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Localised knowledge spillovers vs. innovative milieux: Knowledge "tacitness" reconsidered

Stefano Breschi[1], **Francesco Lissoni**[2]

[1] CESPRI, Università L. Bocconi, Milan; and Università Castellanza LIUC, 21053 Castellanza, Italy (e-mail: sbreschi@verdi.liuc.it)
[2] CESPRI, Università L. Bocconi, Milan; and Università degli Studi di Brescia, Italy (e-mail: lissoni@bsing.ing.unibs.it)

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Abstract. This article provides a critical discussion of the recent econometric literature on "localised knowledge spillovers" and the related notion of tacit knowledge. The basic claim of the article is that the increasing, and more or less automatic reliance of industrial geographers upon such econometric evidence and theoretical concepts to support their work on industrial districts, hi-tech agglomerations and, more broadly, local innovation systems is not well placed and risks to generate conceptual confusion and to distort research agendas. Following some recent advances in the economics of knowledge, the article also suggests that more research efforts should instead be devoted to exploring how knowledge is actually transmitted, among whom, at what distance, and on the basis of which codebooks.

JEL classification: O18, O30, R12

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1 Introduction

This article originates from a critical assessment of the recent fortunes met by the econometric literature on "Localised Knowledge Spillovers" (LKSs), and develops it further into a re-examination of the concept of "knowledge tacitness", as it has been used within the broad realm of the New Industrial Geography (NIG). Following Martin's and Sunley's (1996) definition, we identify the latter with that vast and heterogeneous literature dealing with regional agglomerations from a non-mainstream economic viewpoint, stressing the role of innovation opportunities as a locational factor, best represented by influential case studies on US hi-tech clusters, Italian industrial districts, and, more generally, on a num-

ber of "innovative milieux" (local innovation systems) in Europe and elsewhere (Markusen 1996; Keeble and Wilkinson 1999).

The logical link between the two concepts of LKS and tacit knowledge is provided by the frequent claim that knowledge transmission is mostly a matter of face-to-face contacts and labour mobility, i.e., that the most important knowledge carriers are people, in particular people who know and possibly trust each other, meet frequently, and trade job offers very often (more formal means of transmissions, e.g., scientific articles or technology licences, are seen as playing a much lesser role). Knowledge is then regarded as a local public good, to be retained by co-located economic agents, to the exclusion of distant ones. On this point, one can compare the same insistence on knowledge tacitness by authors as different as Jaffe (1989) and Feldman and Florida (1994), on the LKS side, and Cossentino et al. (1996) and Keeble and Wilkinson (1999), on the NIG side.

The research link between the econometrics of LKSs and the NIGs' knowledge-based geography of innovation systems is witnessed by a large number of cross-references, which clearly suggest that the quantitative evidence on LKSs has been increasingly quoted and discussed in the debate both among NIGs, and between NIGs and a rival school of thought, namely the New Economic Geography, started by Paul Krugman's authoritative re-assessment of location theory and soon developed into a research field of its own (Krugman 1991a,b, 1999). In fact, a major point of contention between the two schools resides precisely in the role assigned to knowledge flows as an agglomeration force, a role about which many New Economics Geographers (NEGs, this particular acronym being suggested by David 1999) are clearly sceptical.[1]

More precisely, LKS-econometricians openly claim to be providing some econometric support to many of NIGs' fascinating accounts of self-sustained growth of innovative clusters. A few NIGs, in turn, are keen on the idea of being able to count upon some further evidence than their case studies, especially if such evidence cannot be dismissed by mainstream economists as methodologically irrelevant. Also a few NEGs, wishing to model LKSs as a source of increasing returns to location, are eager to exploit both the concept of knowledge tacitness and any favourable evidence that will meet mainstream criteria for acceptance.[2]

In this article we cannot pretend to survey effectively both NIG and NEG, or even only one of the two.[3] As for the econometrics of LKSs, we discuss it

[1] Terminology, as it often happens with definitions of schools of thought, may be somehow confusing. While NEGs do not hesitate to identify themselves as such (but see Martin's and Sunley's definition of Krugman's work as "Geographical Economics", as opposed to more genuine "Economic Geography"), very few New Industrial Geographers would share eagerly the common label we assign to them.

[2] See for example Krugman (1991a, b), whose dismissal of LKS as a relevant agglomeration force is quoted critically by Jaffe et al. (1993), and Martin (1999), as well as by Audretsch and Feldman (1994), Ottaviano and Thisse (2000), and Anselin et al. (1997), who in turn share references to Saxenian (1990, 1994) and Storper and Walker (1989). Audretsch and Feldman (1994), in turn, are quoted by Martin (1999) as providing counter-evidence to Krugman's claims, as the two authors indeed openly declare.

[3] In any case, authoritative surveys are already available. See, among others, Ottaviano and Puga (1997), and Martin (1999).

at some length in a related article (Breschi and Lissoni 2001). Therefore we set ourselves two, more limited, tasks.

First, we will try to show that, so far, the econometrics of LKSs has not been up to the task of testing seriously the propositions coming from the rich set of case studies and anecdotic evidence collected by NIGs. A number of internal weaknesses (both conceptual and empirical) make its links with NIGs' work quite foggy, certainly foggier than many LKS-econometricians seem to realise when interpreting their results. As a consequence, more circumspection should be placed by anyone wishing to link the two research fields. We tackle this issue in Sect. 2.

Second (in Sect. 3), we will try to go beyond the specific problems affecting the econometrics of LKSs, and suggest that its excessively broad interpretation of the concept of "tacit knowledge" is a weakness shared by many NIGs' contributions, as witnessed by some recent re-thinking of the two categories of knowledge "tacitness" and "codification" within the NIG field (e.g., Capello 1999; Lawson and Lorenz 1999). Here we push that re-thinking to an extreme, and suggest that the difficulty of testing many of NIGs' contributions mainly originates from the lack of conceptual clarity when it comes to disentangle the different ways knowledge flows are appropriated by economic agents, both local and non-local.

We conclude that in order to defend, and possibly popularise, local innovation systems as a legitimate research agenda, one has to do better than seeking refuge in the econometrics of LKSs. At the same time, in order to avoid the LKS trap, the research agenda on innovative milieux and local innovation systems ought to set out more articulate targets and methodologies, some of which we try to enumerate.

2 The econometrics of LKSs

LKSs can be defined as "knowledge externalities bounded in space", which allow companies operating nearby key knowledge sources to introduce innovations at a faster rate than rival firms located elsewhere. They are the key object of enquiry of a fast-growing stream of econometric and statistical studies which exploit the increasing availability of large data sets on the innovative input and outputs of firms and regions (see references in Baptista 1998, and more recent work by Henderson 1999; Maurseth and Verspagen 1999; Baptista 2000; Verspagen and Schoenmakers 2000). Although originally proposed as an extension of previous research on the relationship between public and private R&D, innovation, and productivity growth (Mohnen 1996), these studies have increasingly focussed on the impact of spillovers from "local" academic and industrial R&D to firms' and regions' innovative output, thus being increasingly regarded as important contributions to the study of hi-tech industry location.

The most popular tool employed by LKS econometricians is the so-called "knowledge production function", which addresses the impact of external R&D (public, academic, or from rival companies) on private firms' innovation capabilities, the latter being measured alternatively by R&D, patents, innovation counts,

productivity growth, or positive answers to questionnaires enquiring about the interviewees' adoption/introduction of new technologies.[4]

LKSs are also defined as pure externalities, as opposed to pecuniary ones, such as the existence of economies of specialisation and of labour market economies. LKSs exist insofar information about novelties is proved to flow more easily among agents located within the same area, thanks to social bonds that foster reciprocal trust and frequent face-to-face contacts. Therefore, geographical clusters offer more innovation opportunities than scattered locations.[5]

Although often refused by NIGs (see below), these definitions are commonplace in mainstream economics. NEGs' models accept them fully, and so does the econometrics of LKSs.[6] Indeed, the crucial task assigned to the latter is precisely that of providing an empirical counterpart to a theoretical variable, the knowledge externality, which many NEGs often regard as non-measurable, and therefore irrelevant.[7]

All authors of the best-known studies on LKSs (as surveyed by Feldman 1999) seem to be unanimous in concluding that they have accomplished their task (with the only possible exception of the pioneering one, i.e., Jaffe 1989).

To share their view, however, one should first put under severe scrutiny the typical LKS story. In Breschi and Lissoni (2001) we propose to break it into a three-step logical chain:

a. knowledge generated within innovative firms and/or universities is somehow transmitted to other firms;
b. knowledge that spills over is a (pure) public good, i.e., it is freely available to those wishing to invest for searching it out (non-excludability), and may be exploited by more than a few users at the same time (non-rivalry);
c. despite b., knowledge that spills over is mainly "tacit", i.e., highly contextual and difficult to codify, and therefore is more easily transmitted through face-to-face contacts and personal relationships, which require spatial proximity; in other words, it is a public good, but a local one.[8]

Such a logical chain exposes itself to a number of critiques, two of which we recall here.

[4] Other methodological approaches are reviewed by Breschi and Lissoni (2001).

[5] On this point see again the references in Footnote 2.

[6] Both the LKS econometricians and NEGs share the definition of their object of enquiry as being given by intra-industry or Marshallian or MAR externalities, where the latter stands for "Marshall-Arrow-Romer", as opposed to urbanisation externalities, which are said to occur whenever job or innovation opportunities are enhanced by exchanges and cross-fertilisation among technologies and sectors, i.e. inter-industry externalities. The latter are most likely to appear within large urban centres, while the former may be available even at some distance.

[7] Most notably, scepticism about the operational relevance of LKSs has been expressed by Krugman (1991a, 1999) and contested by Audretsch and Feldman (1996). See also David (1999).

[8] As Audretsch (1998, p. 23) puts it: 'The theory of knowledge spillovers, derived from the knowledge production function, suggests that the propensity for innovative activity to cluster spatially will be the greatest in industries where tacit knowledge plays an important role. (. . .) it is tacit knowledge, as opposed to information, which can only be transmitted informally, and typically demands direct and repeated contacts.'

First, it might be that what standard methodologies (such as the production function) and data sets (patents and innovation counts) suggest to be pure externalities will turn out to be, at a more careful scrutiny, knowledge flows that are mediated by market mechanisms (Griliches 1992; Geroski 1995). These mechanisms influence local firms' innovation opportunities indirectly, that is via pecuniary, rather than knowledge externalities.

Second, the a.-to-c. logical chain regards "tacitness" as an intrinsic property of some scientific or technical fields' knowledge base (stock), and a synonym for non-codifiability. This goes against the most recent developments in the economics of knowledge codification, which suggest that tacitness ought to be referred to knowledge flows rather than stocks, and codification to be both a means for diffusion, and a powerful tool for exchanging messages which appear tacit to outsiders (Cowan et al. 2000; Steinmueller 2000).

2.1 LKS and the knowledge production function

The knowledge production function relates R&D (and other innovative inputs) to innovation output measures, such as patents or innovation counts. A distinction is then put forward between local vs. distant external innovation inputs, i.e. between inputs coming from outside the observation unit, but within its own geographical area (or in a nearby one), and those inputs originated not just outside the observation unit, but also far away from it. Significant differences between the estimated parameters of the two kinds of R&D are then interpreted as evidence in favour of the existence and the localisation of R&D spillovers. As we discussed above, knowledge tacitness is called in to explain why distance matters.

However, a number of logical shortcomings stands in the way of a full identification of LKSs, as measured by this approach, and the implications of knowledge tacitness.

In early works (such as Jaffe 1989; Acs et al. 1992 and 1994), input and output indicators were usually grouped into a restricted number of:

1. Technological areas (e.g., "electronics, optics, and nuclear technology" or "mechanical arts", as in Jaffe 1989);
2. geographical units (most typically, the US state).

We notice immediately that the choice of too broad technological areas goes against the presumption of any serious matching between firms' technological competencies, corporate R&D objectives and public bodies' research topics and expertise. Technological and scientific distances are far too great to let us presume that people active in the specific disciplines comprised in such areas will be more likely to share or combine their knowledge than people active in disciplines belonging to different fields. That is, arguments militating in favour of localisation of knowledge spillovers, such as the highly specific and tacit nature of technical

and scientific knowledge, are at odds with the most easily available econometric proxies.

Similarly, state boundaries are a very poor proxy for the geographical units within which knowledge ought to circulate. US states simply are too large geographical units to allow us to assume that inventors, entrepreneurs and managers living in one state will have more chances to have face-to-face contacts between each other than with people living elsewhere. Similarly, there is no reason to presume the existence of a common cultural background, nor a close set of parental or friendship ties, which ought to make mutual understanding and trust easier, and reduce transaction costs.

This tendency to force an interpretation on the data is even stronger in Feldman and Florida (1994), who insist upon explaining the agglomeration effects they measure by calling in the existence of (non-measured) "network effects". If by "network" we mean a set of interpersonal relationships, this explanation clashes against the fundamentals of tacit knowledge, which requires mutual understanding of working practices, and can hardly believed to be exchanged across 3-digit industries by means of informal contacts. On the contrary, if networks are referred to commercial inter-firm relationships, it becomes once again very hard to distinguish pure (knowledge) externalities from pecuniary ones.

Jaffe (1989) was well aware of these problems and tried to work out some remedy by adding to his regression an index of co-localisation for the various knowledge sources, whose significance, however, was admittedly poor. More recently, Anselin et al. (1997, 2000) have proposed to solve these problems by including explicitly in the model a spatially lagged variable, namely the university R&D expenditures carried out within varying distances from the recipient firm, and by adopting a smaller spatial unit of observation than the states (i.e., the so-called SMSA). In addition, they also applied spatial econometric techniques to take into account the possible effects of spatial autocorrelation either in the dependent variable or in the error term.

Also Audretsch and Feldman (1996) have improved upon their previous work, by making use of less aggregated technological areas (proxied by 4-digit SIC sectors). Their results show, more convincingly, that innovative activities tend to cluster spatially. However, much less convincing is the authors' claim that such results may be explained by what they call the 'considerable evidence supporting the existence of knowledge spillovers' (i.e., the studies we have just commented above). This amounts not to prove, but rather to assume the existence of knowledge externalities and then recall it as the only reasonable explanation for their results.[9]

[9] Similarly, Feldman and Audretsch (1999) make use again of the innovation production function (by city *s* and 4-digit SIC industry *i*) to test the role of specialisation vs. diversity, i.e., Marshallian vs. Jacobs LKSs. When they reach the conclusion that diversity matters more than specialisation, they rush to interpret this as evidence that knowledge spills over across sectors rather than within, although they have provided no evidence whatsoever regarding the existence of knowledge spillovers as such.

2.2 Knowledge tacitness reconsidered

When coming to exemplifying what they mean by LKSs, many authors end up with mixing up radically different kinds of externalities. On the one hand, it is argued that critical knowledge inputs diffuse through the markets for specialised services and through the market for skilled workers, both of which imply that knowledge is embodied, and shows up through pecuniary externalities. On the other hand, it is also argued that intangible knowledge diffuses through informal contacts and meetings at the bar.

At the very least, one should keep these two notions well distinct, and not equate them under the heading of LKSs. Even more desirable it would be to sort out what is the relative importance of the various mechanisms supporting the diffusion of knowledge. In this respect, apart from anecdotical evidence and casual observations, there are only a few studies that have attempted to identify and examine the mechanisms by which technical knowledge is shared.[10] Although generalising from these studies is quite difficult, some points are worth being stressed:

a. Knowledge sharing is less likely in industries that are experiencing a rapid pace of technological change. "Collective invention" is a suitable way of organising the innovation process if and only if firms do not devote appreciable resources to the discovery of new knowledge, and it is very costly or simply impossible to keep relevant information secret, so that it is individually profitable to release technical information (Allen 1983). Many hi-tech industries, although located by cluster, do not fit these quite stringent conditions (e.g., biotechnology, as in Zucker et al. 1998).
b. The higher the level of turnover in labour market and the stronger the intellectual property regime, the more likely it is that the departed employees will resort to previous co-workers for technical advice. However, this knowledge sharing is likely to involve no more than the exchange of "small ideas", whose disclosure will not jeopardise the originators' rights over related more strategic knowledge. Given common work experience, both parties are in the position to carefully estimate what can be requested and what can be disclosed without resulting in a "competitive backlash" for the disclosing company (Von Hippel 1987; Appleyard 1996).
c. Inter-personal channels of communication are relatively more important for sharing knowledge with customers (possibly being the spy of transaction-intensive relationships), than for sharing knowledge with competitors. Moreover, friendship ties do not play any significant role in heightening the likelihood that two engineers will share knowledge (Schrader 1991; see also Lissoni 2001).

[10] Among others: Rogers (1982), Allen (1983), Von Hippel (1987), Schrader (1991), Appleyard (1996), and Lakhani and Von Hippel (2000) (more references in Cowan and Jonard 2000). See also Zucker et al. (1998a, b) on the relative importance of knowledge sharing vs. labour mobility. In Breschi and Lissoni (2001) we dig further into the issue of labour mobility as a vehicle for knowledge diffusion.

d. Overall, the evidence on inter-personal knowledge sharing does not point at physical proximity as a necessary requirement for the success of the interaction: ICT technologies, coupled with a limited number of meetings may well serve the purpose of exchanging technical advice (Lakhani and Von Hippel 2000).

Altogether, these studies suggest that technical or scientific knowledge is not just "tacit". More precisely, knowledge exchanges may be tacit, even when they are trusted to very formal means of communications (such as mails, scientific articles, or even public conferences). This is so because technical knowledge (and even more scientific knowledge) is highly specific, and the jargon by means of which it can be transmitted is not the same jargon of the broader social community, which hosts the firm and its workers. Rather, it is the jargon of a much closer and restricted community (an "epistemic community"). Members of the community learn it by joining it to practical experience, and cannot transmit it to any outsider by informal means. Even when the jargon gives way to a structured language, i.e., it is fully codified and accessible through study, tacit exchanges are still possible: the access to the codebook will discriminate between those who can grasp the meaning of the messages, and those who cannot (or at least have to sink in very high costs to learn, or reverse-engineer the codebook). Far from being incompatible, the codification of knowledge and the exchange of tacit messages are often complementary (Steinmueller 2000; Cowan et al. 2000).

Besides, technical knowledge, far from being static, is highly dynamic: incremental technical change takes place in all sectors of activity, and brings about new codes of communications as well as new artefacts, which change the practitioners' vocabulary: outsiders, however close, may learn nothing of that vocabulary. Physical proximity does not imply any social proximity, and not only in large urban centres: epistemic communities are never as wide as to include all members of a local community, and in many cases not even a significant minority of the latter's members. Therefore, knowledge may be far from accessible to most of those who are located nearby its sources.

Conversely, epistemic proximity may arise from shared work or study experiences, or former co-operation efforts that required face-to-face contacts and a high degree of socialisation, but then survive to their end. Although highly dispersed in space, members of these epistemic communities share more jargon and trust among them than with any outsiders, no matter how spatially close. More generally, social proximity has many more dimensions than the spatial one. Communities of scientists, as well as community of engineers and practitioners (such as those working for large multinationals or transnational public bodies) may be as tightly linked, as they are geographically dispersed (Rallet and Torre 2000).

If anything these remarks point out that the sharing of tacit knowledge, as an explanation for the existence of LKSs, has been probably overrated. The concept itself of knowledge tacitness has been stretched too far for being still useful.

In the next section, we argue that those NIGs who insist upon it, fail to differentiate enough their arguments from the LKS-seekers, and do not serve

well the cause of countering NEGs' dismissal of innovation as an agglomeration force, no matter how righteous that cause may be.

3 NEGs, NIGs, and LKSs

In this section we explore the links between the LKS story and NIGs' research on local innovation systems. We try to show that, despite a few contrary claims from the NIG field, one can detect some crucial contact points, especially in the way the concept of tacit knowledge is dealt with. A useful starting point for our excursion is the recent debate between New Industrial Geography and New Economic Geography, especially with respect to NEGs' frequent dismissal of localised knowledge diffusion as a meaningful agglomeration force.

3.1 NEGs' scepticism

Since the early 1990s, NEG has been one of the fastest growing fields in contemporary economics. Following Krugman's (1999) assessment of the literature, we can characterise NEG as a re-discovery of classical location theory, where most emphasis is placed upon Marshallian externalities as the key agglomeration force, and new theoretical elements consist mainly in the application of models of monopolistic competition to describe firm behaviour, in contrast with former assumptions of perfect competition. By means of their models, NEGs insist on location being driven not by exogenous distribution of natural resources in space, but by path-dependent trajectories set in motion by historical accidents.

NEGs assume the 'tendency of production activities to cluster in space' as a stylised fact. Although they do not commit themselves to stylise *formally* the scale at which clustering ought to be measured (cities, regions or states, all being dots and spots on a Cartesian space) a general preference seems to be given to 'large inter-regional agglomerations such as the "Manufacturing Belt" in the US and the "Hot Banana" [sic] in Europe' (Ottaviano and Thisse 2000, pp. 8–9).

Rather than checking empirically for the accuracy of the assumed "stylised fact", NEGs concentrate on theoretical models, which they charge with three tasks:

1. to explore the extent at which different market structures (perfect vs. monopolistic competition) and technological conditions (constant vs. increasing returns) are more or less conducive to agglomeration;
2. to discuss which kind of externality, pecuniary vs. technological, is more likely to drive agglomeration;
3. to promote "mainstream" economic modelling as the best way to deal with the stylised facts, in contrast with less rigorous, non-formal theorising coming from other social scientists, in particular more traditional economic geographers.[11]

Tasks 2. and 3. are closely linked. Most NEGs are wary of explanations based upon knowledge spillovers, and insist upon pure pecuniary externalities, with labour market and demand externalities coming top of the list.[11] One typical argument is that knowledge transmission is costless, or that costs do not depend on distance, so that there is no *a priori* reason to believe that proximity may ease access to knowledge spillovers; or, more cautiously, that knowledge flows leave no track, so that no LKS-based theoretical model can be seriously tested (Krugman 1991, p. 53). Alternatively, it is suggested that LKSs cannot (yet) be properly modelled, since they are the result of complex non-market social interactions, whose analysis require modelling techniques that are presently missing from the mainstream economists' toolbox (Ottaviano and Thisse 2000, p. 9).

These remarks explain why one of NEGs' preferred polemical target, when it comes to task 3., are New Industrial Geographers (NIGs), who in turn have increasingly recognised NEGs as a serious threat to their disciplinary status (Martin and Sunley 1996; Martin 1999).

3.2 NIGs' enthusiasm

Despite being a much wider and more heterogeneous group, NIGs accept, and often openly propose LKSs as a very important agglomeration force. Indeed, many research efforts within NIG are placed upon explaining how and why knowledge spillovers are extremely likely to be highly localised. Most favourite explanations call in, once again, the distinction between tacit and codified knowledge that we have seen informing the econometrics of LKSs.

Admittedly, it would be hard to find any NIG agreeing explicitly on "knowledge spillovers" to be an acceptable explanation for industrial location. A quick browse through the writings by the likes of Annalee Saxenian or Giacomo Becattini would reveal a number of instances in which the authors oppose their concepts of "industrial system" or "*mercato comunitario*" to textbook definitions of "external economy". In particular, most NIGs would insist on a number of pre-conditions for knowledge to diffuse (more) effectively on a local base. Such conditions have to do with the existence of local institutions and culture promoting mutual trust, entrepreneurship, and, possibly, a sense of belonging to the local community of people and firms.[13]

[11] Co-evolution of technologies and institutions (public administration bodies as well as rules and norms) is also neglected, along with research on National Systems of Innovation.

[12] Promotion techniques vary a lot: not all NEGs share Krugman's patronising attitude that offended so many economic geographers (Martin 1999, pp. 82–83). However, even more appeasing authors, such as Ottaviano and Thisse (2000), propose their work as a necessary toolbox for introducing some rigour in a field that for too long has been lacking it: 'Although [our] insights are not necessarily new (. . .) we believe that their formalisation is both useful and promising. First, there is a distance between 'ideas' and 'theorems' that social scientists sometimes underestimate. In particular, analytical economic models allow for a more precise description of the forces at work and of their interplay as well as for their welfare implications' (Ottaviano and Thisse 2000, p. 2).

[13] See in particular Saxenian (1994, pp. 4–6) and Becattini's (1989) classification of local industrial clusters, according to the intensity of internal social networking.

To what extent such pre-conditions can be met by different localities is a matter of lively discussion within NIG. The explanations that derive the existence of effective institutions and corporate attitudes from long-term historical developments (as it often happens in the Italian literature on industrial districts) often clash against more policy-oriented interpretations of the same intuitions, as long as such interpretations suggest that a proper institutional framework can be set, and the right "mentality" fostered, even in local settings that lack any manufacturing tradition, or have gone through deep de-industrialisation processes (Morgan 1997). More generally, the issue of cultural specificity stands in the way of a general agreement on the definition of what is required by an industrial cluster to be defined as an industrial district, or an innovative milieu.[14]

Much less discussion, however, would be spurred, among NIGs, by the concept of knowledge tacitness. Hardly any disagreement would be raised by the statement that much part of the technical knowledge leading to valuable innovations can be exchanged only via intense face-to-face communication, on-the-job practical examples, and labour mobility (which include recurrent self-employment of skilled workers, technicians, and scientists, for the exploitation of innovation opportunities). Even less disagreement would be raised by defining knowledge trusted to such diffusion means as "tacit". And no disagreement at all would be raised by the statement that the specific institutions and social norms of successful local innovation systems are indeed responsible for having promoted such diffusion. The final step would be then to suggest industrial clusters meeting the right requirements as legitimate 'observation units', both for the analysis of innovation processes and even more for policy purposes (as in the "learning region" research project outlined by Keeble and Wilkinson 1999).

This brings us back to the LKS story, since hardly none of the authors we mentioned in Sect. 2 would disagree with our (forcefully simplified) account of the way NIGs discuss the reason for the localisation of (tacit) knowledge. Indeed a few of them quote it explicitly (see again Footnote 2).

Going back to the three-step logical chain we outlined in Sect. 2, NIGs' contribution can fit in it quite nicely, as an explanation of the conditions which allow knowledge to become a "club good",[15] i.e., a good which is shared by the members of a local community of firms and/or people. If provided with the necessary observables, any good LKS econometrician would control for them

[14] See, for example, Storper's (1992, pp. 89–90) proposal of "technology districts" as a special case of industrial districts, which rests upon, among others, the different pace of technical change, industrial strcuture, and "conventions of economic life". More generally, over-abundance of definitions and catchwords (industrial district, local system of innovation, technology district, innovative milieu, just to name a few) betray some degree of uncertainty in classifying the degree of "institutional thickness" (Amin and Thrift 1995) and the nature of social bonds (family ties, or a common corporate or educational background) that ought to sustain the innovative capabilities of an industrial cluster. Further areas of disagreement, which indeed have promoted much of the most recent research in the field, have to do with the influence of external links on the innovative capacity of local clusters (Keeble and Wilkinson 1999).

[15] The use of Buchanan's (1965) definition of club good for describing the way in which knowledge is shared within local systems of innovation is intriguing but ambiguous. Compare, for example, our use in Breschi and Lissoni (2001) with Capello's (1999).

by adding a few variables to her regression exercise, in order to capture the existence/non-existence of a milieu, or the different socio-institutional structure of different milieux. NIGs' same insistence on the need for a multidisciplinary approach to the study of local innovation systems would provide some arguments in favour of this treatment, which simply pushes that insistence to the extreme of considering the sociological and institutional features of local systems as exogenous control variables. With this respect, there is a seed of truth in Kenney's and Von Burg's (1999) criticism of cultural explanations of the Silicon Valley story, which they mark as "static".

It is as if NIGs' contributions, despite their non-orthodoxy, were running the risk of being re-absorbed in quite a mainstream economic approach such as the econometrics of LKSs, especially in its knowledge production function version. Worse than this, if NIGs' work can be reduced to a sociological addendum to the knowledge externality theory, New Economic Geographers would be right in listing it either as merely introductory evidence on the importance of pure vs. pecuniary externalities (as it happens with most benevolent NEGs, such as Ottaviano and Thisse), or as non-rigorous claims to be dispelled by proper economic modelling (as in Krugman's writings, as quoted by Martin and Sunley 1996).

Why is it so? Our answer points to the treatment of the concept of knowledge tacitness, that NIGs do not handle much better than LKS researchers.

3.3 Knowledge tacitness (once again) reconsidered

Case-study accounts and generalisations about what is really going on inside innovative milieux vary a lot. As pointed out by Lazerson and Lorenzoni (1999), on the one hand there are suggestions of (small) firms within the clusters to be tightly linked by stable networks (Storper and Harrison 1991; De Vet and Scott 1992), while on the other hand most emphasis is placed on the quasi-perfect competition conditions that supposedly reign, with high turnover rates and frequent changes of vertical specialisation (as in much of the Italian literature on Industrial Districts operating in traditional manufacturing). A similar distinction is also proposed by Capello (1999), who opposes innovative milieux (as the only clusters capable of collective learning) to other forms of agglomeration, such as Marshallian districts.[16] At a superficial glance, this variety of knowledge-localisation mechanisms looks like a fascinating collection of sensible explanations. At a closer look, however, a number of logical twists and dead ends come to the surface.

Although both types of local firm networks (stable vs. quasi-competitive) can be perfectly suitable and effective, one should also recognise that the mechanisms supporting knowledge flows are very different and do not forcefully imply physical proximity as a requirement for knowledge exchanges. Above all, some of

[16] The former would host firms' partnership openly addressed at exchanging knowledge, as well as sharing innovative aims, while the latter would be no more than favourable sociological environments for the deployment of knowledge externalities. See also Storper (1992), as quoted in Footnote 14.

these mechanisms are incompatible with the view of a specific location (whether a region or a district) as a "learning" entity, i.e., as a sensible unit of analysis.

In the case of stable networks, local firms are tied in a transaction-intensive system of production. This set of network-mediated transactions, is a key mean for internalising knowledge: network-specific technologies are developed by co-operation and/or long term supply relationship, and are largely appropriated by network participants. The co-localisation of the network participants (and therefore the resulting agglomeration of innovative activities) has not much to do with the need to access a pool of knowledge spillovers from outside the network. Rather, when firms are constantly innovating and are frequently changing process and product configurations, there may be the need to be close to a constellation of allied firms and specialised suppliers in order to smooth input-output linkages. These observations have two important implications:

a. The same geographical area can host *competing firm networks*, and therefore it may not represent a meaningful observation unit as such: firms within the same area may share very little of their technical knowledge with local competitors (see evidence in Lissoni 2001).[17]
b. Localised labour mobility and the co-existence of competing networks, as means for diffusing knowledge within a region, may be mutually incompatible. At the very least, if it is labour that embodies top-rate knowledge, labour mobility can hardly take place across competing networks, because that would undermine the latter's stability (even vertical mobility inside the network may need to be ruled by informal agreements and rules of compensation among firms).[18] On the contrary, if network knowledge is embodied in organisational routines and co-operation practices, mobility may be confined to unskilled workers, while skilled ones will be wary to move around, as their knowledge assets are highly complementary to the firm, or the network, wherein they developed them (see again some evidence, although weaker, in Lissoni 2001).

Here one can find it useful to consider once more the recent theorising on the economics of knowledge codification we have recalled in Sect. 2. In particular, we can observe that competing firm networks may hide their knowledge to each other even when communicating openly, or even when loosing some knowledgeable employee to each other, as long as this happens on an occasional basis. This is because lasting inter-firm co-operation results in knowledge specificity and a common codebook, both of which cannot easily understood by local competitors, no matter how close they are located. Similarly, locating closely to networks members enhance the creation of "epistemic communities" of technicians, scientists or engineers within the network: the latter will open up to

[17] This does not prevent local entrepreneurs from setting up joint promotional activities, or exerting some joint political action to ask for infrastructure or economic incentives. However, none of these cooperative experiences imply any joint innovation effort, nor any exchange of technical information.

[18] On this point, Almeida and Kogut (1999) find that, within the field of electronic technologies, local cluster with comparable rates of innovation activity are affected differently from the mobility of engineers, with Silicon Valley being the exception, rather than the rule.

members of other networks' communities, but will retain their loyalty towards the firm or the network they belong to, i.e., they will exchange generic, rather than specific knowledge. Individual networks, and the regions they belong to, could be the right observation units of analysis, especially if those networks may also count upon (non-shared) external links.

Concerning the quasi-competitive interpretation of local networks, these are more correctly seen as made of individuals, rather than firms. In addition those individuals, far from being described as "economic agents" as in standard microeconomic textbook, are first and foremost defined by their belonging to a "local community", which has a well-defined cultural identity and is often seen as an inexhaustible reservoir of entrepreneurial forces.

Therefore, according to this view, it is not the firm that innovates. Rather, it is the surrounding social community that share the relevant knowledge and diffuse it by informal conversation, while producing incessantly new entrepreneurs eager to exploit and refine it. Alternatively, it is individual workers who are supposed to embody all relevant knowledge, and it is suggested that high, but localised labour mobility and firm spin-offs ensure both fast diffusion inside the area, and no diffusion outside it.

Even in this case one can contrast the view of regions as "learning entities" to the much more restricted concept of "epistemic community". The latter hardly extend to the whole of local community, and at the same time may cross many geographical boundaries. As long as common working or study experiences (as in the "Fairchildren story", or in many accounts on the role of local universities) contribute to create some degree of "social proximity", by no means we need to believe that this will not resist to physical distance. At the same time, social bonds are often the outcome, and not the premise, of the economic or professional partnerships.

Above all, whatever their origins, those partnerships could be maintained even at a distance. As long as tacit messages can be exchanged by codified means (if the code is not disclosed), distance is not a problem, and a few meetings are always possible. How frequent must face-to-face contacts be? Very few authors ask this question, and even less have answered it (a key exception being possibly Von Hippel 1994).

Nevertheless this is a crucial question. Codification is costly, but it does not reduce knowledge to pure information, and indeed can ease communication between members of the resulting epistemic community, without necessarily diminishing appropriability (and possibly enhancing it). As a result, investing in it can be a sensible choice, which may be particularly attractive for dispersed communities, or for local companies in search of knowledge outside their local realm.

This is not deny that flexibility, pecuniary externalities, political effectiveness, and whatever virtues are attributed to industrial districts and the likes may play a role in fostering agglomeration. Rather, it is to stress, once again, that many of those virtues do not have necessarily to imply any knowledge-related activities, not at least of the kind more immediately conducive to technological innovation.

More recent work on the issue of innovative milieux seem to acknowledge this. Besides Capello (1999), whose definitional remarks we have already quoted, one can find some critical reflections also in Lawson and Lorenz (1999), who follow Becattini and Rullani (1996) in recalling Nonaka's distinction between codified and contextual (largely intended as "tacit") knowledge (Nonaka 1991; Nonaka and Takeuchi 1995). They do so because interested in stressing, quite rightly, that no "learning region" could without external knowledge sources; and that the latter can hardly be accessed by the same informal means that supposedly reign within those learning regions. It follows that the usual counterposition of tacitness vs. codification, as imposing different location requirements for accessing knowledge, cannot hold.

The authors argue thus that the absorptive and innovative capacities that Nonaka attribute to a few Japanese (large, or very large) companies are indeed very often found in 'successful high technology regions' (Becattini and Rullani found them in the most innovative among Italian industrial districts). Knowledge outside those regions is codified, but only a limited number of agents inside the regions can access it, provided that they share both the regional culture (and social ties) and the scientific or technical language used by external sources. Those agents are suggested to have the power of translating local tacit knowledge into codified knowledge, in order to recombine it and enhancing it with external knowledge, and bringing it back into the region, where it will be further enhanced, and turned into tacit knowledge once again.[19]

Besides a number of weaknesses in the analogy between companies and regions,[20] this line of reasoning keeps the concept of tacit knowledge at a highly metaphorical level, and fails to grasp the key message from much of same theoretical research it claims to recall. Which is that tacitness is no intrinsic property of any stock of knowledge, but a property of how knowledge is used or transmitted, and has much more to do with the relative understanding capability of those who communicate, than with the specific means of communication. Tacit messages can be exchanged at a distance, as long as the level of mutual understanding of those who exchange it is similar. And the balance between face-to-face interaction and other forms of communication has no less to do with economic calculations, than it has with social bonds and institutions.

This brings us back to same critique we levelled against the LKS story. It does not matter how much emphasis one places on the institutional and sociological framework, as pre-conditions for the appearance of some (local) public good features in technical and scientific knowledge: the problem is further upstream, and it stays with the impossibility to associate geographical distance and know-

[19] In their discussion on the relationship between tacit and codified knowledge, Lawson and Lorenz also acknowledge Cowan's and Foray's (1997) remarks of knowledge codification as a contribution to knowledge creation.

[20] For instance, how can company routines be assimilated to the 'rich history of local interaction between users and producers' in hi-tech regions? Both are said to produce tacit knowledge, but one can hardly compare large company employees' administrative behaviour to local entrepreneurs knowledge of people and crafts.

ledge characteristics, by arguing that the latter impose the use of transmission means which require the former.

Therefore, in order to counter NEGs' scepticism, more research efforts should be placed on finding out how knowledge is transmitted, among whom, at what distance, and on the basis of which codebooks. We come back to this in the Conclusions.

4 Conclusions

This article has provided a critical re-assessment of the recent literature on localised knowledge spillovers (LKSs). The central point we have stressed is that the related notions of LKSs and tacit knowledge have been somehow abused, thereby generating conceptual confusion and creating distortions in research agendas.

Contrary to NEGs, we are not denying that knowledge flows are an extremely important agglomeration force, and that a very large part of these flows takes place at the local and regional level. What we question is the strategy of putting all these flows under the common heading of LKSs, as a way of (re-)discovering regions as the right unit of observation. The problem is not merely one of terminology.

In fact, as soon as one tries to open the black-box of LKSs, it becomes quite clear that:

a. what might appear at first as 'pure' knowledge externalities are actually 'rent' (or pecuniary) externalities, which are mediated by economic (market and non-market) mechanisms, such as the labour market and firm networking;
b. what might appear as involuntary (pure or rent) knowledge externalities are actually well-regulated knowledge flows across firms, or between research institutions (or individuals therein) and firms, that are managed with deliberate appropriation purposes.

These observations set a tight research agenda for all those who want to understand how and why geography really matters for innovation.

The first entry in the agenda is the labour market. A crucial mechanism through which knowledge diffuses locally is via the mobility of technologists and scientists, either across firms, and between firms and academic institutions. We expect that studying the career patterns of these professional figures will reveal a number of relevant aspects about how knowledge is diffused.

The second entry has to do with firm networks, and particularly with the geographical dimension of such networks. These are likely to be a much more fruitful unit of observation than the region or the state as such, since they are an organisational arrangement that allow firms both to circulate and to internalise many knowledge flows. In particular, an explicit link should be established between the geographical dimension of knowledge flows and the research on all the contractual arrangements that allow firms and individuals to appropriate their knowledge rents, as well as the disclosure rules foreseen in those arrangements.

A third line of research should deal with the "real" impact of research facilities and local universities, on firms' innovative activities. Our opinion is that the 'spillover' perspective has obscured the wide set of mechanisms through which local universities actually contribute to firms' research efforts. More efforts could be placed in studying the knowledge-based services sold by the academic institutions (or individual scientists therein) to local and non-local business companies.

In all cases, local ties ought to be explored by overcoming the easy metaphor of the "local community". Similarly, much less emphasis should be placed upon interviews (especially open ones) as a means (often the chief one) for collecting evidence: tales about the importance of culture and institutions now circulate widely even within the most common interviewees, whether they are managers, entrepreneurs or scientists and engineers. Telling those tales apart from the actual experience of the interviewees is too often quite a hard task.

In most cases, the existing data sets on R&D, patents, and innovations counts will still have to play a prominent role. But they will need to be coupled with additional evidence on the identity and the activities of individual firms and inventors; and their use will have necessarily to be much more creative than fitting them all into one production function. In this respect, some recent exploratory works making a more creative use of existing data sets and aiming to develop new indicators include studies on the localised mobility of researchers and engineers (Almeida and Kogut 1999), R&D, citation, co-publication and inventor networks (Cockburn and Henderson 1998; Tijssen 1998, 2001; Verspagen 1999), and surveys of industrial and academic scientists (Mansfield 1998; Audretsch and Stephan 1996).

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