WP4/11 SEARCH WORKING PAPER

European Integration as Policy Metaphor for future EU-EN Knowledge Sharing

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January 2013

SEARCH
SHARING KNOWLEDGE ASSETS: INTERREGIONALLY COHESIVE NEIGHBORHOODS

EUROPEAN COMMISSION
European Research Area

SEVENTH FRAMEWORK PROGRAMME

Funded under Socio-economic Sciences & Humanities

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2010-2.2-1) under grant agreement n° 266834

European Integration as Policy Metaphor for future EU-EN Knowledge Sharing

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Abstract

This paper focuses tightly on how EU post-accession countries and regions evolved in their reliance upon and growing participation in beneficial knowledge flows that result from the information embedded in patent citations from advanced countries. In this paper we illustrate one aspect of the cross-border knowledge flow process more fully in situations structurally similar to future ENP circumstances.

Relying upon OECD's patent data base and network analytics, we note patent citation in Europe included more than 200,000 citation links between 1999 and 2008, about 48% occurring in the first 5 years and 52% in the second 5 year period, an increase of about 7%, of which 10,500 patent citations crossed the East-West border and grew more rapidly (23%) between the periods. Communities of reciprocal patent citation observed in Europe are likely to evolve over time, eventually to include ENP countries, particularly the advantageously favored regions and those closest to borders. These are also the places most likely to cite patents in different patent classes as novel circumstances generate new innovations.

The effects of other closely-related ENP initiatives will influence which ENC regions can take fullest advantage of potential knowledge flows within relevant citation exchange communities. Developing ENC regions are expected to be citation-knowledge consumers in early rounds, similar to accession country experience, a dependence which may continue indefinitely for all but the most advanced or technically-specialized ENC regions, although more standardized industrial process and business practice technologies could benefit ENC border regions initially from physical proximity. The possibility that cross-border agents may be better positioned to take advantage of new innovative possibilities by cross-citing patent classes should be exploited with absorptive capacity measures in ENCs.

Introduction. A significant element of the EC's intention in pursuing a robust European Neighborhood Policy is to raise the standards and capabilities of neighboring states as active regional partners. While such improvements range widely over many spheres of action, the recent evidence in EU-15 and several subsequent accession countries points to the primacy of knowledge flows and innovative advances in stimulating such improvements.

However, recent research has highlighted important limitations to the search for innovative knowledge flows or the capacity to capitalize upon them (Goldberg, Branstetter, Goddard, Kuriakose, 2008). Their research finds post-socialist Eurasian countries patent and innovate less than expected, gain little—sometimes even lose—innovative capacities from the presence of potential FDI sources, while efforts to learn by exporting has had widely varying impacts on absorptive capacities and innovative upgrading of neighboring countries. They note (p. 32) that:

> …seven countries—the Czech Republic, Estonia, Hungary, Poland, the Slovak Republic, Slovenia, as well as Turkey—started off by participating in network trade in clothing…However, prompted by rising wages, these countries were able to move into sectors such as automotive and information technology (IT)—which are intensive in skilled labor and capital and, in the case of IT, *intensive in knowledge as well*—by using foreign capital and know-how and the so-called "producer-driven" production chains….Such a transition to producer-driven networks has, however, not taken place for CIS countries such as the Kyrgyz Republic, Moldova, and Turkmenistan, which are involved in the buyer-driven production chains of the clothing trade. Nor has it happened in Belarus, Russia and Ukraine…

The many facets of FDI, trade, regulatory reform and skill upgrading that are linked to the successful acquisition and absorption of knowledge flows may be found in a range of literatures [see as examples: Alam, A., Anos Casero, P, Khan, F & Udomsaph, C (2008); Bell, M (1997); Bell, M & Pavitt, K (1993); Campos, NF. & Coricelli, F (2002); Cohen, W & Levinthal, D (1989); Crafts, N & Kaiser, K (2004); Falcetti, E; Lysenko, T & Sanfei, P. (2006); Goldberg, I, Branstetter, L, Gabriel Goddard, J, & Kuriakose, S, 2008; Goldberg, I, Branstetter, L, Gabriel Goddard, J, & Kuriakose, S, 2010; Kravtsovaa, V & Radosevicb, S (2009)] and is investigated further in several companion SEARCH working papers.

However this paper focuses tightly on how those EU post-accession countries mentioned in the passage above evolved in their reliance upon, and growing participation in, the beneficial knowledge flows that result from the information embedded in patent citations. Their successful transitions relied upon externally-sourced knowledge to fuel their industrial dynamics. By illustrating one aspect of the knowledge flow process more fully, we propose that much can be learned about what is possible among the EU's present neighbors, given EC initiatives to promote a vigorous ENP.

Drawing upon empirical evidence such as previous patent citations to formulate future policies is invariably retrospective, not prospective. Therefore, it is important that the evidence brought to bear was generated in situations structurally similar to future application. In this case, we are interested in the possible effects on knowledge flows between the EU and its adjacent Neighbors to the east and south. As documented elsewhere and at considerable length [DeBresson C, Amesse F (1991); Freeman C (1991); Gulati, R, (1998); Jaffe, AB & Trajtenberg, M, & Fogarty, MS, 2000; Jaffe A & Trajtenberg, M, (2005); Kale, P, Singh, H,

& Perlmutter, H (2000); Kogut, B (2000); Mowery DC, Oxley JE, & Silverman BS (1996)], a useful indicator of knowledge flows is the citation of patents awarded in one place by subsequent patent applicants in the same or other places.

We are interested in the EU and the EN as places between which knowledge might be expected to flow following the enactment of successful ENPs (European Neighborhood Policies). The closest analog to this situation is the pre/post-enlargement situation experienced as the EU expanded from 15 to 27 countries, all 12 being post-socialist, beginning in the mid-1990s. While the ENP falls well short of an enlargement scenario, the basic ideas remain the same: opening the EU borders to much greater interaction along a range of policies that are intended to stimulate greater trade, movement of capital, mobility of talent and knowledge flows.

To examine the potential for such interaction, this paper extends earlier and continuing efforts to understand the dynamics of patent citation across once-impenetrable borders that become open through EU initiatives. We have analyzed and described elsewhere how the centroid of patent citers by post-socialist/pre-EU entrant applicants (East) migrated closer to the historical border with the West (EU border countries) patent holders (Bergman and Usai, 2008). More recent preliminary work underway along related lines attempts to trace the effects of patent citation-based knowledge flows on conditional convergence of regional GDP/capita (Ondos and Bergman, 2012).

Relying upon the same OECD patent data base, this working paper exploits network analysis to describe the changes in patent citation flows between 1999 and 2008 between countries East and West of the 2003 accession border. It begins with a description of the data and theoretical perspective, moving to Europe-wide visualizations of key citation links, then to a descriptive analysis of cross-national links, followed by a broad overview of IPC shifts and a conclusion.

Conceptual and Evidentiary Framework. The system of flows created interregional patent citation links is based on the declared location of residence of patent inventors generates a dynamic and complex network of large size to which an increased attention has recently been directed, although the objectives of many such investigations differ from our rather simple application [Audretsch, DB & Feldman, MP, (1996); Bottazzi, L & Peri, G, (2003); Criscuolo, P & Narula, R & Verspagen, B, (2005); Jaffe, AB & Trajtenberg, M, (2005); Jaffe, AB & Trajtenberg, M, & Fogarty, MS, (2000); Maurseth, PB & Verspagen, B, (2002); Paci, R & Usai, S, (2009); Verspagen, B, (1997)]. Understanding the specific cross-border network structure and the principles according to which it evolves, we argue, appears to offer valuable descriptive evidence, potentially bringing to light new insights into knowledge flows across space from the perspective of economy.

There are two crucial features embedded in the network structure of patent citations. The first is that the direction of each network link is known and important. Flow directions are inferred from order of appearance in pairs of citing and cited patent documents that indicate which is the older innovation. An interesting theoretical meaning of citation traces is that they establish a way of observing the phenomenon of *learning* across spatially bounded populations, *diffusion* of innovations shared to certain extent through informal channels, and random *interaction* of specialists exchanging their inspirations. The second feature of the citation network is that the time dimension goes only one direction; a given patent can only cite

patents in existence prior to the applicant invention. This means that network topology itself contains also information on network evolution, reflecting the 'learning' process.
This section explores how patent citation network in a sample of European regions formerly divided in two geo-political blocks evolves in conditions of an ongoing integration of the continent as the EU enlarged. A standard prediction from the neoclassical growth model is that removal of the knowledge diffusion barriers separating two sets of processes in the West and in the East Europe should permit these processes to become increasingly connected as time passes, which in this case is revealed by reliable data between 1999 and 2008 that arise from a cooperation between the EPO and the OECD. Availability of these data is itself a part of cooperation possible in circumstances of a wider European integration.

From the reasons described in methodological section, we select a set of 284 NUTS2 level regions of 27 current EU members, which is further enlarged by Turkish regional set. Our sample excludes Switzerland and Norway, which potentially leads to minor bias in description of the real spatial interaction system affected by ENP. The full decade-long, evolving network consists of 213,490.1 citation links, 103,119.3 of which (48.3%) are observed in first five years, and 110,370.8 (51.7%) in last five years. We can observe a network system with an increasing interaction activity, corresponding to 7.0% between two subsequent periods of equal length. Flow data are represented in a standard interaction matrix of dimension 284^2, elements of which located on main diagonal have a substantive meaning in description of the network structure. Diagonal elements represent network loops, or regional self-citations, in which the citing applicant and cited patent holder are domiciled in the same region. The share of citation links on the main diagonal is about one quarter of the overall interaction activity. The ratio is not stable; it is increasing from 24.7% in the former to 25.9% in the later period. As overall activity increased by 7.0%, we also observe a 5.1% *increase* of main-diagonal share in the full interaction matrix. This observation of endogenous citation itself is an interesting phenomenon worth further attention.

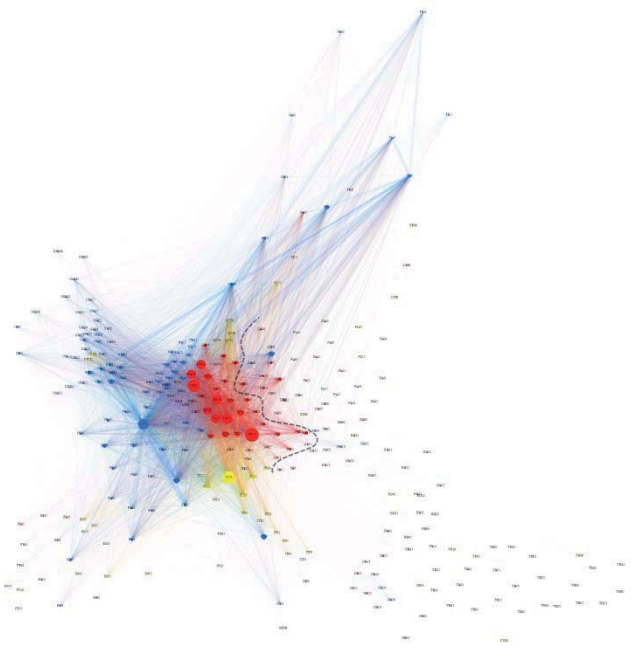
Our main interest is; however, not in the full interaction network, but rather a sub-network analysis of direct links that captures the exchange between two formerly divided regional blocks in the West and in the East. The sample of 284 regions is separated by the former geo-political barrier running between 223 vertices on the West side, and 61 vertices on the East side. The citation exchange between two sets of vertices has been arisen through channels cut by 10,522.1 citation links over a full decade, of which 4,716.5 have been realized in the former, and 5,805.6 have been realized in the later period. The growth of full-sample citation activity is exceeded by exchange of citations between the East and West only, which has increased by 23.1% between the two periods. The share of East-West exchange flows from all non-diagonal flows has also increased from 6.1% to 7.1%, which is a 17.0% increase in proportion. A major question remains, whether such strengthening of East-West interaction is more than it would be expected in case of a completely random network evolution.

Visualizing Trans-European Citation Links

It is common knowledge that some European regions produce many more patents than others, which then become cited in the less patent-intensive regions on both the East and West sides. We might therefore expect to see concentrations of links emanating from these central patent producers to more peripheral patent citers. The following sub-sections lay this out in more detail.

Figure 1. Complex network description. These direct-link networks are aggregated over two periods (1999-2003, 2004-2008). The size of nodes is determined by standardized value of betweenness centrality, which describes the frequency of appearance on shortest paths between all possible node pairs. The most central nodes enjoy the best possible graph location or concentration in terms of total information exchange. The two illustrations below show relatively stable centrality value distributions with the most important vertices located in the core of the continental economy[1]. Colors represent network communities identified by Louvain modularity maximization without hierarchy and overlaps.

Graphs from both periods are dominated by three giant communities, one of which is clearly German, illustrated in red, and other two are blue, and yellow, which represent other generalized knowledge-sharing collectives. Blue appears to originate along the Atlantic-North Sea-Baltic fringe countries, while yellow appears to be Italian and ranges north through mid-continent to the edge of Scandanavia. An emergent green community and further redefinition of the non-German citation communities arise in the second period. The new green group includes some former EFTA countries (A, F, SE), while the Anglo-Francophone blue community absorbs much of Italy as it spins off some Danish and Swedish nodes to the yellow community. Each of these communities is shown separately in attachment 2. Some redefinition of citation-communities doubtless results from national shifts in trade, fiscal health, FDI and marginal expansions of the EU; shifts in intellectual property regimes may also come into play.



[1] The following visualizations do not permit the inclusion of national borders, but they able to portray the East-West border, which is shown.

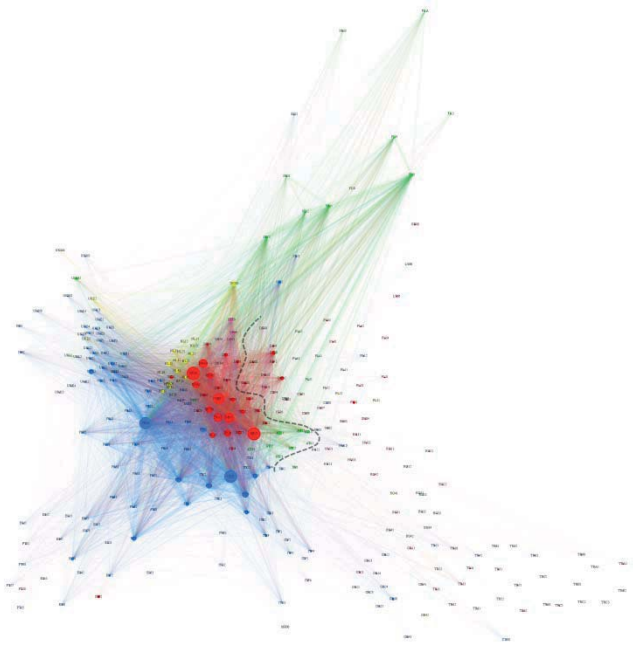


Figure 2. Complex East-West citation description. Two sub-networks of cross-border citation exchange are now defined exclusively between vertices in the East and in the West. During the two periods between 1999 and 2008, about 6.1% and 7.1% of all interactions shown in Figure 1 occurred. Despite a significant increase in network size over the full period, the structure appears to be stable and remains centered on a few key German regions. Virtually all exchange in our database seems to take place within Germany, or between German and non-German regions. Three cross-border communities identified by modularity maximization are centered in Berlin, Dresden, and Thüringen. The former East Germany appears to play a role as the heart of innovation exchange between the West and the East Europe.

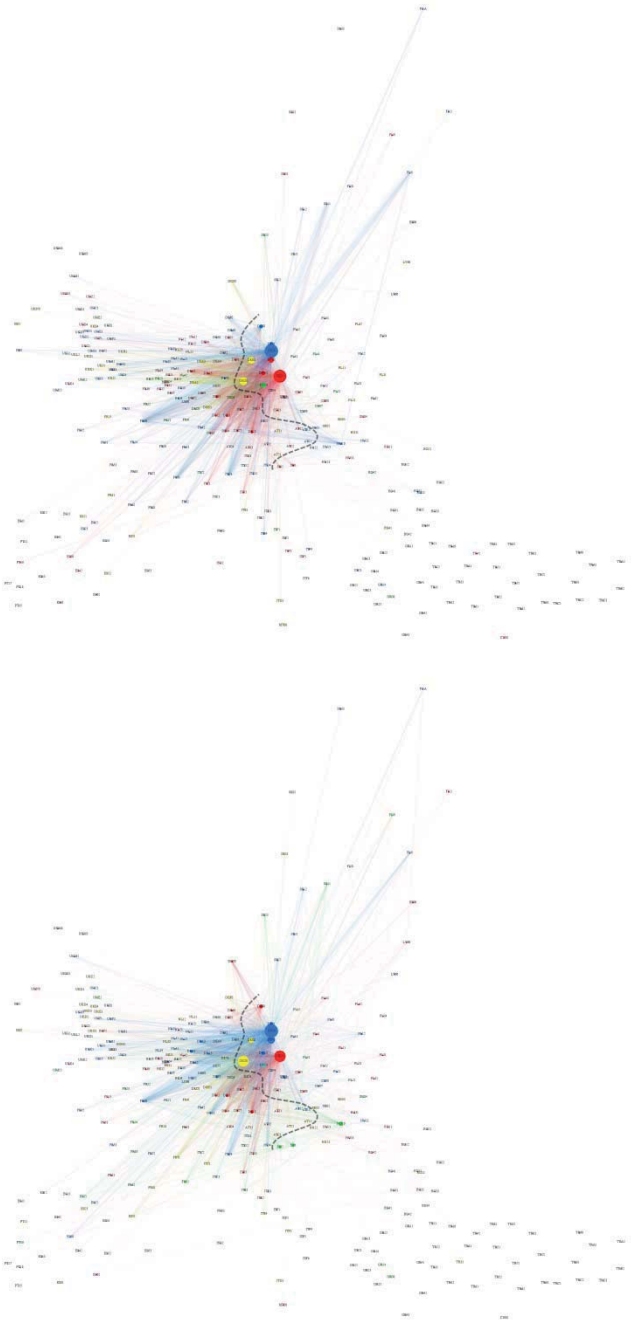
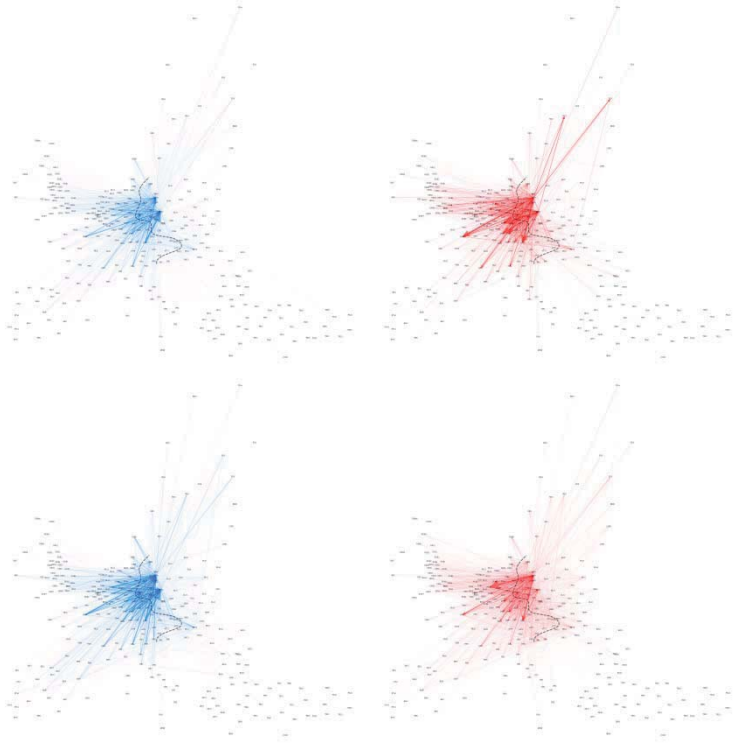


Figure 3. Directed network visualization. The following four illustrations show aggregated and directed West → East (left), and East → West (right) exchange flows over 1999-2003 (top) and 2004-2008 (bottom) periods. A typical feature common in evolving series like this one is the network stability and reciprocity of flows. Most of the exchange activity seems to happen within Germany, between a few centers in the former East Germany and the former West Germany regions, and between these and the rest of the West part of the continent.

Relatively few citations include the non-German East. The illustrations depict with some difficulty what happens in the network peripheries, especially in the East part of the graph. Sparse link densities and small relative weight of citation connections to and from the East Europe, except East Germany, reveal the limited importance of the East from the perspective of full citation exchange in Europe.



Descriptive Analysis of East-West Citation Exchanges

This section describes the evolving network using exactly the same methods on which visual part of this paper was built. We use spatial (East vs. West) and temporal (1999-2003 vs. 2004-2008) contrasts; further reliance upon the basic network description helps delimit links among 28 nations included in the sample, resulting in two simplified spatial structures. Basic network descriptions were presented graphically in Figures 1, 2, and 3, constructed upon the measurement of betweenness centrality and network community detection.

Since these clearly point to the special role played by German regional system, we employ here a nation-based delimitation of the exchange network between the East and the West in following step. The German regional system proves to be crucial in shaping patent citation exchanges, exactly as our network description has revealed. More than one half of the interaction activity we are focusing occurs *within* the national borders of Germany. This level of concentration leads us to question whether Delaunay contiguity-based spatial weights employed in the autocorrelation corrections of the analytical part would be sufficient were German nodes removed. Another possibly critical part of our analysis is Eurostat's historically indifferent inclusion of former West Berlin into the East block together with the rest of the city, both now entering our data as a single NUTS2 regional unit. Including West Berlin, even after a decade since unification, still may crucially bias our description and analysis as well since it may be assumed that interaction links are traditionally strong with the rest of the West Europe.

Table 1. International distribution of patent citations. Patent citation exchanges between East and West Europe appear in a distribution in directed pairs of countries scaled by their contribution to the full exchange. Both tables sum to 100.0, of which more than one half stays

within the national borders of Germany (53.5% and 50.9%). Germany is also the only row/column with a value entering diagonal position, suggesting endogenous sources of its technological leadership. These tables reveal that interactions are unevenly distributed with a strong level of concentration, leaving most of the potential interaction links empty over the decade.

Origin 1999-2003																												
	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	TR	UK
AT	-	-	0.02	-	-	1.26	-	0.01	-	-	-	-	0.04	-	-	-	-	-	-	-	0.04	-	0.00	-	0.13	-	-	-
BE	-	-	0.01	-	0.05	1.17	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-
BG	-	-	-	-	-	0.03	-	-	0.02	-	-	-	-	-	0.06	-	-	-	-	0.00	-	-	-	0.01	-	-	-	-
CY	-	-	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CZ	-	-	-	-	-	0.19	-	-	-	-	0.02	-	-	-	0.01	-	-	-	-	0.06	-	-	-	0.01	-	-	-	0.02
DE	1.49	1.01	0.07	0.00	1.12	53.51	0.52	0.00	0.56	0.44	5.21	0.04	0.54	0.07	3.77	0.02	0.11	0.01	-	1.24	0.16	0.01	0.05	0.66	0.73	0.13	0.03	2.14
DK	-	-	-	-	0.00	0.26	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	-
EE	-	-	-	-	-	0.07	-	-	-	-	0.01	-	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-	0.01
ES	-	-	-	-	0.02	0.27	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	-	-	0.00	-	0.02	-	-	-
FI	-	-	-	-	-	0.91	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-
FR	-	-	-	-	0.25	6.43	-	0.01	-	-	-	-	0.31	-	-	-	-	0.00	-	-	0.08	-	0.00	-	0.15	0.00	-	-
GR	-	-	-	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HU	0.08	0.13	-	-	-	0.83	0.06	-	0.03	0.02	0.37	-	-	-	0.17	-	-	-	-	0.07	-	-	-	0.01	-	-	-	0.04
IE	-	-	-	-	0.02	0.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-
IT	-	-	-	-	0.29	2.55	-	-	-	-	-	-	0.02	-	-	0.02	-	-	-	-	0.13	-	0.00	-	0.06	-	-	-
LT	-	-	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LU	-	-	-	-	-	0.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LV	0.00	-	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MT	-	-	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NL	-	-	-	-	0.15	1.59	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	0.07	-	0.04	-	0.04	-	-	-
PL	0.02	-	-	-	-	0.29	0.01	-	0.01	-	0.05	-	-	-	0.10	-	-	-	-	-	-	-	-	0.02	-	-	-	-
PT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-
RO	-	-	-	-	-	0.04	-	-	-	-	0.02	-	-	-	0.03	-	-	-	-	0.02	-	-	-	-	-	-	-	-
SE	-	-	-	-	0.01	1.52	-	-	-	-	-	-	0.04	-	-	0.04	-	-	-	-	-	-	-	-	-	0.02	-	-
SI	-	0.02	-	-	-	0.13	-	-	-	-	-	-	-	-	0.06	-	-	-	-	0.02	-	0.02	-	-	-	-	-	-
SK	-	0.00	-	-	-	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
TR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK	-	-	-	-	0.11	3.76	-	-	-	-	-	-	0.28	-	-	-	-	-	-	-	0.07	-	0.02	-	0.07	0.02	-	-

Origin 2004-2008																												
	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	TR	UK
AT	-	-	-	-	0.08	1.26	-	-	-	-	-	-	0.05	-	-	-	-	0.03	-	-	0.07	-	-	-	0.08	0.02	-	-
BE	-	-	-	-	0.05	0.97	-	-	-	-	-	-	0.03	-	-	-	-	0.04	-	-	0.07	-	-	-	0.03	0.01	-	-
BG	0.01	0.01	-	-	-	0.01	-	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-
CY	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CZ	-	0.03	-	-	-	0.48	0.04	-	0.00	0.02	0.14	-	-	-	0.05	-	-	-	-	0.02	-	-	-	0.00	-	-	-	0.05
DE	1.36	0.96	0.03	-	1.26	50.94	0.54	0.05	0.77	0.37	4.05	0.03	1.24	0.11	3.40	0.07	0.04	0.07	0.01	1.13	1.35	0.05	0.24	0.89	0.89	0.26	0.07	1.42
DK	-	-	-	-	0.03	0.55	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.03	-	-	-	0.04	0.02	-	-
EE	-	-	-	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
ES	-	-	0.02	-	0.07	0.48	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.04	-	0.02	-	0.11	0.02	-	-
FI	-	-	-	-	0.04	0.70	-	-	-	-	-	-	0.02	-	-	-	-	0.03	-	-	0.04	-	0.01	-	-	0.01	-	-
FR	-	-	0.01	-	0.29	5.10	-	0.03	-	-	-	-	0.42	-	-	-	-	-	-	-	0.37	-	0.02	-	0.39	0.14	-	-
GR	-	-	0.02	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HU	0.03	0.08	-	-	-	0.64	0.02	-	0.07	0.04	0.19	-	-	-	0.14	-	-	-	-	0.15	-	-	-	0.05	-	-	-	0.09
IE	-	-	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IT	-	-	0.04	-	0.20	2.55	-	-	-	-	-	-	0.13	-	-	0.01	-	0.04	-	-	0.24	-	0.02	-	0.37	0.07	-	-
LT	-	0.01	-	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LU	-	-	-	-	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LV	-	-	-	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MT	-	-	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NL	-	-	-	-	0.06	1.78	-	-	-	-	-	-	0.09	-	-	0.01	-	-	-	-	0.18	-	-	-	0.03	0.01	-	-
PL	0.02	0.03	-	-	-	0.35	0.03	-	0.01	0.03	0.04	0.02	-	-	0.02	-	-	-	-	0.06	-	-	-	0.00	-	-	-	0.08
PT	-	-	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	0.02	-	-	-
RO	-	0.02	-	-	-	0.04	-	-	0.02	-	0.03	-	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-
SE	-	-	0.04	-	0.11	1.12	-	-	-	-	-	-	0.06	-	-	0.01	-	-	-	-	0.10	-	-	-	0.31	0.01	-	-
SI	0.04	0.01	-	-	-	0.31	0.00	-	0.09	-	0.08	-	-	-	0.08	-	-	-	-	0.05	-	0.04	-	0.01	-	-	-	0.06
SK	0.02	0.02	-	-	-	0.06	-	-	-	-	0.06	-	-	-	0.01	-	-	-	-	0.02	-	-	-	-	-	-	-	0.01
TR	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK	-	-	-	-	0.19	3.54	-	-	-	-	-	-	0.16	-	-	0.00	-	0.03	-	-	0.34	-	0.02	-	0.19	0.07	-	-

Table 2. International citation distribution, rows and columns summarized. This table combines row and column sums from both previous tables and offers a more concise overview of the changing importance of different countries in the role of citation generating or receiving actor. Germany, for example, has lost relative share in citations generated and received, while Czech Republic Hungary, Slovakia and Poland have all gained importance as

cited locations (Origin), while Hungary alone appears to cite less (Destination). Figure 4 replicates the same illustration graphically at the NUTS2 regional level, offering how the change in roles looks like in the contrast between the West and the East regions of Europe.

Patent citation exchanges between the East and the West is heavily dominated by the German regions as both citation source and citation target. Comparing the four columns of Table 2 uncovers three groups of countries across the continent from the perspective of a trend in participation in citation exchange between the East and the West. *Most countries in East Europe have increased their share on both sides of flows*, as have only a few countries in the West Europe. Other countries in the West Europe have lost a relative share in both aspects, which indicates limited but important evidence of knowledge flow convergence. Finally, there is a heterogeneous group of those who cite less and are cited more, or those who cite more and are cited less between the periods.

	Origin		Destination	
	1999-2003	2004-2008	1999-2003	2004-2008
AT	1.6	1.5	1.5	1.6
BE	1.2	1.1	1.3	1.2
BG	0.1	0.1	0.1	0.1
CY	0.0	-	0.0	-
CZ	2.0	2.4	0.3	0.8
DE	75.2	71.1	73.6	71.6
DK	0.6	0.6	0.4	0.7
EE	0.0	0.1	0.1	0.0
ES	0.6	1.0	0.3	0.8
FI	0.5	0.5	1.0	0.8
FR	5.7	4.6	7.2	6.8
GR	0.0	0.0	0.0	0.0
HU	1.5	2.3	1.8	1.5
IE	0.1	0.1	0.1	0.1
IT	4.2	3.7	3.1	3.7
LT	0.1	0.1	0.0	0.0
LU	0.1	0.0	0.1	0.1
LV	0.0	0.2	0.0	0.0
MT	-	0.0	0.0	0.0
NL	1.4	1.4	2.0	2.2
PL	0.6	2.8	0.5	0.7
PT	0.0	0.1	0.0	0.0
RO	0.1	0.3	0.1	0.1
SE	0.7	1.0	1.6	1.7
SI	1.2	2.5	0.2	0.8
SK	0.3	0.6	0.1	0.2
TR	0.0	0.1	-	0.0
UK	2.2	1.7	4.3	4.5

Figure 4. The East-West exchange citation reciprocity at NUTS2 regional level. Regions in both periods that are located along the diagonal line show a perfect reciprocity of citing others and being cited. Each arrow illustrates the inter-temporal change of rates for regions that either cited or were cited in flows of patent knowledge between East and West Europe between 1999-2003 and 2004-2008 periods. Blue arrows illustrate the behavior of West regions, red arrows illustrate the behavior of East regions. The East regions strengthen their position by moving in a seemingly coordinated way on the lower side of distribution (more citing than cited vertices) becoming those learning from Western regions located, or moving, above the diagonal line.

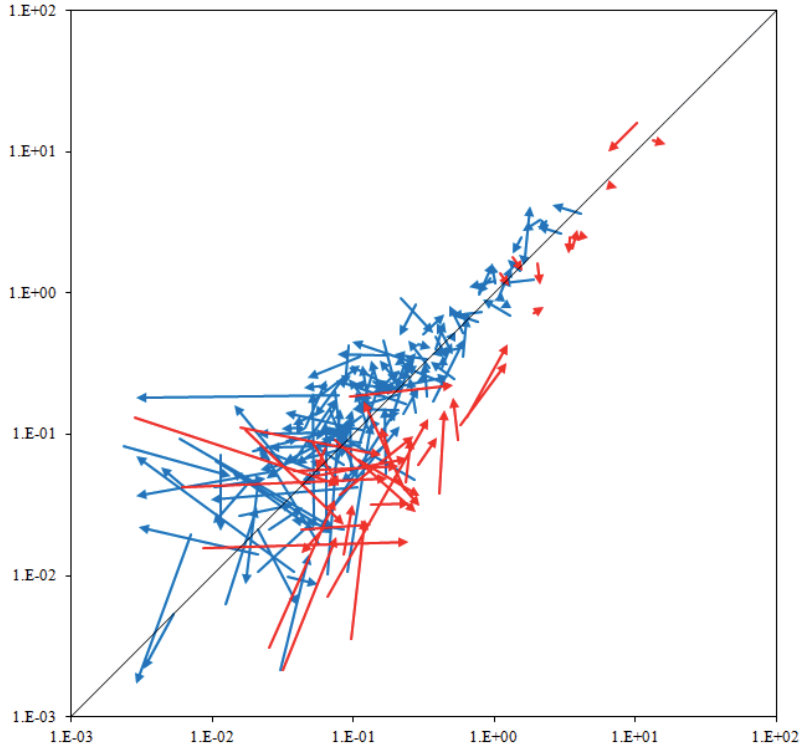
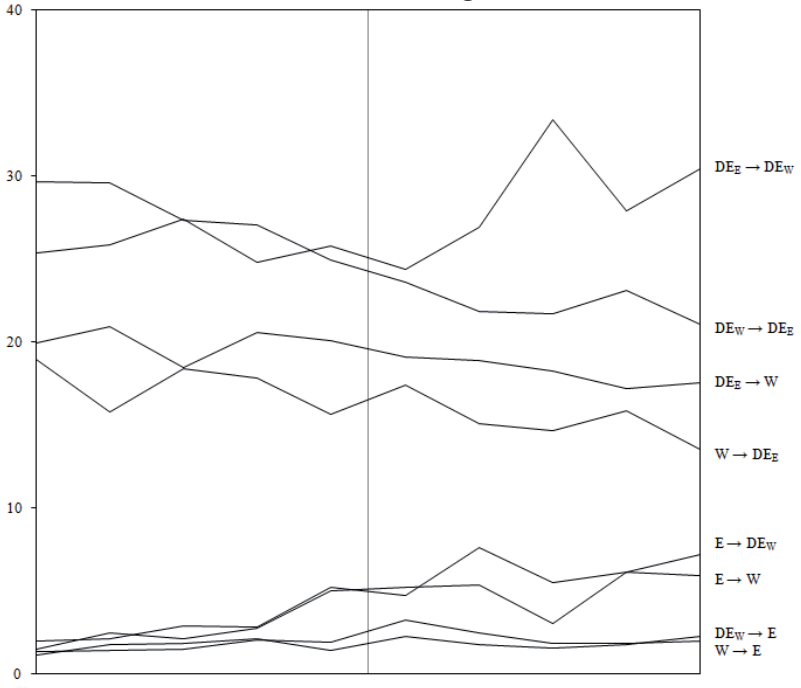


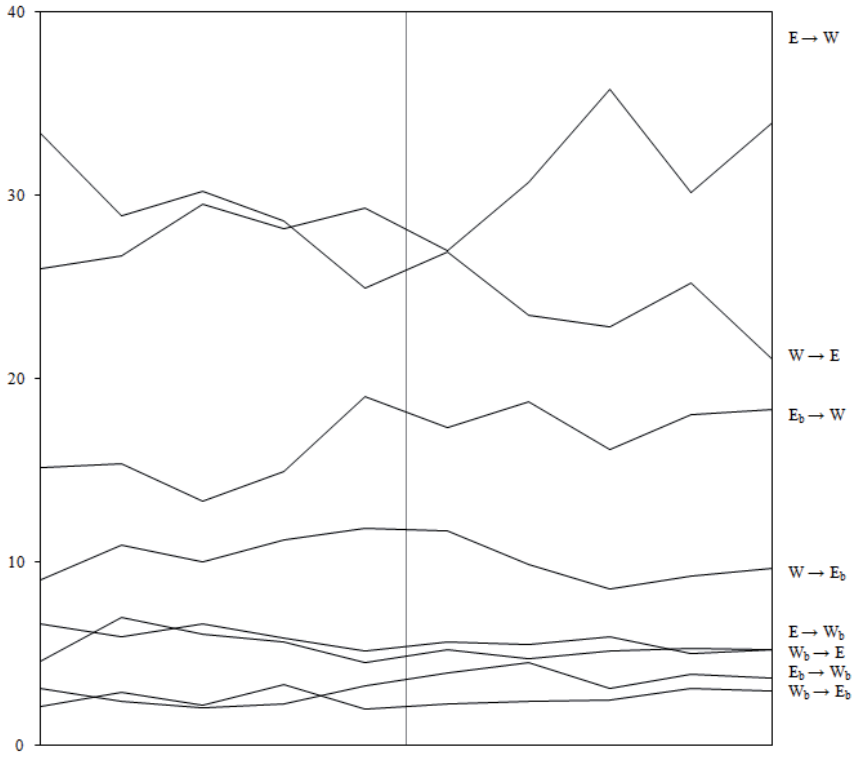
Table 3. / Figure 5. Distribution of the East-West citation exchanges in a four-region system: East and West German regions vs. non-German East and non-German West regions of rest of the continent. Two highest lines illustrate a decrease in share of DE_W regions citing DE_E regions, and also an opposite, abrupt mid-decade trend in opposite direction inside Germany as investment in citation-active facilities moved to East Germany. A similarly slow decrease is found between DE_E regions and non-German West regions. A clearly growing trend appears as the non-German East regions increasingly cite the patents of West regions both in and out of Germany. Much slower, but still growing, is the share of West regions citing East regions as shown in two lines at the bottom of the figure.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
$DE_E \rightarrow DE_W$	25.4	25.9	27.4	24.8	25.8	24.4	26.9	33.4	27.9	30.5
$DE_W \rightarrow DE_E$	29.6	29.6	27.3	27.0	25.0	23.6	21.9	21.7	23.1	21.1
$DE_E \rightarrow W$	19.9	20.9	18.5	20.6	20.1	19.1	18.9	18.3	17.2	17.6
$W \rightarrow DE_E$	19.0	15.8	18.4	17.8	15.6	17.4	15.1	14.6	15.8	13.5
$E \rightarrow DE_W$	1.5	2.5	2.1	2.7	5.0	5.2	5.4	3.1	6.2	7.2
$E \rightarrow W$	2.0	2.2	2.9	2.8	5.2	4.7	7.6	5.5	6.1	5.9
$DE_W \rightarrow E$	1.2	1.7	1.9	2.1	1.4	2.3	1.8	1.5	1.8	2.3
$W \rightarrow E$	1.4	1.4	1.5	2.0	1.9	3.2	2.5	1.9	1.8	2.0

Table 4. / Figure 6. Distribution of the East-West citation exchange between Delaunay delimited bordering regions on both (E_b, W_b) sides, and rest of the East and the West Europe across the former border. Citation exchanges between non-border regions on both sides dominate the network in both periods, with slightly diminishing average level of 57.1% and 55.4% for two periods considered. On the other hand, the exchange within the border zone is small but rising between an average level of 5.1% and 6.5% for two periods.

Note also a significant asymmetry between the two sides of the border zone, of which the East part appears far better connected with the opposite side than the West part is with the East. This may be a historical residue of the geo-political border, which "shaded" the remote, relatively underdeveloped West border regions while it helped "nourish" East border regions with valuable contacts and mobility.



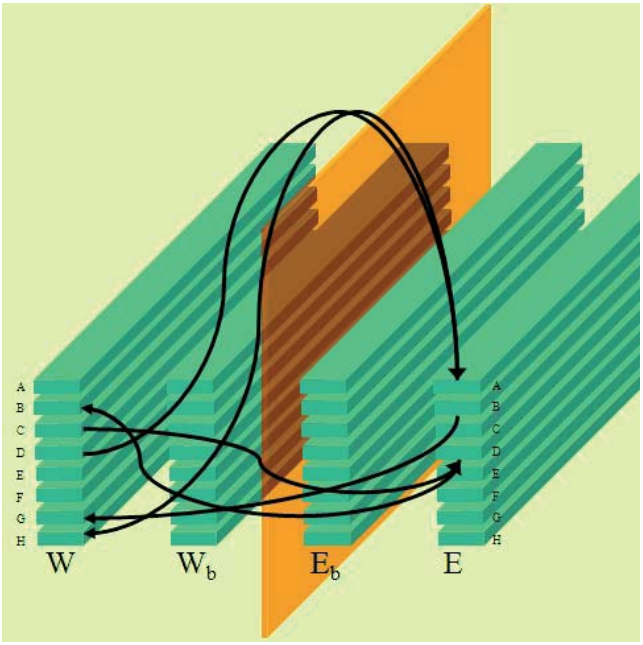
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008

E → W	26.0	26.7	29.5	28.2	29.3	27.0	30.7	35.8	30.2	33.9
W → E	33.4	28.9	30.2	28.6	24.9	26.9	23.4	22.8	25.2	21.1
E_b → W	15.2	15.4	13.3	14.9	19.0	17.3	18.8	16.2	18.1	18.3
W → E_b	9.0	10.9	10.0	11.2	11.9	11.7	9.9	8.5	9.2	9.6
E → W_b	4.6	7.0	6.1	5.6	4.5	5.2	4.7	5.2	5.3	5.2
W_b → E	6.6	5.9	6.6	5.9	5.1	5.7	5.5	5.9	5.0	5.2
E_b → W_b	3.1	2.4	2.0	2.2	3.2	3.9	4.5	3.1	3.9	3.6
W_b → E_b	2.1	2.9	2.2	3.3	2.0	2.3	2.4	2.5	3.1	3.0

Patent Class Patterns in East-West Citations

We have thus far left undefined the technology class of patents being cited, preferring first to sketch broader trends and relationships among citing and cited regions or countries. There is much to be learned from knowing how firms and other economic agents in places cite *specific patent technologies* over time, as these may indicate important underlying shifts in the structure of innovation, investment, industrial composition and overall technical advance. Remaining alert to the changes that arise over the inter-temporal period being studied here may also provide insights in future changes to be expected with results from successful ENP. To manage this task, we must simplify the geography as a pair of East-West dichotomies at the same time we expand citation detail to include its core patent classification.

Figure 7. The structure of IPC-disaggregated inter-regional network. Patent citations are now accounted for as directed technology-oriented flows between the NUTS2 European regions. The flows are then collapsed to four regional classes corresponding to former divide of the continent and border location from Delaunay contiguity (W, W_b, E_b, E). Regionally categorized flows are additionally disaggregated according to the IPC sections, to which the citing and the cited patents have been assigned. The network structure is replicated in two versions, one for the 1999-2003, and one for the 2004-2008 period. The following illustration shows several flows, including $W_{(D)} \rightarrow E_{(A)}$, for example.



Industry structure of exchange. The international patent classification (IPC) is a system allowing for the creation of specific statistics regarding technological development in various areas of inventing activity. It is a hierarchical, regularly updated list organized into sections, each further subdivided into classes, subclasses and groups. The highest level of classification, which is a single level used in our description, consists of:

(A) human necessities,
(B) performing operations, transporting,
(C) chemistry, metallurgy,
(D) textiles, paper,
(E) fixed constructions,
(F) mechanical engineering, lighting, heating, weapons, blasting,
(G) physics, and
(H) electricity.

As each patent can be assigned to several classifications by a patent examiner, generalization to a core classification is necessary to avoid multiple counting of fragments. The second dimension to be represented in description is the geographical structure of citation network. Instead of the NUTS2 regional system consisting of 284 vertices we reduce this detail to a generalized regional system consisting of only four vertices, according to side and mutual contiguity or border location, between two former blocks (W, W_b, E_b, E). Using both dimensions, a network of $4^2 \times 8^2 = 1{,}024$ specific inter-regional inter-section flows is aggregated over time. The cross-border sub-network is only a small fragment of citation network, in which degrees of variation appear large only as relative expressions. Instead of thousands of citations we now examine at maximum hundreds or tens of citations, further disaggregated into very small elements distributed across Table 5.

Table 5. Inter-section cross-border citation flows. Since our intention is to show dynamics of cross-border citation exchange in terms of industry structure, we simplify the regionalization by producing eight pairs of 8 × 8 inter-section matrices describing share of specific citation flows on general directed exchange over two five-year periods: 1999-2003, and 2004-2008. More than a half of the exchange usually stays within core IPC sections, which is quite similar earlier observations of the U.S. system (Jaffe, Trajtenberg, 1993). The main diagonal includes 58.2% of citations during the former period, and rising to 60.7% during the later period. An interesting observation is that adjacent cross-border citations network assign slightly more weight to the exchange between different sections in the early period (58.6%), which falls to 57.9% rather than rises in the latter. The system of eight 8 × 8 inter-section matrices offers a valuable expression of how different areas of inventing activity generate patent citations in specific geographically classified flows. The column and row sums are used in Figure 5.

The matrices depict relative shares of patent citation flows between and within different IPC sections generated from the aggregated flows of citations between specific regional groups comprising the former East / West division of the sample. Matrix elements sum to more than 100.0 since each patent is usually classified into more than one group assigning it, not necessarily, only into a single section, which is the technological resolution of our interest. However, each matrix element is limited by 100.0 reached in a theoretical case when all patents generating and receiving citations share the same IPC class. The largest elements are located on matrices diagonals, maximum value appears in the description of $W_{b\,(B)} \rightarrow E_{b\,(B)}$ flows in the period 1999-2003, which is 46.5%, changing to 35.8% in the period 2004-2008.

Many of the inter-section flows are empty (-), meaning no patent citations generated between specific IPC sections over that time.

Citation exchanges across the former boundary between East and West seem also to span more frequently different industry boundaries. The industry distribution of citations is also not equal across classifications. One of them, (B) performing operations, transporting, dominates both the full network and the border crossing sub-network; it generates 26.4%, which drops slightly to 26.2% of all citations, and 25.6% dropping to 24.5% of cross-border citations. The counterpart—share of *citations received*—is quite similar at the levels 26.0% and 26.4%, and 24.9% and 23.5% in case of cross-border sub-network.

Five classification sections (A, C, F, G, H) generate smaller, similar shares of citations (between 9.2% and 14.3%) and receive (between 9.1% and 13.0%). The exchange among them, including citations within a section, is responsible for 53.3% rising to 54.2% of all flows, and 54.9% also rising to 56.3% of cross-border flows. The exchange between them—excluding diagonal elements—generates 16.0% dropping to 15.4%, and 17.0% dropping to 18.1% in case of cross-border flows.

Notable cross-border shifts in shares of West citing East patents can be observed in the case of human necessities (A): 33% more West border citing East, 50% more West citing East border, and 100% more West border citing East border. Less pronounced but no less significant is the 50% increase in Chemistry and metallurgy citations by West of East patents. Quantitatively less influential classifications overall are D and E, although Textiles and paper (D) citations by East of West border patents exploded by 400%, no doubt occasioned by cross-border FDI to capitalize upon reduced wage scales. Further details concerning disaggregation of the cross-border sub-network of patent citations are provided in Table 5.

	Origin 1999-2003									Origin 2004-2008							
W → E	A	B	C	D	E	F	G	H	W → E	A	B	C	D	E	F	G	H
A	13.6	1.6	2.4	0.2	0.2	0.8	1.5	0.6	A	14.8	1.8	3.7	0.6	0.1	0.7	0.6	0.4
B	2.0	25.3	3.2	0.5	1.2	4.5	3.9	2.0	B	2.1	23.4	3.8	0.8	0.8	3.0	3.2	2.1
C	3.3	3.2	10.0	0.4	0.2	1.1	1.0	1.0	C	3.6	2.7	13.2	0.4	0.3	1.0	1.3	0.8
D	0.5	0.7	0.1	2.5	0.1	0.3	0.5	0.3	D	0.7	0.4	0.3	4.2	0.2	0.1	0.5	0.1
E	0.0	1.1	0.5	0.3	3.8	0.8	0.5	0.2	E	0.3	0.7	0.1	0.1	4.6	1.2	0.1	0.4
F	0.5	4.2	1.1	0.1	0.7	14.9	1.5	1.7	F	0.8	3.1	1.1	0.2	0.6	15.5	1.1	1.7
G	1.6	6.0	1.4	0.6	0.9	1.5	17.0	5.0	G	1.7	3.2	1.5	0.3	0.1	1.0	13.6	3.2
H	0.9	2.7	1.0	0.3	0.3	1.8	5.4	21.9	H	0.5	1.8	0.7	0.2	0.2	1.6	3.3	15.8
W → E_b	A	B	C	D	E	F	G	H	W → E_b	A	B	C	D	E	F	G	H
A	16.7	2.3	3.0	0.1	0.7	1.0	2.2	0.7	A	17.5	2.3	2.7	0.3	0.1	0.7	1.2	0.6
B	3.4	32.4	6.2	1.1	1.9	3.4	3.4	1.7	B	1.8	28.2	4.2	0.7	1.1	3.5	3.7	1.7
C	5.5	6.4	17.9	0.6	1.0	1.8	2.5	1.5	C	4.8	5.1	15.8	0.6	0.6	1.4	2.8	0.7
D	1.0	1.3	1.1	4.6	0.2	0.1	0.3	0.2	D	0.3	0.9	0.6	3.4	0.2	1.3	0.5	0.3
E	0.5	1.9	0.3	0.3	7.4	0.5	0.7	0.4	E	0.3	1.1	0.5	0.4	7.6	2.0	0.3	0.1
F	0.5	4.1	1.3	0.0	1.1	9.4	0.5	0.8	F	0.8	2.0	1.2	0.1	0.8	9.2	0.5	0.4
G	1.5	4.3	2.7	0.9	0.6	2.1	14.2	4.3	G	1.5	4.4	2.3	0.3	0.3	1.0	16.3	3.0
H	0.7	2.0	0.7	0.0	0.2	1.6	3.0	9.3	H	0.3	1.6	0.9	-	-	0.6	3.3	8.2
W_b → E	A	B	C	D	E	F	G	H	W_b → E	A	B	C	D	E	F	G	H
A	15.9	3.3	0.8	0.4	-	0.8	2.6	0.7	A	10.2	1.3	0.8	0.2	-	0.8	1.1	0.0
B	2.2	29.6	1.9	0.4	0.8	3.4	2.5	3.2	B	2.7	25.5	2.6	0.5	0.7	2.6	1.9	1.6
C	0.5	2.3	4.4	0.2	-	0.8	0.1	1.4	C	1.4	2.5	6.0	0.1	0.1	0.6	1.3	0.6
D	1.0	0.5	0.4	2.9	0.4	0.5	0.4	0.1	D	1.0	2.4	0.3	13.2	0.1	0.4	0.3	0.4
E	0.1	1.7	0.2	0.1	5.0	1.2	0.8	0.5	E	-	1.4	0.2	0.2	5.3	1.1	0.2	-
F	0.8	4.3	0.3	0.7	0.7	12.7	1.2	1.1	F	1.5	2.1	0.4	1.4	0.8	11.4	2.0	1.5

G	1.9	5.2	0.4	0.4	1.1	1.6	15.2	3.5	G	0.8	3.2	1.2	1.2	0.6	1.4	12.8	3.0
H	1.2	5.0	1.0	0.1	0.2	0.7	5.0	19.2	H	0.2	2.9	0.6	0.3	0.4	1.3	4.5	18.4
$W_b \rightarrow E_b$	A	B	C	D	E	F	G	H	$W_b \rightarrow E_b$	A	B	C	D	E	F	G	H
A	13.0	2.9	2.5	1.0	-	1.1	2.0	0.3	A	9.3	1.9	0.8	0.1	-	0.1	2.0	-
B	3.6	46.5	7.3	0.9	3.0	6.0	2.5	1.6	B	1.9	35.8	3.8	2.2	0.7	1.8	2.0	2.0
C	3.7	6.4	13.9	1.1	1.0	0.3	1.2	0.1	C	3.5	4.4	9.8	0.2	-	0.6	1.9	1.1
D	0.9	2.5	2.1	1.8	1.7	0.9	-	-	D	0.3	1.3	0.0	4.9	1.3	-	-	-
E	-	2.6	0.9	0.9	8.2	2.6	1.7	0.9	E	1.1	2.9	0.3	0.6	12.3	3.4	0.6	0.3
F	0.9	6.2	0.9	0.4	1.8	9.7	0.4	1.2	F	0.5	1.8	0.9	0.1	3.0	12.7	0.8	0.9
G	1.1	4.6	1.2	-	0.4	2.1	11.6	2.3	G	0.4	2.8	1.2	-	0.6	1.3	10.4	1.7
H	0.3	2.6	0.1	-	-	0.2	2.8	6.2	H	1.1	2.8	0.8	-	-	1.8	1.9	6.2
E → W	A	B	C	D	E	F	G	H	E → W	A	B	C	D	E	F	G	H
A	12.5	1.1	3.7	0.2	0.3	0.3	1.7	0.2	A	11.0	1.3	2.9	0.2	0.3	0.3	1.3	0.5
B	1.8	29.3	3.9	0.8	1.2	3.4	3.2	1.4	B	1.7	24.3	5.0	0.3	1.5	3.7	2.9	1.0
C	3.1	4.0	12.3	0.6	0.2	1.5	1.4	0.8	C	3.3	11.1	18.0	0.3	0.4	5.8	1.5	1.3
D	0.4	0.8	0.4	2.6	0.0	0.3	0.3	0.2	D	0.3	0.6	0.5	2.5	0.0	0.2	0.2	0.1
E	0.3	1.1	0.3	0.1	5.6	1.4	0.8	0.3	E	0.0	1.4	0.2	0.1	4.8	1.0	0.3	0.2
F	0.8	3.5	1.2	0.2	1.1	11.1	1.0	0.9	F	0.7	8.1	4.9	0.4	0.5	15.1	2.1	1.2
G	1.0	3.9	1.0	0.9	0.8	1.2	16.8	3.4	G	1.6	2.8	1.5	0.3	0.4	1.2	13.1	2.5
H	0.4	1.8	0.4	0.1	0.4	1.3	3.9	16.7	H	0.9	0.8	0.7	0.1	0.2	1.5	3.0	15.0
E → W_b	A	B	C	D	E	F	G	H	E → W_b	A	B	C	D	E	F	G	H
A	15.3	1.1	1.5	0.6	-	1.6	1.4	0.8	A	20.1	2.5	3.3	0.3	-	2.2	2.3	1.4
B	1.6	23.5	3.3	0.4	1.7	1.2	4.5	1.0	B	3.1	23.4	1.8	1.3	2.5	4.2	2.3	2.2
C	0.8	3.5	10.8	0.1	-	-	1.4	1.1	C	4.3	3.8	11.0	0.5	0.5	1.5	0.7	0.9
D	0.4	0.7	0.7	3.2	-	0.0	0.4	-	D	0.4	0.6	0.5	7.1	-	0.7	-	-
E	-	1.0	0.8	-	10.6	1.3	0.7	0.5	E	-	1.3	0.1	0.2	6.9	0.7	-	0.1
F	2.5	2.2	0.2	-	0.8	8.2	0.5	0.4	F	1.1	3.0	0.6	0.7	0.4	10.9	0.8	0.4
G	0.1	2.5	1.8	-	1.0	0.6	12.1	6.1	G	1.6	3.4	0.4	0.6	0.4	0.8	10.6	3.0
H	0.6	1.1	0.5	0.4	-	1.4	3.8	21.0	H	2.4	0.7	0.8	0.6	0.2	0.7	2.5	15.5
$E_b \rightarrow W$	A	B	C	D	E	F	G	H	$E_b \rightarrow W$	A	B	C	D	E	F	G	H
A	12.0	1.7	2.1	0.1	0.2	0.4	0.8	0.7	A	18.1	1.7	5.5	0.3	0.4	0.1	1.3	0.3
B	1.8	29.9	4.6	0.6	3.0	5.0	2.2	1.3	B	4.0	26.0	4.5	1.4	1.6	4.3	3.5	1.6
C	3.1	5.5	12.1	0.5	0.2	2.0	0.7	1.3	C	6.5	2.4	13.4	0.4	0.3	0.5	0.9	0.5
D	0.2	0.7	0.9	3.7	0.6	0.1	0.0	0.0	D	0.4	1.5	0.8	2.5	0.2	-	0.1	0.1
E	0.8	1.7	0.8	0.3	11.3	1.3	0.2	-	E	0.5	2.1	0.5	0.2	8.5	0.7	0.1	0.1
F	0.7	6.0	1.1	0.1	0.6	16.2	0.9	0.8	F	0.9	3.2	0.9	0.0	0.8	11.2	1.0	0.9
G	0.8	2.8	1.1	0.1	0.8	1.5	13.2	3.1	G	1.9	3.3	1.6	0.1	0.3	1.0	15.0	1.9
H	0.8	1.5	0.5	0.0	0.3	2.0	5.3	10.0	H	0.4	1.7	0.7	-	-	0.9	3.0	9.9
$E_b \rightarrow W_b$	A	B	C	D	E	F	G	H	$E_b \rightarrow W_b$	A	B	C	D	E	F	G	H
A	11.2	1.2	2.6	-	-	1.6	1.8	-	A	23.3	2.5	6.4	0.5	0.3	-	1.7	-
B	3.2	26.1	3.0	0.3	2.0	5.1	2.5	1.1	B	4.5	32.0	5.1	1.9	5.6	3.8	2.2	1.0
C	3.5	3.8	11.3	1.8	0.0	1.2	1.3	0.8	C	8.0	4.0	13.1	0.2	1.0	0.6	0.6	1.2
D	0.3	0.9	1.1	4.2	0.6	-	-	-	D	1.0	1.6	-	3.0	0.9	0.5	-	-
E	-	2.4	-	-	13.4	0.8	0.2	-	E	-	5.8	0.1	1.4	14.0	1.7	-	-
F	0.8	1.6	1.7	-	0.8	15.6	1.1	0.1	F	1.1	2.8	1.0	1.1	1.6	11.9	1.2	0.7
G	0.2	2.5	0.5	-	0.2	1.6	11.1	2.3	G	1.6	2.7	1.1	-	0.8	0.3	10.1	2.0
H	-	1.8	0.9	0.2	-	0.9	5.0	9.6	H	0.5	1.5	2.1	-	-	0.2	2.7	8.6

Principal Findings

The extent of patent citation in Europe included more than 200,000 citation links between 1999 and 2008, about 48% occurring in the first 5 years and 52% in the second 5 year period, an increase of about 7%. Approximately ¼ of the patents cited came from applicants located within the same NUTS 2 region, with the share of same-region citations rising slightly between the two periods. Considering only the 10,500 patent citations that crossed the East-West border, these grew instead by 23% between the periods, which shows the emergence of a vigorous exchange of patent-based knowledge.

Patent citations do not appear to occur between random NUTS 2 regions, but arise within relatively stable communities of knowledge exchange. We detected 3 exchange communities in the first period: one dominated by Germany, another along the Atlantic-North Sea-Baltic seaboards, and a third north-south community running from Italy to Denmark. These communities had shifted somewhat by the second period, with the dominant German community essentially unchanged, Italy now joining the seaboard community, the Danish-Swedish border community concentrating geographically and the emergence of what appears to be a post-EFTA community comprised mainly of Austria, Finland and parts of Sweden. These may be expected to evolve and perhaps fragment further as new accession countries become more fully assimilated and ENP relations filter through the system.

Looking more closely at the national presence, we see clearly the dominance of Germany in the European patent citation system and the relative absence of eastern concentrations of shared knowledge[2]. Germany accounts directly for over 50% of all European citations, although it lost share—as did other Western countries—between the periods even as, for example, patents issued in the Czech Republic, Hungary, Slovakia and Poland all gained citation-shares. Share convergence within the EU is entirely to be expected, although its continued pace and stable distribution remains unknown.

It is also possible to focus attention directly on the regions that adjoin the former East-West border to detect citation effects arising from physical adjacency. Non-border region citations dominate those of border regions, the latter accounting for a bit more than 5% in both periods, rising slightly. A strong asymmetry is revealed by the East border regions that are far more engaged in cross-border citations of West and West border patents than are West border regions with their counterparts.

Using the same regionalization scheme, we examine citation patterns among the eight principal technology classes of patents (A-H). The plurality of patent citations emanate from class B (performing operations, transporting), about ¼ of both EU-wide and cross-border patents, while the others range from about 14% and downwards. Cross-border citation of cross-classified patents, while initially higher than the West average, has also gained slightly, while West cross-classified citations declined. The converse is that within-classification patents show an opposite pattern of change. Together, these may indicate a further concentration or clustering of like-technologies in the West, while cross-border agents may be better positioned to take advantage of new innovative possibilities by cross-citing patent classes.

Implications for SEARCH

The EU "East" regions in this analysis are now "West" (and "North") of EN countries for purposes of ENP. While the "West" represented by the EU-27 includes large, technologically-advanced countries and regions, the ENP *border*-West is far less developed, although advancing rapidly. An open question our analysis cannot answer is whether *pace or level* of technological advance will have greater effects on ENCs. If the former, ENP success could arrive rather soon, while the latter will delay its arrival.

[2] Within Germany, there is rapid growth of West German patents being cited economic agents in the former East German regions, but equally rapid *reductions* in the reverse flow.

Either way, it is important to note a few key points concerning the East-West knowledge flows observed in a recent decade of experience:

1. Cross-border citations increased by about 23%, as compared with about 7% within the West following EU enlargement policies. This is likely to be the case with ENPs.
2. While many East regions cite and are cited more frequently, some may do less of both as previously favored regions may be technologically less agile as others better positioned to capitalize on EU policies (e.g., FDI, trade, university exchange). The effects of other ENP initiatives will influence which ENC regions can take fullest advantage of potential knowledge flows within relevant citation exchange communities.
3. Overall, East (and East border) region citations of West patents can be expected to rise markedly, although the reverse citation flows are extremely unlikely. Developing ENC regions are expected to be citation-knowledge consumers in early rounds, similar to accession country experience, a dependence which may continue indefinitely for all but the most advanced or technically-specialized ENC regions.
4. Knowledge flows measured by patent citations across immediate cross-border regions are unlikely to be large, to grow rapidly, or to benefit other distant regions, although more standardized industrial process and business practice technologies could benefit ENC border regions initially from physical proximity.
5. The possibility that cross-border agents may be better positioned to take advantage of new innovative possibilities by cross-citing patent classes should be exploited with absorptive capacity measures in ENCs.

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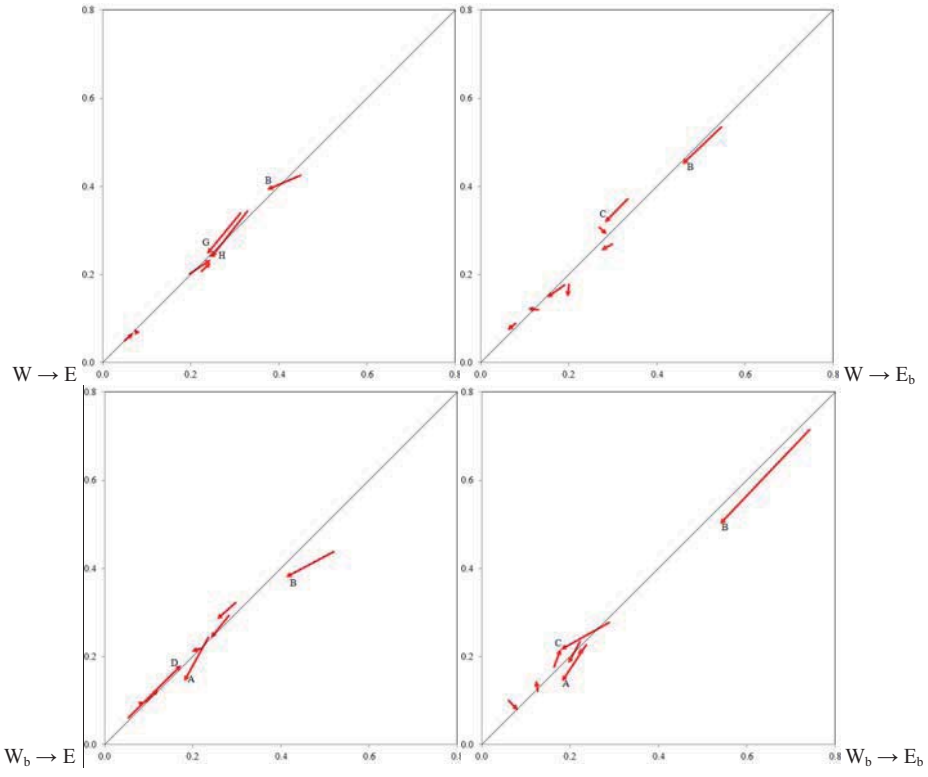
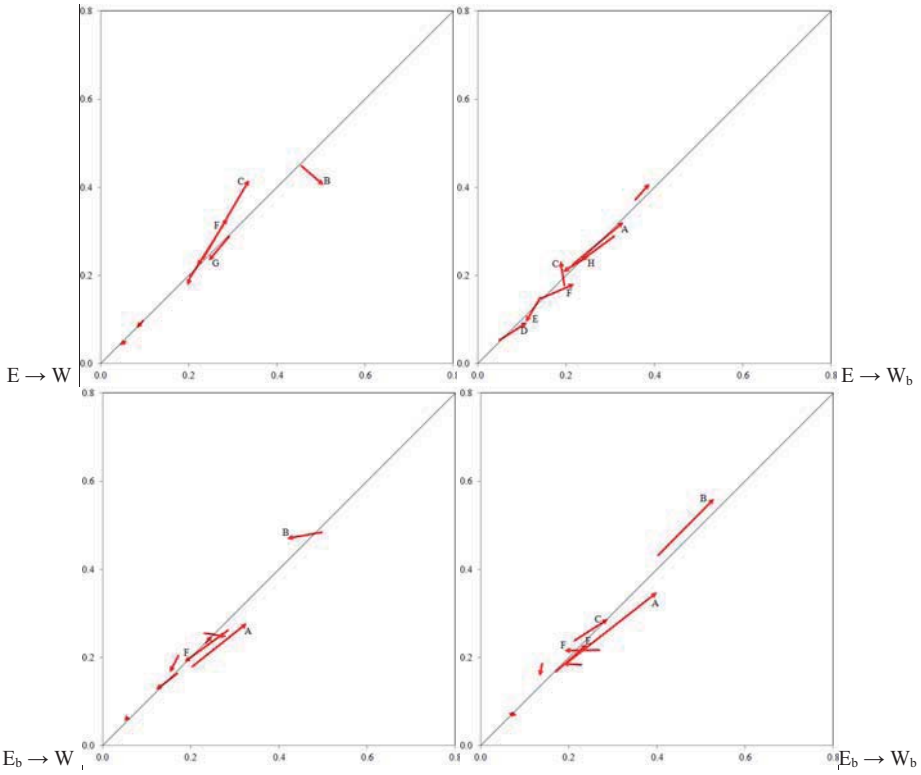
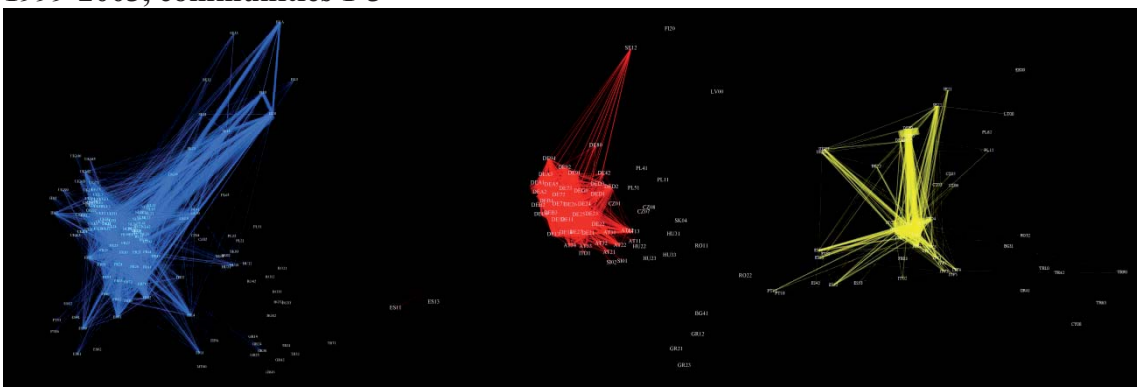
Appendix I. Dynamic sub-networks among IPC sections. Probably a more useful illustration of the same contents is provided in Figure 8. Eight IPC sections are responsible for unequal share of citations generated in different geographic flows, and these shares are changing between two periods observed. The scatter-plots document the relative share of IPC sections on origin (horizontal) and destination (vertical) of aggregated flows. Each arrow illustrates the position of one section. The longer the arrow appears, the more change related with relative position of a section between 1999-2003 and 2004-2008 period is observed in Table 5. More important transitions are indicated by the section sign. Less significant transitions are not indicated. The expectation of detecting systematic distinctions that offer easy interpretation is so far unfulfilled. Generating hypothesis concerning dynamics in industry structure of cross-border sub-network will not be straightforward, and probably will need to be less aggregated in both dimensions.



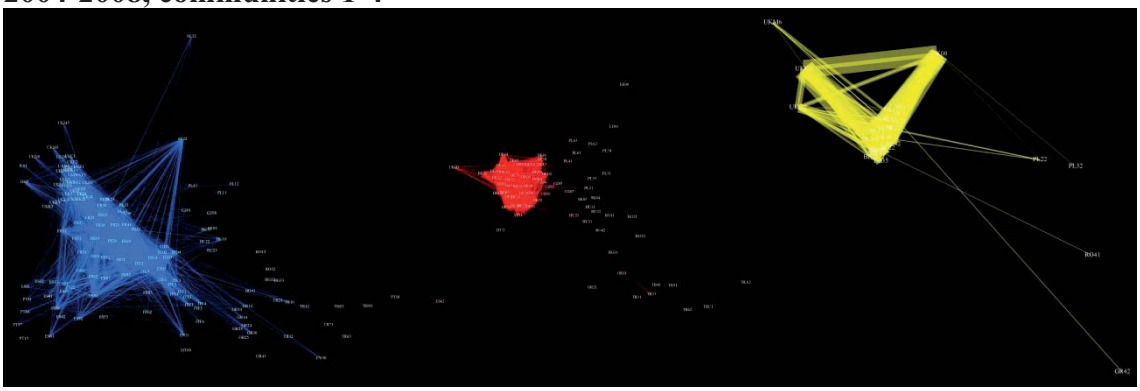


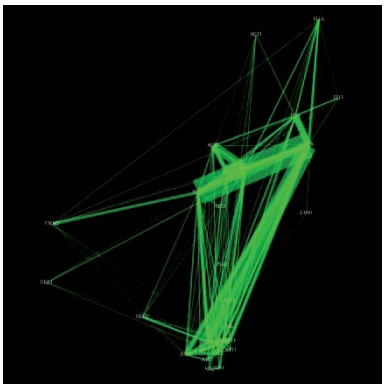
Appendix 2. Distinct European Citation Communities: 1999-2003 and 2004-2008

1999-2003, communities 1-3



2004-2008, communities 1-4



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