 18 ***II.2 Accessibility to Knowledge*** 19

20 As far as measurement is concerned, switching from the externalities issue to the one
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22 of accessibility to knowledge helps us to go beyond the methodological difficulties we
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24 underlined above.
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27 - *Lack of micro-economic foundations.* Many works present “transmission
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29 mechanisms” and absorptive capacities as necessary conditions for externalities to occur.
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31 Thus, in a perspective of accessibility, we can consider knowledge flows as resulting from
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33 deliberate actions of agents, aiming at having access to knowledge at the lowest cost.
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35 ANDERSSON and EJERMO (2003; 2004) determine the opportunity cost of access to
36
37 knowledge. They suggest pinpointing the efforts made to attain research by describing the fact
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39 that each research unit of a firm k seeks to maximize profits from its innovations, those profits
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41 being considered as dependent upon university and firm research expenses:
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$$45 \quad \max_{U, R_k} Y_k = \max_{U, R_k} U^\alpha R_k^\beta - \tau_u U - \tau_R R_k \quad (2)$$

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47 where: τ_u is the average time/distance cost of access to university research (U); τ_R is the
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49 average time/distance cost of access to firm research (R); τ_u and τ_R are the opportunity costs
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51 of access to knowledge.
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56 - *Excessive local/global dichotomy.* As a result, the challenge cannot be reduced to
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58 locating the existence or non-existence of local externalities but is about understanding in
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60 greater detail the determinants of a geographical diffusion differentiated from knowledge

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3 flows. Thus, we share CRESCENZI's (2005, p. 12) view that "*Defined as relative opportunity*
4 *of interaction and contact (sources of knowledge transfer) across geographical space*
5 *afforded by location in a particular town or region, accessibility could be relevant to measure*
6 *the "easiness" not only of local interactions but also of those taking place on a wider spatial*
7 *scale"*.

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15 – *Methodological difficulties due to spatial autocorrelation.* Using spatial econometrics
16 constitutes a real advance for the measurement of knowledge externalities. In addition to the
17 fact that these techniques correct the estimation bias due to the spatial interdependences, they
18 permit a more precise modelling of these interdependences, going beyond a pure local vs
19 global dichotomy, so as to obtain a valid estimation of the geographical range of externalities.
20 Such an approach however, keeps the "black box" on the microeconomic foundations of
21 interdependences. Another method consists of modelling these interdependences as resulting
22 from strategies of accessibility to external knowledge implemented by the local participants.
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34 On the whole, such methodological issues lead to a shifting from a "zone-based" spatial
35 framework to a point-based one (KWAN, 1998). Indeed, as shown by KWAN (1998), the
36 zone-based perspective is prone to problems of aggregation and of intra/inter zone
37 delimitations (as we noticed for the measurement of externalities). It is also not suitable for
38 evaluating an individual's efforts to access knowledge. As we aim to emphasise the strategic
39 determinants of accessibility, we need a point-based approach that permits us to grasp the
40 individual characteristics determining accessibility to knowledge.
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50 51 **III ACCESSIBILITY FORMULATIONS AND CHARACTERISTICS OF** 52 **KNOWLEDGE DIFFUSION** 53 54

55 Measuring accessibility is an appropriate method for interpreting proximity since it is
56 related to concepts such as the ease of spatial interaction and the potential of opportunities for
57 interaction (see inter alia WEIBULL, 1980).
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III.1 Usual Potential Functions

In geography, accessibility does not only refer to the possibility of just reaching a given location but also translates the difficulty of travelling and getting in touch. Integral measures of accessibility (via gravity and “cumulative-opportunity” type of indices) are presented as follows:

$$A_i = \sum_j g(W_j) f(c_{ij})$$

Where A_i , is the accessibility of region I ; $g(W_j)$ is a measure of the attractiveness or weight, W_j , is the activity W to be reached in region j – activity function and c_{ij} , is the generalised cost of reaching region j from region i (measurement of impedance factor: distance, time, cost etc.) –in the impedance or weight function, f , expressing the ‘resistance function’).

Referring to the law of gravitation, the attraction of a distance body is supposed to be equal to its mass weighted by a decreasing function of its distance. So, considering the activities to be reached as being attractors and the distance as the impedance function (friction of time, distance...), several accessibility indicators can be elaborated upon (SCHUERMANN *et al.*, 1997; VICKERMAN *et al.*, 1999). In particular a “potential” accessibility formulation can be proposed.

[Table 1 : Typology of Accessibility Indices]

Initially, the geography of innovation has almost exclusively modeled the local effect by confining externalities within a zone (using daily accessibility function where $f(c) = 1$ inside the zone and $f(c) = 0$ out of the zone). ANDERSSON and KARLSSON (2004) and ANDERSSON and EJERMO (2004) use a potential function with exponential decrease to measure the accessibility of intra-corporation knowledge, inter-corporation knowledge and the accessibility to university research influencing the number of patents.

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3 Such a use of the “potential” functions is however, still far from perfect when it comes
4 to accessibility to knowledge. Although these types of indicators permit a fine analysis of
5 transmission mechanisms, we generally observe rather simplistic formulations of the function.
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10 11 *III.2 Conditions for knowledge transfers to occur...* 12

13 Beyond the usual potential functions, we assume that the definition of an accessibility
14 measure should take into account the necessary conditions for knowledge diffusion to occur.
15 These conditions should be characterized and integrated : i) existence at a location of a
16 capacity to produce knowledge and put knowledge externalities forward; ii) existence in
17 another location of a capacity to absorb this knowledge; iii) existence of means of
18 transmission enabling these knowledge externalities to spread.
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27 The necessary existence in a place of a capacity to produce knowledge and put
28 knowledge externalities forward raises the question of the identification of knowledge sources
29 describing the opportunities of interaction or, in this case, the definition of the activity
30 function W . Two relevant distinctions of potential knowledge sources are usually made
31 according to origins of spillovers. In the literature on geography of innovation, the distinction
32 between university research expenses and private corporation research expenses is made,
33 considering that these knowledge sources are likely to answer to different transferability
34 mechanisms. The distinction between intra- and inter-sectoral knowledge sources is also
35 made, based on the importance of creative processes resulting from cross-knowledge
36 originating from different disciplinary and sectoral fields.
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51 But as emphasized by COHEN and LEVINTHAL (1989, 1990), acquiring the results
52 of R&D spillovers from other firms requires effort by the recipient firm. On the one hand, the
53 absorptive capacity of the firm could be the ratio of *usable* to *actual* external R&D carried out
54 by other firms and institutions (LEAHY and NEARY, 2004). On the other hand, a vector of
55 variables could be used to represent both the absolute and relative firms' absorptive capacity
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3 (see VINDING (2002) for instance). Finally, if the determinants of absorptive capacity differ
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5 depending on the knowledge sources (public/private, intra/inter-sectoral), the weight of
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7 internal R&D have to be put into perspective compared to a more organisational type of
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9 determinants, namely organisational structures and practices, knowledge management
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11 (SCHMIDT, 2005).
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15 Finally, in reference to the works from HÄGERSTRAND (1967) on spatial diffusion of
16
17 innovations, we assume that accessibility is connected to the spatio-temporal constraints of
18
19 human activity and of those interactions which facilitate knowledge diffusion. Thanks to the
20
21 space-time framework, geographers measure accessibility (see inter alia KWAN *et al.*, 2003)
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23 considering this one as the geographical area or the number of opportunities individuals can
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25 reach knowing the spatio-temporal characteristics of their daily activities (taking the sequence
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27 of the duration of these activities into account) and the fixed locations (home, office...) (KIM
28
29 and KWAN, 2003). But, the operationalisation of such a measure in the geography of
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31 innovation remains difficult however. A possible way of taking these space-time constraints
32
33 into account in an accessibility function would be to distinguish the friction coefficient
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35 according to the time frame of the trips. By using the characteristics of the resources mobility
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37 (ANDERSSON and MANTSINEN, 1980) and putting the emphasis on human transfers
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39 thereby allowing physical contacts, we can define the spatio-temporal “units” and distinguish
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41 different spatio-temporal characteristics of the trips: trips within a city and intra-regional or
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43 inter-regional trips, for instance.
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50 51 ***III.3 ...Through Networks*** 52

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54 Moreover, we share KWAN's (1998) conclusions that accessibility is a context-
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56 dependent notion. By focusing on the access to external knowledge stock, we must pay
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58 attention - beyond individual determinants of decision - to global frames surrounding the
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60 (situated) agents: the firm, social networks, institutional and cultural environment. Situated

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3 agent interactions reveal, to a certain extent, the “limits” of geographical proximity due to
4 possible “local” divisions and tensions between actors. Thus, from a strategic point of view, in
5 order to circumvent these negative effects and thanks to mobility, a “temporary” geographical
6 proximity (TORRE and RALLET, 2005) allowing effective knowledge exchanges can be
7 privileged. Moreover, this phenomenon might be all the more significant since the
8 development of Information and Communication Technologies permits unplanned remote
9 relations based on relational proximity once the first connexion is established. This could
10 justify a trade-off between localisation proximate to sources, on the one hand, and remote
11 localisation associated with an intensive use of ICT and social proximity, on the other hand.
12 Consequently, to describe the determinants of knowledge transfer a better assessment of the
13 relational proximity is needed.

14
15 If we consider social proximity as that resulting from the structure of the network of
16 relations between actors, the indicators developed by the social network’s theoreticians⁶ can
17 allow us to grasp accessibility to resources via networks. This network point of view allows
18 us to provide operational measures of social proximity. Such measures result from the relative
19 positioning of the agents within the relevant network. They can simply account for the notion
20 of social or relational proximity between two agents on the one hand, or, on the other hand,
21 address the more complex question of the strategic positioning of agents within the global
22 structure of networks.

23
24 The main advantage of such a network approach is to capture two important features of
25 accessibility to knowledge: agents can deliberately create links with others agents in order to
26 access their knowledge, such knowledge transfers are costly. Consequently, agents have to
27 choose their partners so as to access knowledge efficiently. We must therefore consider the
28 observed networks as reflecting the incentives faced by actors; the geographical distance
29 being only one element of these incentives. The relational network between agents can be
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3 represented by a graph, that is to say a set of nodes (agents) connected by links (relations).
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5 Considering the process of knowledge transfer through the emitters-transmitters-receivers
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7 perspective, we could at first glance distinguish two types of agents in the network according
8
9 to their diffusion or receptive role. Here, we are interested in cooperative relations based on
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11 knowledge barter. Indeed, many instances of knowledge transfers are deliberate and
12
13 reciprocal and involve agents that are simultaneously both sources and receivers of
14
15 knowledge. Indeed, the value of knowledge is difficult to assess ex-ante, so knowledge barter
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17 is often the main incentive to cooperate (HELSLEY and STRANGE, 2004).
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22 The simplest measure of distance through relational networks is the *geodesic distance*
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24 between two agents. A *path* is a sequence of links between two agents such as $g_{i_1,i_2} = g_{i_2,i_3} = \dots$
25
26 $g_{i_{k-1},i_k} = 1$ where $i_1=i$ and $i_k=j$. The *geodesic distance* between two agents i and j is the
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28 number of links of the shortest path between them. The distance is considered as infinite when
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30 there is no *path* between two agents. If we consider the number of relations between i and j ,
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32 we obtain a measure of the intensity of the link. And *tie intensity* can be transformed into *tie*
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34 *strength* using network proportions (BURT, 1992; UZZI, 1996). Network proportions define
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36 the strength of a tie within the context of the aggregate level of effect across an agent's
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38 network. Indeed, beyond the very existence of a link, the capacity to access knowledge is
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40 certainly dependant on the strength of this link. One can guess that, through learning by
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42 interaction, the higher the number of co-operations established between two agents; the better
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44 is the capacity to absorb the knowledge transferred.
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50 The second way to consider network effects in the accessibility analysis consists of
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52 considering the overall resources available globally within a network and linking accessibility
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54 to the individual positioning within the network. This leads us to introduce the strategic
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56 perspective and in particular the existence of a trade-off between the objectives of maximizing
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58 the knowledge acquired on the one hand, and of minimizing the loss of appropriability of our
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3 own knowledge, on the other hand. So the advantage of cooperation increases with the
4 number of partnerships tied to a firm and also with the number of ties formed by its own
5 partners. Firms are however, highly conscious of the problems of control or knowledge
6 appropriability that can emerge from the diffusion of information amongst them. So, they
7 generally face a trade-off between the necessity to increase the number of their direct and
8 indirect partners in order to absorb new knowledge and the necessity to reduce this number so
9 as to be able to control the dissemination of their own knowledge. This explains the star and
10 small world structures of real networks that allow the multiplication of direct links, with
11 partners themselves developing few links elsewhere. Consequently, measuring the
12 accessibility to knowledge through network requires indicators capable of catching such
13 strategic dilemma.
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30 IV PROPOSALS

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32 Let us now turn to more concrete proposals for the empirical estimation of the
33 determinants of knowledge accessibility.
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37 In order to describe the opportunities of interaction the *identification of knowledge*
38 *sources* is needed. Here the definition of the activity function W has to take into account the
39 “emitters” of knowledge.
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44 The activity function W can then be written as follows:

$$45 \quad W = U_i + R_i + U_e + R_e \quad (3)$$

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48 Where U and R are respectively university expenses and private research expenses external to
49 the cluster in question, indices i and e indicate the intra- or extra-sectoral nature of these
50 sources.
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56 Moreover, rather than seeking to understand the knowledge-generating activities (U
57 and R) via a research expenses indicator, suggesting a measure via knowledge-carrying
58 human potential could be relevant. The tacit knowledge which is the hardest to transfer
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3 implies personal contacts with the carriers of this knowledge. The opportunities for interaction
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5 are then directly dependent upon the quantity of personnel attached to these research
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7 activities.
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10 These potentials of external knowledge are more or less accessible depending on
11
12 transmission means and *absorptive capacities* of receivers. In the potential functions
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14 introduced above, the question of the difficulties caused by the existence or absence of
15
16 knowledge absorptive capacities is merged with that of the transmission difficulties in the
17
18 weight function. However, a distinction deserves to be done. From an accessibility
19
20 problematic standpoint, two points must be underlined. First of all, the costs implied by the
21
22 implementation of an absorptive capacity result in three types of internal requirements,
23
24 namely having: a sufficient internal level of knowledge, a diversity of domains that increases
25
26 the connection possibilities with outside knowledge and an organisation in favour of
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28 knowledge assimilation and learning. In terms of measurement in a knowledge production
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30 function, we may propose that the accessibility variable coefficient depends on the absorptive
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32 capacity, which comes to use cross-variables. Hence, the following type of knowledge
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34 production functions (in a log-linear form):
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$$I_i = \alpha + \beta_1 RD_i + f(CA_i)A_i + \varepsilon_i \quad (4)$$

40
41 where RD_i is the internal research and development of the firm, A_i is a function of the
42
43 potential accessibility to external knowledge and CA_i is an absorptive capacity measure.
44
45 Giving f a log-linear form amounts to including a cross-variable in the production function:
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51 $CA * A_i$.

52 Secondly, the absorptive capacity is not independent from the conditions of
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54 transmission. We may think that the transmission methods facilitating knowledge
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56 transferability enable the reduction of requirements as regards internal absorptive capacity or
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58 help to implement this capacity. Thus, both the characteristics of the local environment and
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3 the connectivity to public or private external sources of knowledge (POWELL *et al.*, 1996;
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5 COCKBURN and HENDERSON, 1998) of a corporation have to be taken into consideration.
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7 In that case, absorptive capacity contributes to defining which part of the available activities
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In order to define *the weight function*, following ANDERSSON and EJERMO (2003) and ANDERSSON and KARLSSON (2004), we retain the idea of distinguishing different levels of accessibility corresponding to different space-time units. Each space-time units defines itself according to the specific degree of sensibility of the accessibility to the distance: no role of the geographical distance in a space-time, for instance, lower than 15 mn travel (l), stronger sensibility depending on the frequency of the movements necessary for the transfer of knowledge beyond ($ir = \text{intra-regional}$; $er = \text{external to the region}$)⁷.

$$A_i = \sum_{i,h \in l} W_h + \sum_{i,j \in r} W_j e^{-\beta_{ir} c_{ij}} + \sum_{s \notin r}^n W_s e^{-\beta_{er} c_{is}} \quad (5)$$

Where $\sum_{i,h \in l} W_h$ measures the accessibility at the local level, $\sum_{i,j \in r} W_j e^{-\beta_{ir} c_{ij}}$ measures the accessibility at the intra-regional level and $\sum_{s \notin r}^n W_s e^{-\beta_{er} c_{is}}$ measures the accessibility to knowledge produced outside the region.

As we insist upon earlier, the relational networks within which the actors are incorporated are means by which access to knowledge can be facilitated. Thus, in terms of measuring the accessibility to knowledge, this supposes that we identify the relevant network and define indicators of social proximity within the network.

We therefore consider that the identified sources of knowledge constitute the nodes of the network. There is a link between two nodes each time these nodes have set up an effective relation which is likely to enhance the knowledge transfers. Such relations can be identified through their outcomes (co-publications or co-patenting) or through the forms they take

(setting-up of a common R&D structure, commitment in a common R&D project...). The structure of the existing networks results from individual and bi-lateral decisions of link formation. Here, the *relevant network*, g , can be defined as a graph where the set of agents sources of knowledge are the nodes $N = \{1, 2, \dots, n\}$, and they are considered as connected if they have intentionally created a collaboration based on knowledge barter (links). So, $g_{i,j} = 1$ (and equivalently $g_{j,i} = 1$) if agents i and j have set a link with each other, otherwise $g_{i,j} = 0$. Once built up, these networks constitute the framework that can underline our measure of social proximity.

Coming back to the accessibility function, one can simply substitute or add this sort of *relational proximity measure* to the spatial proximity measure in the weight function. Coefficient c_{ij} would thus grasp relational distance rather than geographical distance between the studied units and the knowledge sources (measured via the geodesic distance, the relative intensity or the strength of the ties). As we pointed out earlier, we should pay attention to the institutional and cultural belonging environment of the (situated) agents. Due to very different practices, habits or communication languages, knowledge transfers are more or less complex according to the context. We can then assume that the sensibility of the knowledge accessibility to social proximity is thus higher for inter-institutional contacts than for intra-institutional ones.

Thus, the accessibility coefficient presented below can be used again, switching from the geographical context to the *relational context*.

$$A_i = \sum_j W_j e^{-\beta_{pp} d_{ij}} + \sum_s W_s e^{-\beta_{pupr} d_{is}} \quad (6)$$

So, here, d represents the relational distance (geodesic or measured through the strength of ties), j represents an agent of the same type as i , s represents an agent of a different type to i , and we distinguish the pp and the $pupr$ context as respectively the intra-institutional context (public-public or private-private) with low sensibility to the relational distance (β) and the

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3 extra-institutional context (public-private) with a greater sensibility to relational distance.
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5 The relational context given let us turn to *the strategic positioning in the networks*.
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7 The structural analysis of network allows us to define complex positioning indicators which
8 are likely to account for the different strategic trade-offs that underline the problematic of
9 accessibility to knowledge. From the point of view of one agent, different notions of
10 *centrality* within a network have been proposed to account for this problematic (see
11 BORGATTI, 2005, for a review). One can simply measure the *density* for an agent which is
12 defined as the number of links set up by this agent compared to the total number of potential
13 partners existing within this network⁸. Strategically, the notion of *Betweenness Centrality* is
14 finer because this statistic measures how many times one agent is situated on the geodesic
15 path (smallest path) between two other agents⁹. This indicator is based on a simple intuitive
16 notion: the capacity of an individual to control (facilitate, prevent, hinder) the diffusion of
17 knowledge between other individuals.
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34 In a more complex approach, REAGANS *et al.* (2004) present two conceptions of the
35 position advantage within a network. One follows the sociological and economic theories of
36 exchange and considers positioning from the degree of control on the terms of exchange it
37 provides to the agent. The other presents the position advantage from the differential of access
38 to resources it allows. In his theory of structural holes, BURT (1992) shows that the same
39 type of position ensures both advantages. The measure of the constraint weighing on the
40 players captures this phenomenon¹⁰.
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50 In the BURT's perspective, the positioning ensuring the lowest constraint is the best and
51 is achieved when the individual maximizes the size of his/her network by multiplying his/her
52 relationships (in order to maximise our access to external knowledge in our perspective) and
53 minimizes the connections between these relationships (in order to limit the risk of loss of
54 appropriability), or in other words maximizes the number of structural holes around him/her.
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3 To the contrary, REAGANS *et al.* (2004, p.1) describe arbitration situations according to the
4 observation of the structurally equivalent or non-equivalent nature of the contacts: “*The key*
5 *difference is that, while the absence of relations between structurally equivalent alters is*
6 *essential for granting ego leverage when exchanging with these contacts, such a structural*
7 *hole does little to widen ego’s access to information. This implies that there is a trade-off*
8 *between efforts at developing ties that expand access to information and those that augment*
9 *control over the terms of exchange”*. Altering the structural constraint measure is suggested in
10 this sense.
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22 Actors who maximise the number of structural holes around them also have another
23 advantage with respect to accessing information. They are in a position to bring together
24 otherwise disconnected sub-groups within the network. This allows them to benefit from the
25 high density and transitivity of the connexions internal to their group (intra-group buzz and
26 positive effect of information redundancy) as well as from a great diversity of new
27 information and new ideas coming from other groups (inter-group pipelines and positive
28 effect of non-redundancy) that can feed their knowledge base (BURT, 2000; BATHELT *et*
29 *al.*, 2004).
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41 Therefore, one can weigh the accessibility to intra-regional resources by the individual’s
42 degree of centrality or constraint within the scientific collaborations network within this
43 region.
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48 Thus the accessibility coefficient can be measured as follows:
49

$$A_i = W_n e^{-\beta c_{ni}}$$

50 where W_n measures the overall resources available globally within a network and c_{ni} is the
51 degree of centrality (whatever the measure of centrality we choose) of i inside this network.
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56 Theoretically, this can be applied to any geographical levels. The main obstacle we face then
57 consists in finding data describing complete networks.
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In fact, the data requirements constitute a problem for empirical application, for the

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3 usual procedure of taking samples of firms is not appropriate when analysing networks and
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5 few systematic databases are available (CANTNER and GRAF, 2006). Consequently, many
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7 empirical applications which study networks of innovators or inventors make use of
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9 publications or patent data either by building citation or co-authorship networks. Even though
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11 this has the advantage of considering the very process of collaboration and not only the output
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13 in terms of publications or patents, very few papers use data on direct collaborative
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15 agreements in R&D. One can notice however, some recent works using social network
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17 analysis to describe the structure of the R&D collaboration established between firms¹¹, hence
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19 providing some empirical data to measure accessibility through networks.
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25 V CONCLUSIONS

26
27 In order to provide a better understanding of the factors shaping the innovative and
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29 economic performances of territories or firms the “accessibility to knowledge lens” deserves
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31 to be widely developed in both theoretical and empirical ways. We can already outline some
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33 theoretical and empirical implications that the switching from an externality framework to an
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35 accessibility one has on the geography of innovation.
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40 It has become obvious that the measurements carried out by economists to geographical
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42 dimension of knowledge externalities until now are insufficient. In fact, they are no real
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44 means for refuting economic theories as they hardly distinguish actual externalities from other
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46 forms of contract-based interactions. In order to mitigate the methodological difficulties
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48 encountered in measuring the geographical dimension of knowledge externalities, the
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50 adoption of the accessibility to knowledge lens leads us to assume the need to take into
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52 account both the potentials of “places” and the geographical and relational “space” of
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54 knowledge diffusion in the firm’s location choice. By focusing on the conditions knowledge
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56 diffusion needs in order to occur, we formulate proposals consisting in the integration of: i)
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58 the quantity of personnel attached to knowledge generating activities (distinguished by their
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3 intra or inter sectoral and private or public knowledge source); ii) an accessibility coefficient
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5 which depends on absorptive capacity; iii) the degree of sensibility of the accessibility to
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7 different space-time units; iv) the measure of the accessibility through social proximity
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9 resulting from the relative positioning of the agents within the relevant network.
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13 Although there exists a wide theoretical literature concerning the articulation between
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15 geographical and social proximity; some considering social proximity as a substitute to
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17 geographical proximity for relations at distance, others considering the geographical
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19 proximity as a simple by-product of the more fundamental role of social proximity, existing
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21 empirical studies don't really confront these different effects. The operationalisation of
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23 proximity provided through accessibility can improve our understanding of the articulation
24
25 between the role of geographical proximity and that of relational proximity in the exploitation
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27 of the external knowledge flows by the firms. To our knowledge, there are no works
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29 implementing such accessibility indicators via networks to assess knowledge production
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31 functions. The methodological approach presented in this paper constitutes a first step towards
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33 this objective. The operational implementation of such an approach for empirical estimations
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35 however, still faces two main obstacles. Firstly, this is a formal exercise through which the
36
37 formulation of localized knowledge production functions can be enriched by including
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39 various measures of accessibility to knowledge. In order to reduce the well-known restricted
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41 nature of indicators and avoid misinterpretations however, estimations using these indicators
42
43 have to be based on sound theoretical frameworks. This suggests paths using theoretical
44
45 works on location, cooperation decisions and network formation¹², in order to develop more
46
47 structural empirical models thereby enabling the endogeneization of the firms' location and
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49 cooperation choices. Secondly, for a better understanding of the fundamental links existing
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51 between innovativeness and accessibility to external knowledge we have shown that a new set
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53 of "relational" key indicators needs to be defined and data needs to be collected. In this
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3 perspective, proposals to replace the science and technology regional scoreboards are under
4 way. This should provide us with a better diagnostic on the accessibility to knowledge offered
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8 by a region.
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10 11 12 13 14 VI REFERENCES

- 15 ACS Z., AUDRETSCH D. and FELDMAN M. (1992) Real effects of academic research: Comment, *American*
16 *Economic Review* **82**, 363-367.
17
18 AMIN A. and COHENDET P. (2005) Geography of knowledge formation in firms, *Industry and Innovation*
19 **12**(4), 465-486.
20
21 ANDERSSON M. and EJERMO O. (2003) Knowledge Production in Swedish Functional Regions 1993-1999,
22 CESPRI Working Papers 139, Centre for Research on Innovation and Internationalisation, Università
23 Bocconi, Milano.
24
25 ANDERSSON M. and EJERMO O. (2004) How does Accessibility to Knowledge Sources affect the
26 Innovativeness of Corporations? - Evidence from Sweden, CESIS Working Paper Paper No. 03, The
27 Royal Institute of Technology, Stockholm.
28
29 ANDERSSON M. and KARLSSON C. (2004) The Role of Accessibility for Regional Innovation Systems, in
30 KARLSSON C., FLENSBURG P. and HÖRTE S.-Å. (Eds.) *Knowledge Spillovers and Knowledge*
31 *Management*, pp. 283-310. Edward Elgar, Cheltenham.
32
33 ANDERSSON M. and MANTSINEN J. (1980) Mobility of Resources, Accessibility of Knowledge and
34 Economic Growth, *Behavioral Science* **25**(5), 353-366.
35
36 ANSELIN L., ACS Z. and VARGA A. (1997) Local Geographical Spillovers Between University Research and
37 High Technology Innovations, *Journal of Urban Economics* **42**, 422-448.
38
39 ANSELIN L., VARGA A. and ACS Z. (2000) Geographic Spillovers and University Research a spatial
40 econometric perspective, *Growth and Change* **31**, 501-516.
41
42 ASHEIM B.T., COENEN L. and VANG J. (2006) Face-to-Face, Buzz and Knowledge Bases: Exploring Socio
43 Spatial Implications for Learning and Innovation, *Environment & Planning C*, submitted.
44
45 AUTANT-BERNARD C. (2001) The geography of knowledge spillovers and technological proximity,
46 *Economics of Innovation and New Technology* **10**(4), 237-254.
47
48
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2
3 BATHELT H. and GLÜCKLER J. (2003) Toward a relational economic geography, *Journal of Economic*
4
5 *Geography* **3**, 117-144.
6
7 BATHELT H., MALMBERG A. and MASKELL P. (2004) Clusters and knowledge: local buzz, global pipelines
8
9 and the process of knowledge creation, *Progress in Human Geography* **28**, 31-56.
10
11 BORGATTI S. (2005) Centrality and network flow, *Social Networks* **27**, 55-71.
12
13 BRESCHI S. and CUSMANO L. (2004) Unveiling the texture of a European Research Area: emergence of
14
15 oligarchic networks under EU Framework Programmes, *International Journal of Technology*
16
17 *Management* **27**(8), 747-772.
18
19 BRESCHI S. and LISSONI F. (2006) Mobility of inventors and the geography of knowledge spillovers. New
20
21 evidence on US data. ADRES International Conference, 14th and 15th September, Saint-Etienne.
22
23 BRESCHI S. and LISSONI F. (2001) Knowledge spillovers and local innovation systems: a critical survey,
24
25 *Industrial and Corporate Change* **10**(4), 975-1006.
26
27 BURT R. (2000) Structural holes versus network closure as social capital, Miméo University of Chicago and
28
29 INSEAD.
30
31 BURT R. (1992) *Structural Holes: The Social Structure of Competition*. Harvard University Press, Cambridge
32
33 (Massachusetts).
34
35 CANTNER U. and GRAF H. (2006) The network of innovators in Jena: An application of social network
36
37 analysis, *Research Policy* **35**(4), 463-480.
38
39 CARAYOL N. and ROUX P. (2004) Behavioral foundations and equilibrium notions for social network
40
41 formation processes, *Advances in Complex Systems* **7**(1), 77-92.
42
43 CLOODT M., HAGEDOORN J. and ROIJAKKERS N. (2006) Trends and patterns in inter-firm R&D networks
44
45 in the global computer industry: a historical analysis of major developments during the period 1970-1999,
46
47 *Business History Review* **80**, 725-746.
48
49 COCKBURN I. and HENDERSON R. (1998) Absorptive capacity, co-authoring behavior, and the organization
50
51 of research in drug discovery, *The Journal of Industrial Economics* **46**(2), 157-181.
52
53 COHEN W.M. and LEVINTHAL D.A. (1989) Innovation and learning: the two faces of R&D, *The Economic*
54
55 *Journal* **99**, 569-596.
56
57 COHEN W.M. and LEVINTHAL D.A. (1990) Absorptive capacity: A new perspective on learning and
58
59 innovation, *Administrative Science Quarterly* **35**(1), 128-152.
60
61 CRESCENZI R. (2005) The role of local innovative activities, education and peripherality in the EU regional

- 1
2
3 growth patterns, Final Open Conference COST A-17 Knowledge and Regional Economic Development,
4
5 9th-11th June, Barcelona.
6
7 FELDMAN M.P. (1994) *The geography of innovation*. Kluwer Academic Publishers, Boston.
8
9 FELDMAN M.P. and MASSARD N. (Eds.) (2002) *Institutions and systems in the geography of innovation*.
10
11 Kluwer Academic Publishers, Boston.
12
13 GERTLER M. (1995) 'Being there': proximity, organization and culture in the development and adoption of
14
15 advanced manufacturing technologies, *Economic Geography* **71**, 1-26.
16
17 GERTLER M. (2003) Local knowledge: tacit knowledge and the economic geography of knowledge or the
18
19 undefinable tacitness of being there, *Journal of Economic Geography* **3**, 75-99.
20
21 GOYAL S. *et al.* (2006) Economics: An Emerging Small, *Journal of Political Economy* **2**, 403-438.
22
23 GRANOVETTER M.S. (1983) The strength of weak ties: A network theory revisited, *Sociological Theory* **1**,
24
25 201-233.
26
27 GRILICHES Z. (1979) Issues in assessing the contribution of research and development to productivity growth,
28
29 *The Bell Journal of Economics* **10**(1), 92-116.
30
31 HAGEDOORN J. (2002) Inter-firm partnerships: an overview of major trends and patterns since 1960, *Research*
32
33 *Policy* **31**(4), 477-492.
34
35 HÄGERSTRAND T. (1967) *Innovation diffusion as a spatial process*. The University of Chicago Press,
36
37 Chicago.
38
39 HELSLEY R.W. and STRANGE W.C. (2004) Knowledge barter in cities, *Journal of Urban Economics* **56**, 327-
40
41 345.
42
43 JAFFE A. (1989) Real effects of academic research, *American Economic Review* **79**(5), 957-970.
44
45 KIM H.-M. and KWAN M.-P. (2003) Space-Time Accessibility Measures: A Geocomputational Algorithm with
46
47 a Focus on the Feasible Opportunity Set and Possible Activity Duration, *Journal of Geographical Systems*
48
49 **5**(1), 71-91.
50
51 KWAN M.-P. (1998) Space-Time and Integral Measures of Individual Accessibility. A Comparative Analysis
52
53 Using a Point-Based Framework, *Geographical Analysis* **30**(3), 191-216.
54
55 KWAN M.-P. *et al.* (Eds) (2003) Accessibility in Space and Time: A Theme in Spatially Integrated Social
56
57 Science, special issue of *Journal of Geographical Systems* **5**(1).
58
59 LEAHY D. and NEARY J.P. (2004) Absorptive capacity, R&D spillovers, and public policy. CEPR Working
60
Paper WP04/18, University College Dublin, Dublin.

- 1
2
3 PARENT O. and RIOU S. (2005) Bayesian Analysis of knowledge spillovers in European Regions, *Journal of*
4
5 *Regional Science* **45**, 747-775.
6
7 PECQUEUR B. and ZIMMERMANN J.B. (Eds) (2004) *Economie de proximités*. Hermès, Paris.
8
9 POWELL W.W., KOPUT K.W. and SMITH-DOERR L. (1996) Interorganizational collaboration and the locus
10
11 of innovation, *Administrative Science Quarterly* **41**, 116-145.
12
13 OVEN-SMITH J. and POWELL W. (2004) Knowledge networks as channels and conduits: the effects of
14
15 spillovers in the Boston Biotechnology Community, *Organisation Science* **15**(1), 5-21.
16
17 REAGANS R. E., ZUCKERMAN E.W. and McEVILY B. (2004) Two holes in one? Information and control in
18
19 the analysis of structural advantage. Working paper, Columbia Business School, Columbia University,
20
21 New York.
22
23 ROSENTHAL S.S. and STRANGE W.C. (2004) Evidence on the nature and sources of agglomeration
24
25 economies, in HENDERSON V. and THISSE J.F. (Eds.) *Handbook of Urban and Regional Economics*,
26
27 pp. 2119-2171. Elsevier-North Holland, Amsterdam.
28
29 SCHMIDT T. (2005) What Determines Absorptive Capacity?, DRUID Tenth Anniversary Summer Conference,
30
31 Copenhagen.
32
33 SCHUERMAN C., SPIEKERMANN K. and WEGENER M. (1997) Accessibility Indicators: Model and
34
35 Report. SASI Deliverable D5, Institut für Raumplanung, Universität Dortmund, Dortmund.
36
37 SINGH J. (2005) Collaborative networks as determinants of knowledge diffusion patterns, *Management Science*
38
39 **51**(5), 756-770.
40
41 STORPER M. and VENABLES A.J. (2004) Buzz: face to face contact and the urban economy, *Journal of*
42
43 *Economic Geography* **4**, 351-370.
44
45 TORRE A. and RALLET A. (2005) Proximity and Location, *Regional Studies* **39**(1), 47-59.
46
47 UZZI B. (1996) The sources and consequences of embeddedness for the economic performance of organizations:
48
49 The network effect, *American Sociological Review* **61**, 674-698.
50
51 VICKERMAN R., SPIEKERMANN K. and WEGENER M. (1999) Accessibility and Economic Development in
52
53 Europe, *Regional Studies* **33**(1), 1-15.
54
55 VINDING A.L. (2002) Interorganizational Diffusion and Transformation of Knowledge in the Process of
56
57 Product Innovation. PhD Thesis. IKE Group/DRUID. Department of Business Studies, Aalborg
58
59 University, Aalborg.
60
61 WASSERMAN S. and FAUST K. (1994) *Social Network Analysis*. Cambridge University Press, New York.

1
2
3 WEIBULL J.W. (1980) On the numerical measurement of accessibility, *Environmental Planning A* **12**, 53-67.
4
5
6
7
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Table 1 : Typology of Accessibility Indices

Type of Accessibility	Activity function $g(W_j)$	Impedance function $F(c_{ij})$	Accessibility Formulation A_i
Travel cost : accumulated travel cost to a set of activities	W_j 1 if $W_j \geq W_{\min}$ 0 if $W_j < W_{\min}$	c_{ij}	A_j c_{ij} if $W_j \geq W_{\min}$ 0 if $W_j < W_{\min}$
Daily accessibility: accumulated activities in a given travel time	W_j	1 if $c_{ij} \leq c_{\max}$ 0 if $c_{ij} > c_{\max}$	W_j if $c_{ij} \leq c_{\max}$ 0 if $c_{ij} > c_{\max}$
<u>Potential</u> : accumulated activities weighted by a function of travel cost	W_j^α	$\exp(-\beta c_{ij})$	$W_j^\alpha \exp(-\beta c_{ij})$

From SCHUERMAN *et al.* (1997).

¹ See FELDMAN (1994), FELDMAN and MASSARD (2002) and, for a review, ROSENTHAL and STRANGE (2004).

² Drawing their inspiration from STORPER and VENABLES (2004) and OWEN-SMITH and POWELL (2004).

³ BRESCHI and LISSONI (2006) and SINGH (2005) are exceptions. They find that social proximity is more relevant than geographical proximity when evaluating the degree of knowledge transfers.

⁴ Speaking about knowledge accessibility does not mean that we neglect spillover phenomena. It means that, contrary to the geography of innovation that insists on unintentional and “in the air” form of externalities, we wish to put the stress on the intentional (strategic) and embodied forms of spillover.

⁵ Which falls within the scope of what BATHELT and GLÜCKLER (2003) name the “*relational economic geography*”.

⁶ See GRANOVETTER (1983), WASSERMAN and FAUST (1994).

⁷ Following ANDERSSON and KARLSSON (2004) we choose here a negative exponential form ($-\beta c_{ij}$) to model the distance decay effect. For a discussion on the relevance of such a form see KWAN (1998). She shows that such a form (as well as the simple inverse power function ($c_{ij}^{-\alpha}$) tend to decay too rapidly close to the origin and suggest a modified Gaussian function.

⁸ This corresponds to the *Degree centrality* simply defined by the number of direct connections of one summit with other summits. It measures potential associated to the topological distance threshold l , i.e. the number of direct relationship opportunities. To do so, we measure the distance of summit i by adding all its geodesic distances to the other summits:

$$C_{APi}^{-1} = \sum_{j=1}^n dij$$

From this absolute distance, a relative proximity index can be calculated by comparing it to the maximum centrality $C_{max} = n-l$:

$$C_{NPi} = \frac{n-l}{C_{APi}^{-1}}$$

⁹ The *betweenness centrality* C_B of an individual i , is then given by:

$$C_{B(i)} = \sum_{j \neq i \neq k \in N} \frac{s_{jk}(i)}{s_{jk}}$$

where $s_{jk}(i)$ number of shortest path from j to k that some individuals i lie on. s_{jk} the number of shortest paths from j to k .

¹⁰ Measure for the *degree of constraint* i 's contacts posed upon it is:

$$C_i = \sum_{j \neq i}^j c_{ij},$$

where the constraint posed on i by a given j is:

$$c_{ij} = \left(p_{ij} + \sum_{q \neq i \neq j}^Q p_{iq} p_{qj} \right)^2$$

Here we find two elements, that is relationship intensity between i and j and the degree of triadic closure between i, j and third-parties q .

¹¹ See for instance, HAGEDOORN (2002) on the pharmaceutical industry, CLOODT *et al.* (2006) on the computer industry and BRESCHI and CUSMANO (2004) on EU framework programs.

¹² See for example GOYAL *et al.* (2006) or CARAYOL and ROUX (2004).