Internet, Adjustment of Firms and the Spatial Division of Labor*

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Abstract

There is a growing body of literature on the impact of the Internet as an innovative transaction and networking technique on requirements of organizational change within enterprises, on sectoral differences of E-commerce affinity and penetration, and on country-specific development trends in the New Economy. Research on the spatial impact of E-commerce so far focuses on locational patterns of New Economy firms proper. However, it can be expected that also E-commerce solutions in old economy-firms will substantially alter the economic geography of production and co-operation, because E-commerce will lower spatial transactions costs and has the potential to make distance less relevant for a variety of economic transactions. The spatial impact may run quite along the lines which the well-known telematics debate in the 1980s predicted, i.e. with simultaneously occurring processes of concentration and deconcentration at various layers of the value added chain.

The paper aims at discussing elements of a conceptual approach for evaluating these spatial effects of E-commerce activities on locational patterns in the old economy by identifying suitable proxy indicators from existing evidence, such as connectivity to IT-infrastructures, sectoral differences in B2B solutions, market (de-)concentration processes, or functional changes of employment structures of cities.

Key Words: E-commerce, Spatial Division of Labor

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1. Introduction: In search for spatial effects of the New Economy[1]

The New Economy has attracted substantial attention since the Internet entered on stage. Economists as well as politicians expect the New Economy to raise the level of economic development on a higher development path with higher growth rates due to higher knowledge and information content as well as options to economize on spatial transaction costs (cf. OECD 2000).

The Internet will speed up the process of structural change towards the "weightless economy" (Quah 1999) where traditional commodities are more and more substituted by knowledge-intensive goods and services (which are going to make up an increasing share in overall value-added and employment). This entails the question whether economic development will decouple from the traditional spatial structures of production and consumption which were typical for the interregional division of labor during the era of the "weighty" or old economy. The Internet appears to be a powerful (and irresistible) driver of a new general-purpose technology that will further reduce spatial transaction costs. The deployment of the Internet as a medium for making and performing transactions via information and communication (ICT)-networks will harness the interregional division of labor in business-to-business (B2B) transactions and of retail trade in business to consumer (B2C) with potentially far-reaching consequences for the relative competitiveness of locations and changes in urban hierarchies.

There is a growing body of literature on the impact of the Internet as an innovative transaction and networking technique on requirements of organizational change within enterprises, on sectoral differences of E-commerce affinity and penetration, and on country-specific development trends in the New Economy. Empirical evidence, however, is predominantly related to sectoral analyses. So far, research on the regional impact of E-commerce focuses on locational patterns of New Economy firms proper; there are only a few case studies on the spatial impact of B2B and B2C internet applications in the old economy, e.g. on the decentralization of entrepreneurial functions or on ICT-driven changes in the geography of firm sites of large concerns. Therefore, this paper aims at discussing conceptual issues in order to gain more evidence on Internet-driven spatial structural change.

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[1] This paper builds heavily on Laaser and Soltwedel, forthcoming; Soltwedel and Laaser 2002, mimeo.

The structure of this work-in-progress paper is as follows: Section 2 presents a short survey on existing empirical literature on spatial implications of the Internet. Section 3 looks at basic considerations on potential internet-driven spatial differentiation processes which could provide links to future empirical evidence. Section 4 discusses different proxy indicators for spatial structural change related to these categories. In section 5, some conclusions for further research will be drawn.

However, a specific caveat is warranted: what we are looking at, is very much a moving target instead of being a concise research topic. The fully-fledged impact of E-commerce on the old economy may still be an issue at best looming around the corner instead of being already in the pipeline because the systemic properties are not yet in place to really wire up the economy effectively. Thus, what we will share with you contains a big chunk of speculation.

2. Empirical evidence on spatial effects of the Internet

The existing literature on spatial effects of the New Economy mainly looks at the *locational pattern of New Economy firms* whereas spatially relevant information on New Economy applications in the old economy, i.e., B2B, is not yet collected by public data sources.

Pertinent studies suggest that New Economy firms behave in their locational choice exactly the way one should expect from their feature of being highly innovative and knowledge-intensive enterprises with a highly skilled labor force: These firms are forming clusters as, e.g., in the U.S.A., in important agglomeration areas, close to importent clients, pools of highly skilled collaborators, suppliers of complementary services, such as media or finance, and, given their often high degree of specialization, to other firms of the same branch (Heindl and Pauschert 2000: 176 ff.). Therefore, start-ups of the Internet economy in Germany have a by far the higher growth potential if they choose locations in large cities with an abundant supply of skilled labor and established financial infrastructure (Krafft 2001; see also Dohse 2002). Bade and Nerlinger (2000) found start-ups in Germany to be concentrated on a belt alongside the Rhine southward to Baden-Württemberg, with particular clusters aroud core cities and in proximity to R&D facilities. Accordingly, “dot.com” firms in the United Kingdom apparently prefer locations in or around the agglomeration of London, i.e. in the city or along the radial motorway corridors (Gillespie et al. 2000: 7 f). A similar picture can be

found in the Nordic countries Denmark, Sweden, Norway and Finland where some of the world's leading telecommunications companies are located. The locational pattern of ICT-related consultancy employment which may be taken as a proxy for New Economy activities shows a high concentration record on agglomerations. For instance in Denmark these activities can nearly exclusively be found in the Copenhagen area with a second smaller cone in the Aarhus area, but there is little evidence for a dispersion to remote regions (Winther 2001). Incorporating the whole Nordic ICT industry into a larger European context reveals again two areas of dense concentration of firms: the great "Western and Central European banana" and the small "Nordic potato" (Koski et al. 2001). Even call-center which provide separable functions of customer services, consultancy, information dissemination and communication do not become footloose as one could expect but, instead, show a pattern of clustering to agglomerations with abundant supply of skilled labor, albeit not concentrated in the very central locations but in the adjacent circles of suburbs (see Halves 2001 for Germany and Bristow et al. 2000 for the U.K.). Summing up: New Economy firms locate in urban agglomerations.

It is more difficult, however, to find hard evidence on *changes in the locational pattern in the old economy* caused by pervasive B2B applications in old economy firms. Public data sources so far do not address this issue directly, and available studies on B2B impact concentrate on industry specific topics or firm size, such as EITO (2001) where sectoral differences in B2B feasibility in Western European firms of selected industries are investigated, or Bertschek and Fryges (2001) who analyse the driving forces of B2B implementation in the German industrial sector. Both studies find distinct differences of B2B utilization in the industries under investigation, but unfortunately do not differentiate their results spatially.

Nevertheless it can be expected that E-commerce solutions in old economy-firms have the potential to substantially alter the economic geography of production and co-operation, because B2B applications will lower spatial transactions costs and have the potential to make distance less relevant in the value added chain. Of course, a few studies can be found which address directly these spatial effects of B2B, such as Grentzer (1999) who asked for the locational consequences of increasing ICT-applications, i.e. changes in the geography of domestic and foreign firm sites of a large corporate network, or Caspar et al. (2000: pp. 71) who investigated functional

decentralization and increased inter-firm co-operation entailed by increased utilization of ICT services. Both studies render interesting results — we will return to this later on — but at the same time they exhibit the basic dilemma of empirical research in this context: they — as well as the sectoral studies mentioned before — have to rely either on case studies or on specific questionnaires among a limited population of enterprises in order to generate empirical facts. Learning more about spatial differentiation processes of the Internet in the old economy thus is still a costly and time-consuming affair. Hence, further search for suitable proxies for the Internet's implication in the old economy seems warranted.

3. Basic considerations on spatial effects of the Internet

What is new about the Internet and its potential spatial consequences? Both the technological characteristics of the internet as a means to bridge-up distances and the issue of explaining changing locational activity patterns have had their forerunners: On the technological side, other distance-relevant general-purpose technologies have opened up new vistas of a more intense interregional division of labor; on the explanatory side, the telematics debate of the 1980s paved the road to understanding the spatial impact of the Internet.

3.1 The spatial impact of earlier general purpose technologies

Forerunners as an universal distance-reducing technology were the steam engine and the railways in the 19th century and the telephone in the 20th.

- The analysis by Rosenberg and Trajtenberg (2001) on the spatial effects of the increasing deployment of a specific innovative vintage of the steam engine in 19th century US suggests two-sided spatial effects: The increasing application of the new technology permitted a relocation and reorganization of economic activity which had so far suffered from severe locational restrictions of water-power supply. In this sense, it opened up additional locational options. On the other hand, the new technology "served as a catalyst for the massive relocation of industry away from rural areas and into large urban centers, thus fueling agglomeration economies, attracting further population, and fostering economic growth" (ibid.: 44).
- The advent of the railways entailed — just as the New Economy did — an initial stock exchange hype with subsequent bankruptcies of the majority of players, not least because of declining transaction costs which permitted the opening-up of "new

frontiers" at the periphery, thus causing a "death of distance" (Cairncross 1997). The spatial diffusion of the new rail technology lead to agglomerative and deglomerative tendencies at the same time. The agglomerative impact of railways was their support for urban development because central locations now could rely on fast and reliable supply of all vital commodities being delivered from the rural periphery. The deglomerative impact was the synchronization of time zones along their tracks which is a prerequisite of spatial division of labor over greater distances and which opened distant locations the access to interregional competition (Coyle 2000).[2]

- Similarly, the development of telephone and related networks gave rise to both agglomerative and deglomerative tendencies. As seen from the perspective of technological diffusion, telephone networks and service utilization spread out from business applications in agglomerative centers both to private applications and to less central locations. This functional and spatial diffusion pattern clearly supported agglomerations until applications became ubiquitous. At the same time, increasing applications of telephone and related ICT-technologies have offered a widely unexhausted potential for decentralization of economic activities, in particular physical production, because information and control functions could be centralized due to declining telecommunications costs.[3]

The upshot of this brief historical review is that apparently both agglomerative and deglomerative tendencies were occurring in the course of increased deployment of the innovative technologies.

3.2 A stylized pattern of adjustment

The spatial impact of the advance of ICT implications and, in particular, B2B will depend upon how the balance of centrifugal and centripetal forces at work shaping the incumbent economic landscape will be influenced. The pattern of adjustment may run along the subsequent stylized steps, starting with high transaction costs (see Quah, 2001a: pp. 8)[4]:

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2 Against this backdrop, the seminal theory of spatial differentiation by transport improvements or deficiencies as developed by Fritz Voigt (1965a-d) should be remembered. It can provide the base for evaluating the scope of spatial impacts of E-commerce, because it outlines the space-shaping power of basic innovations which make distance less relevant.

3 Cf. Fritsch and Ewers (1985: pp. 34); Henckel et al. (1984: pp. 64).

4 This stylized pattern is similar toprocesses described in the new economic geography by Krugman (1991); Fujita, Krugman, Venables (1999).

(i) High spatial transaction costs – in particular transport costs in the narrow sense – favor a spatial decentralization since overcoming distance is expensive in that scenario. Local suppliers benefit from a sort of quasi-tariff protection against interregional competition.

(ii) The reduction of transaction costs made possible by E-commerce will give impetus to making the location of economic activities more footloose; the portfolio of locations will increase for producers and for trade.

(iii) However, agglomerative forces are enhanced and regional concentration will increase whenever scale economies in production and distribution are at work, localization or urbanization externalities exist. This will enhance the incentive for clustering.

(iv) Incumbent suppliers at traditional locations will increasingly be under the gun from two sides: locational dependence is getting loose and, potentially, increasing regional concentration will likewise increase the heat of competition.

(v) Path dependencies will favor existing agglomerations because of the need of firms to tap on a multi-faceted, broad and rich pool of qualified labor resources and other specific localized inputs.

(vi) Nevertheless, agglomeration costs such as congestion and pollution as well as a heightened intensity of competition act as countervailing forces against the increase of regional concentration and will foster the evasion towards less central locations.

The new equilibrium that will evolve from the adjustment to the increasing spread of applying ICT-technologies will depend upon the relative strength of these effects. The relative strength of these effects will, in turn, will depend upon a complex interplay between four categories of costs which, to make it even more complicated, are interdependent (Venables 2001):

(i) the search and information costs that will be drastically reduced by ICT-applications;

(ii) transport costs proper; given the secular decline in transport costs ICT-application will add to that by progress in logistics, however, ICT-applications

will hardly have an effect where digitization in the fulfillment and control of contracts does not really make headway;

(iii) control and management costs, in particular where incomplete contracts make governance;

(iv) time costs in fulfilling contracts that may impinge upon the revision of decisions about production and distribution.

3.3 The knowledge/information ratio as a guideline for assessing spatial effects

Among the various transaction costs categories, ICT-applications will primarily reduce information costs. Therefore it is key to the understanding of the spatial processes of agglomeration and deglomeration of economic activities what the specificities of the information are that contract partners exchange alongside the value chain.

A very similar perspective has been taken in the telematics debate in the 1980s which centered on the question of potential spatial impacts of innovative combinations of telecommunications applications and computerization.[5] It came up with the following stylized patterns:

- a decentralization of *standard production activities* due to a decreasing significance of the transaction-hampering power of distance,
- at the same time a centralization of *management tasks* which require face-to-face contacts, and
- possibly a *polarization of economic activities* between agglomerations and periphery with unclear consequences for the locations in-between (Fritsch and Ewers 1985: pp. 50).

The results of the telematics debate of the 1980s have taken a back seat since the end of the 1980s until now, because another important topic for network industries came to the fore, i.e. the deregulation and liberalization of these industries, including transport, telecommunications and energy. Incidentally, this very deregulation movement in OECD countries since the mid-1980s has not only given additional momentum to the secular decline of spatial transaction costs[6]. It has also spurred technological,

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[5] Cf., e.g., Goddard et al. (1983); Marti and Mauch (1984); Fritsch and Ewers (1985); Picot (1985).

[6] Both transport and communicatons costs are today only a fraction of what they have been in the 1920s and 1930s: Average ocean shipping freight rates fell to a third of their former values, air transport fares per pax mile

organizational, and entrepreneurial progress in telecommunications and the networks' amalgamation with new media and the variety of contents being transported via ICT-networks. Not until the liberalization of distance-related networks the boost to technological and organizational progress and to entrepreneurial attitudes in ICT-services were bound to occur which now can trigger off noticeable spatial impacts.

While it is hardly the distance shrinking quality of the Internet itself that is new in an economic sense, its outstanding feature appears to be the "quantitative leap", i.e., the universal availability and operational readiness of the Internet as a transaction technique all over the economy in terms of a process innovation, and the utilization of more and more digitizable information in knowledge production in terms of a product innovation. Nevertheless, the qualitative dimension of the Internet's spatial impact is not so different from that of the older vintages of ICT. Hence, the hypotheses on the spatial impact of the internet to be found in the recent spatial economics literature are running quite parallel to the lines of argumentation to be found in the older telematics debate.

For instance, Leamer and Storper (2001) argue that highly complex and non-codifiable information need face-to-face contacts to be transmitted properly as it is the case with innovative products. These transactions require trust and understanding in co-operation as well as in market exchange and, in many instances, spatial proximity. Basically, this personal exchange of information helps verifying that the contract partner is appropriately investing resources and effort to ensure the mutually beneficial outcome of the transaction. Contrary to the exchange of complex information standardized codified information can be easily transmitted and understood without problems via ICT-networks. Activities that strongly rely on this kind of information can change locations more easily and, therefore, are getting more footloose.[7]

Another aspect of the same distinction is stressed by Audretsch and Thurik (2000: pp. 8) who prefer to define complex information by *tacit knowledge*. They argue that marginal cost of transmitting normal information may well have become invariant to distance due

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dropped to less than a fourth, and international telephone calls cost only one per cent in the nineties compared to 1930. Cf. Siebert and Klodt (1999).

[7] Already the telematics debate revealed that the necessity of face-to-face communication will limit the options for relocation to distant sites (see, e.g., Picot, 1985: 491). Face-to-face communication will be irreplaceable with respect to (a) establishing, verifying and developing social contacts and institutions, such as trust and understanding, (b) complex problems to be solved, and (c) rather fuzzy information being required for problem solutions. This is exactly the same description of crucial features of information that is put forward in recent analyses of the impact of the New Economy, such as in Leamer and Storper (2001).

to the ICT revolution. On the other hand, the marginal cost of transmitting knowledge, and especially tacit knowledge, still rises with distance and has by no means been changed by the introduction of ICT-applications and by globalization. By virtue of a change of relative prices between the transmission of information and knowledge, comparative advantages of different locations will shift from traditional factors of land, labor, and capital towards innovative activity. The diffusion of tacit knowledge necessary for innovation remains localized; the success of spillover is still sensitive to distance. As a result, proximity to sources of knowledge spillover will be decisive for commercial success and for a location's competitiveness in attracting mobile resources.

The synoptic view on the predictions of the telematics debate and on recent reasoning on the spatial impact of the Internet thus leads to the conclusion that the distinction between tacit knowledge and ordinary information provides a guideline for potential spatial structural change as a consequence of B2B-applications. As a consequence, in order to gain empirical evidence on spatial implications of E-commerce it is necessary to look at the characteristics of the information exchange. Spatial clusters of economic activity will persevere or even increase if information to be exchanged in transactions is complex and difficult to digitize and less so if they are standard and easy to digitize.

Clustering of economic activities will evolve where there is a strong need for the exchange of complex information. Very often this is the case with research activities clustering around research and education institutions to benefit from positive externalities. If the complexity of information extends into the backward (B2B) and/or forward linkages (B2C), however, proximity is required to suppliers and customers, respectively. More generally: agglomeration effects will arise at that point of the value chain where complex information is crucial for the economic success of the transaction. The more information can be subjected to codification and digitization, the more dispersed the pattern of location will be. If the increasing penetration of ICT-applications will foster this process, the death of distance may entail a decline of cities – telecommunications and cities seem to be substitutes.

4. Empirical approaches to capture the spatial effects of the Internet on the old economy

The Internet's feature as a general-purpose technology first of all provides ample opportunity for *firms* and *whole branches* to re-organize internal firm structures,

external delivery, sales and co-operation networks as well as whole value-added chains. These opportunities were previously not available because of prohibitive communications, time and control costs (Porter 2001).

The Internet may create new business models, but primarily it provides options for improving "front end" productivity by virtue of process innovations. Internet solutions will be incorporated into normal business of more or less all firms. Spatial differentiation effects at the firm level due to B2B may incorporate

- complete or partial firm-site relocations, in particular of those entrepreneurial functions which can be performed by remote control,
- an outsourcing of functions which, in a process of concentrating on core competencies, can more favorably be performed by external suppliers or buyers,
- new commercial exchange relations via electronic marketplaces with more distant partners and
- new co-operation agreements with other firms, including strategic alliances or even take-overs, leading to new patterns of the regional division of labor in a functional sense.

As a result, a new geography of firm site locations may emerge. The research task is therefore to link relocations or new patterns of suppliers/customers to the knowledge content or digitisation potential of a transaction.

4.1 Case studies and cross-firm surveys on spatial effects of B2B

As already has been mentioned, existing studies on the impact of the internet on the old economy are either *case studies* dealing with single firms or conglomerates, or they are based on *interviews* of potentially affected firms.

A pertinent case study is the analysis of Grentzer (1999) who asked for the locational consequences of increasing ICT-applications for the *geography of domestic and foreign firm sites of a large corporate network* (as a matter of fact: the Siemens AG). Grenzer finds that (i) both ICT-driven globalization and regionalization occurred simultaneously and that (ii) existing domestic locations did not necessarily cease to exist but instead changed their functional character in the context of the value added chain. In this particular case a concentration and clustering of entrepreneurial and dispositive as well as R&D functions in agglomerations could be observed which, at the same time, were

reduced to core competence. Secondary domestic locations lost their former production activities, often to foreign locations with lower factor costs, but at the same time stepped in former headquarter functions which did not require face-to-face contacts but could be performed via ICT-networks.

A cross-firm survey based on field research has been undertaken by Caspar et al. (2000: pp. 71).[8] The authors sent questionnaires to a large number of firms across all size classes in the Rhein-Main labor market region, asked for both *functional decentralization and increased inter-firm co-operation* entailed by increased utilization of ICT services, and received an adequate sample of answers. What makes their survey differ from other inquiries is the explicit consideration of the spatial scope of the ICT applications, i.e. (a) whether ICT is used solely for internal purposes within a firm site or in contact with other firm sites of the same enterprise or even with external enterprises, and (b) the explicit location of the partner of communication. Moreover, the field of ICT-application was differentiated by entrepreneurial function. Their results indicate that (i) only a minority utilized ICT for either decentralization or co-operation, but in particular larger firms made explicit use of these options, (ii) the functions of production of goods/supplying of services, utilization of complementary services, controlling and data processing were dominating the cases of actual decentralization, either by purchase from other firms or, to a lesser extent, by relocation of firm sites, (iii) ICT networks in vertical value added chains clearly dominated horizontal alliances, and (iv) nearly two fifth of the communication partners linked by ICT-networks (decentralized sites as well as co-operation partners) were located in the same region, i.e. Rhein-Main, whereas the intensity of communications significantly decreased with distance (ibid.: pp. 78-86). Caspar et al. (2000 : pp. 85-86) conclude that entrepreneurial functions remain more or less regionally concentrated even under intensified ICT-applications in the production process; in other words: a general trend of entrepreneurial functions becoming more “footloose” is not supported by their data-base.[9]

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[8] The study of Caspar et al. (2000) has been part of the project „Globalization and Regional Labor Markets“ of the Special Research Programme „Competitive Advantage by Networking – Development of the Frankfurt and Rhine-Main Region“ at the Johann-Wolfgang-von –Goethe-University Frankfurt/Main.

[9] This result is similar to findings for the impact of ICT in the USA. Gaspar and Glaeser (1996) investigated the interdependence of increased ICT applications and business trips. For the USA, they found an *increasing* ratio of business trips in relation to GDP over the two last decades, i.e. the era of flourishing of ICT and decreasing ICT-costs after deregulation. They conclude that ICT is not necessarily a substitute to face-to-face-communication but rather may stimulate it and thus may stress the importance of cities and agglomerations. Note, however, that the period which Gaspar and Glaeser chose for their investigation is characterized by

Although the studies cited above differ in their methodology and scope, a common conclusion may be justified: ICT has forced headquarters to concentrate — both with regard to core competencies and spatially in the agglomeration centers —, whereas complementary functions (e.g., business services) as well as the production activities are going to be outsourced — however, not towards the extreme periphery but rather to the medium neighborhood. Apparently, a mild decentralization is occurring as a consequence of ICT which at the same time strengthens the relative importance of cities.

To capture the impact of New Economy applications on B2B, directly one would need data both on internet-driven decentralization processes of firm sites (similar to Caspar et al. 2000) and on changing patterns of transactions partners of firms (in their supplier-customer relations and co-operation partners) caused by B2B on a larger scale. However, publicly available data on this issue are not available; firms may perceive of them as business secrets, i.e., hard to impossible to get for a broad-based analysis. Hence, proxies have to be developed to grasp the potential process of diffusion of standardized activities on the one hand and of clustering of knowledge-intensive activities on the other.

4.2 Structural indicators for the spatial impact of B2B

Basically, we embark on two avenues which could lead to such proxy indicators: (i) The first still very rough line of thought would ask which type of locations may be affected by internet-driven structural change. In this context, different indicators of affectedness could be developed, such as *connectivity to advanced ICT networks* or regional and structural differences in *technology absorption*. (ii) More sophisticated would be the question for the direction and intensity of spatial structural change entailed by the Internet. It is here, where the differentiation between tacit knowledge and codifiable information might apply and where data on the *knowledge-content of information* exchanged in the value added chain could render additional evidence.

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rapidly declining transport costs and, in particular, air fares — another result of the deregulation of US network industries — so that the additional business trips were facilitated from this side. But anyway, increased ICT applications did not bring about an end to face-to-face-communication. Instead it might even have stimulated it.

4.2.1 Affected types of location

Connectivity to the Internet

A first approximation concerning regional affectedness by B2B internet applications might look at potential and significant differences in regional *ICT infrastructure endowment and/or costs of access to the Internet, i.e. connectivity to the Internet*. If such a "digital divide" exists, at least in comparison between urban agglomerations and peripheral regions, then urban agglomeration should be affected insofar as the intensity of decentralization of standardized functions could increase due to additional options of outsourcing, and peripheral region, in turn, as they would lack the capability to host the functions dispensed by the agglomerations. As a result, agglomerations and their adjacent areas might be strengthened.

Whether noticeable regional differences in ICT infrastructure endowment or in Internet costs are relevant at all in advanced countries is an open question. Between different countries, of course, such differences exist (OECD 2000; OECD 2001: 39). But within a country such as Germany differences in endowment should be considered being negligible (Rauh 1999: 64), all the more so as telecommunications costs play a diminishing role as locational factor after the liberalization of telecommunications in 1998, even in the New Economy itself, e.g., for the location of call center (Halves 2001: 104). On the other hand, the dynamics of network provision have to be taken into account (Rauh 1999: 64): the most efficient vintages of ICT network equipment as well as the most favorable rates will be provided to large customers in agglomerations; for a given technology these differences will level off after a while, but in the context of fast or even accelerating technical progress in ICT the endowment/costs differences might persist. Moreover, if regional endowment differences are documented for other industrial countries, such as France where a distinct digital divide between Paris and the peripheral departments exist with respect to access to innovative transmission techniques (see Le Monde 2001), or are made responsible for relatively poor chances of remote regions of Scotland to attract New Economy firms without regional policy support schemes (see Gillespie et al. 2000) then at least a non-negligible impact of the endowment/costs factor should be suspected. This impact would take the form of discriminating against peripheral regions not only with respect to attracting New Economy firms but also production sites relocated from central agglomerations to

remote-control locations. Nevertheless, the relevance of this issue remains unclear, and meaningful data are difficult to obtain.

Structural differences in ICT absorption

Another related approximation to regional affectedness of B2B could be based on differences in the *absorption of ICT applications by existing firms*, i.e. on the demand side for internet applications. According to Quah (2001b) the technological revolution brought about by the New Economy does not so much consist of a shift in the aggregate production function but rather of a new quality of the aggregate utility function due to the new options to bridge distances. This would mean that differences in B2B Internet deployment within and across firms might be crucial for regional structural change: regions with high application rates, either with respect to income or to industry affiliation would be more affected than regions with a poor absorption of B2B applications.

Relevant in this context is the "digital divide" with respect to regions, income, firm size or structural indicators. In several analyses we find a clearly negative slope of application rates from higher utilization in urban agglomerations and regions with higher per capita incomes to peripheral and lower incomes regions.[10] If the deployment of B2B should be a function of income and density of economic activity then again the peripheral regions would be less affected due to their lower income and less intense stocking with B2B-prone enterprises whereas structural change would be more intense in agglomerations. However, the digital divide may be a transitory phenomenon: the application rate might increase also in more remote areas in the course of time due to imitation. Then the spatial impact of B2B would be more evenly distributed. However, available data on this issue reveal only a very rough picture with respect to regional differentiation so that only qualitative statements can be made.

Nevertheless, data on *differences of Internet penetration with respect to industries and to firm size* provided by EITO (2001) and Bertschek and Fryges (2001)[11] show distinct differences in Internet utilization of B2B. Most prevalent is B2B utilization in industries close to the New Economy itself such as the computer and telecommunications

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[10] See OECD (2000). A parallel digital divide exists with repect to B2C users, i.e. consumers at the end of the value-addes chain: The internet-penetration is much higher for high-income consumers as well as for younger consumers. Hence, the impact of B2C should be felt more in agglomerations than in rural areas, although the encyclopedic function of the Internet should favour in particular the latter.

[11] See tables 1-4 in the appendix.

business, electrical engineering or technical services, tourism and wholesale trade. Consumer industries, such as furniture production appear to lag behind. Moreover, larger firms are utilizing B2B more intensely than smaller ones (see Tables 1-4 in the appendix). Both observations could be combined with existing data on the status quo of the regional distribution of industries (employees or value added) and the predicted future course of sectoral structural change in order to arrive at conclusions of the relative affectedness of different types of regions. Note, however: this is a static picture; Bertschek and Fryges (2001: 9 and 16-17) have identified the "bandwagon" or imitation effect as the main driver of B2B adoption in firms across industries. Hence, again, the initial differences in Internet implementation might fade away over time, regional affectedness of B2B would become universal and spatial impact would, at the end of the road, foster convergence instead of divergence. Thus, the regional affectedness-approach can possibly only serve as a very rough initial sketch of spatial effects of B2B; it would hardly grasp that the pattern of adjustment may change over time.

4.2.2 Proxies for the direction of Internet-driven structural change

The telematics debate and the more recent Internet debate have shown that a major impact of Internet-driven decrease of spatial transaction costs can be expected for activities with a high content of codified information either in the product itself or as input in the course of the value chain. Consequently, these activities could become footloose whereas activities with a high content of tacit knowledge would tend to cluster in central agglomerations.

Job qualification and functional employment patterns

If that were true, empirical evidence could be found from changes in the locational pattern of jobs with different qualifications —relative importance of different levels of skilled labor force either at central or at peripheral locations would serve as a proxy for the knowledge/codified information ratio of a transaction. Two avenues of research could be taken in this context: (i) an analysis of regional specialization of different locations which is confronted with functional specialization with respect to specific types of employees as in Duranton and Puga (2001) and (ii) the analysis of the changes

in the regional structure of the human capital of employees as in Bade and Schönert (1997), Bade, Niebuhr and Schönert (2000) and Bade (2001).[12]

Duranton and Puga (2001) found evidence for the USA that the degree of sectoral specialisation of cities of various sizes has decreased in the last forty years (the period of the increasing use of telecommunications) whereas the functional specialisation (measured by the deviation of the ratio of white collar to blue collar employees from the national average) has increased.[13]

The explanation behind the Duranton-Puga-hypothesis is the notion that decreasing spatial transactions costs will suggest a separation of management and production functions beyond certain thresholds. Management functions depend on face-to-face-communication, exhibit a higher level of urbanization economies beyond branch borders, such as in contacts to firm-related services, and will cluster in central cities. Productive functions, on the other hand, are less prone to urbanization economies but subject to factor costs consideration and will be dispersed to a greater variety of more distant and smaller cities. This process may result in the change of a location's sectoral to a functional specialization pattern.

For Germany, the empirical picture seems to contradict Duranton/Puga. The Bade approach e.g. in looks at the change in the distribution of human capital in Germany (measured either by personal qualification or affiliation of workers to specific occupational groups according to the employment statistic) regional perspective and the dimension of regional structural change for highly skilled employment. The analyses present relative growth paths of different occupational qualifications for various classes of locations (agglomeration centers, urban fringes, semi-concentrated regions and the absolute periphery) for longer time-series. They suggest that (i) that there is an ongoing deconcentration process of employment from agglomerations to more remote areas, (ii) this process is not confined to production activities but encompasses all kinds of highly skilled labor including R&D, (iii) the process does not peter off at the border of the urban fringe but extends into the periphery, and (iv) disparities between agglomerations and the periphery are still declining (see Bade, Niebuhr and Schönert 2000: 21-22).

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12 See also Bade and Schönert (1997), Bade and Niebuhr (1999), and Bade, Niebuhr and Schönert (2000).

13 The results of Duranton and Puga (2001) are reported in Table 5 in the appendix.

At first glace these results for Germany —the periphery gains across the board against agglomerations – might contradict the findings of Duranton and Puga (2001) for the USA. However, Bade and Schönert (1997: 78) and Bade, Niebuhr and Schönert (2000: 22) point at two qualifications of their results: The *number* of high-skilled and R&D workers is still increasing in agglomerations, albeit at less than proportional rates, and due to the still existing steep slope in the share of high-skilled labor from agglomerations of the periphery, the pertinent *share* in agglomerations might even grow slightly faster than at the periphery. Moreover, Bade (2001: 357) has found different results for another occupational qualification which can be described by "strategic planning services for enterprises" (management consultancy, accountancy, and legal advisory services). For this group the decentralization process in Germany is much less distinct and dispensed employees from the centers are more or less absorbed by the urban fringe. Both observations taken together might well be in line with the findings of Duranton and Puga (2001) who concentrated on the *ratio* between white collar and blue collar workers.

We are going to use the Bade type of data to do the Duranton/Puga-approach for Germany, and to look for the functional specialization of cities in Germany with respect to some more several occupational qualifications which might be affected by face-to-face rather than ICT-eligible communication.

However, there is reason to be cautious to linking potentially observable spatial trends to the increasing use of the Internet or ICT applications in general. It would mean to overstate the ICT-impact to attribute to it any concentration or deconcentration of qualified jobs in the last decades. Only the period after 1990 when the technical progress accelerated due to the looming liberalization of communications should be considered. But even for this period any potential correlation might remain week due to alternative explanatory variables. However, given the scarcity of available data this approach may render at least some tentative evidence and conclusions.

R&D and technology intensity of products

Another approach for utilizing existing official data sources as proxy for ICT-driven spatial structural change could deploy structural data on R&D and technology intensity or the technology content of the respective industries' products. This approach has been used in international economics in the context of identifying changing comparative

advantages of advanced countries, potential relocation of production plants to less developed countries, and increasing competition by imports from LDCs. Due to the central criterion of "importance of face-to-face-contacts" for distinguishing industries this approach might have some relevance for our problem. Such differences can be found both for manufacturing industries and for service industries.

(1) In *manufacturing*, basically two types of industries can be distinguished: (a) so-called Heckscher-Ohlin industries which with products based on standardized knowledge and an international division of labor determined by relative factor endowments, and (b) Schumpeter industries which are producing with a high technology or R&D intensity. The latter group can be subdivided further into (ba) Schumpeter-mobile and (bb) Schumpeter-immobile industries;[14] this subdivision makes the distinction interesting for the application of ICT:

- *Schumpeter-mobile industries* are characterized by weak complementarities between R&D and production, knowledge production is predominantly conducted by laboratory research (in particular by scientists) and manufacturing is characterized by mass production; R&D expenditures are fixed costs for the entire enterprise but not for the individual plant. Consequently, production plants can be decoupled from R&D laboratories and relocated to regions or countries with more favorable factor costs than agglomerations in advanced countries, and this process may be fuelled by advances in ICT technologies. The technology of these industries becomes mobile in international perspective and can easily be utilized in other countries irrespective of its high-tech content.

- *Schumpeter-immobile industries*, on the other hand, rely upon close local co-operation between R&D and manufacturing plants, proximity matters for success, R&D is performed mainly by engineers and production by skilled workers at small batch sizes, and R&D costs are predominantly variable costs. As a result, the technology of this industry is more or less bound to the location of its implementation and is not easily transferred to less developed countries.

(2) For the *service sector* Klodt (1995: 161-162) uses the Baghwati (1984) distinction between "embodied services" and "disembodied services". Embodied services have to be provided in direct contact between supplier and customer, as it is the case for

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[14] See Klodt (1990: 67-68) and Klodt et al. (1989: 27-34) on this distinction.

classical services such as transportation, health care, catering, or haircutting. In contrast to this, disembodied services can be supplied without such contacts, are characterized by a high information content and, hence, are suited for being traded via ICT networks. Pertinent examples are given by financial and insurance services or consultancy.

However, both classification schemes are, as yet, still too broad to serve as a ready-to-use tool for regional analysis in an unadjusted manner:

- The concept for manufacturing has been developed for explaining the relocation of activities of high-tech industries to less developed countries, but it fails to illustrate the "short-distance structural change". In Schumpeter-mobile industries ICT permits a decoupling of production plants from R&D laboratories and their relocation to sites with more favorable factor costs patterns. But these plants will presumably go abroad and will not choose the domestic periphery as their new location **because international factor cost differential and differences in the institutional set-up are greater than within the domestic economy**. Moreover, the option of decoupling does by no means give evidence on the domestic location of the R&D labs, i.e. the part of production which advanced countries should retain a comparative advantage to host domestically. Likewise, Schumpeter-immobile industries may stay in advanced countries, but it is far from conclusive in which particular region.[15] Nevertheless, an advanced classification scheme for further distinguishing Schumpeter-mobile industries into branches with urban character and others with non-urban character might serve the purpose of providing information on the domestic spatial structural change.
- A similar reservation has to be made against the scheme for services — here with respect to the insufficient disaggregation of "disembodied services". In fact, communications, banking, or insurance services show a distinct picture of clustering

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[15] R&D labs may be dependent on the proximity to other research sites existing mainly in agglomerations, but not necessarily. At least, they may even cohabitate with production sites as the tendency of relocation of R&D employment in the other group of industries, the Schumpeter-immobile ones, demonstrates: If R&D employment in Germany is increasing at a distinctly higher rate outside the core cities of agglomerations as the findings of Bade (2001: 355-356) suggest this result can at least partly be attributed to the requirement of proximity between R&D and manufacturing (ibid., 346), i.e. R&D labs are following the relocation of production plants towards the periphery. As a consequence, industries which are Schumpeter-immobile in the international context are rather mobile in domestic perspective. This may or may not be the case for R&D employment in the group of ICT-sensitive Schumpeter-mobile industries.

in major agglomerations, at least for their headquarters.[16] Apparently, headquarter functions are sensitive to localization and agglomeration economies and could be labeled as urban disembodied services. In contrast to these tendencies of clustering, a variety of business services is less dependent on the different specifications of scale economies, and often requires face-to-face contacts just in the same way as embodied services. Thus they can be considered being more footloose than urban services and might exit from the city core. As a consequence, a more subtle classification scheme for distinguishing disembodied services into "urban" and "footloose" ones is called for.

A refined version of both the manufacturing and of the services classification scheme thus should have the feature of classifying an industry firstly according to its eligibility for introducing ICT applications in its value added chain and secondly according to the degree of its dependence of either localization or urbanization economies.[17] This implies that in particular the ICT-relevant groups of Schumpeter-mobile industries and of disembodied services should both be further subdivided as being industries in need of an "urban" milieu or not.

The urban-periphery employment pattern which could be derived from this attempt might run along the lines of the Thünen-circle model as presented in Klodt (1995: 169-173). Due to different willingness-to-pay functions of services and manufacturing firms for urban real estate (reservation price functions)[18] urban disembodied services concentrate in the core center according to this simple model while footloose disembodied services settle beyond a manufacturing-dominated ring in between. It we take into consideration a further subdivision of manufacturing firms, the manufacturing ring in between should be composed of Schumpeter-mobile R&D labs at the ring's

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16 Branch offices are, of course, dispersed throughout the country (Klodt 1995: 168-169).

17 Support for such an undertaking might possibly come from two sources: The OECD (2001: 31, 46-47) has published, albeit very rough and only for single years, data on ICT penetration and relative ICT investment expenditures by industry for a few OECD members. This might serve as a point of departure for classifying industries according to their ICT-eligibility. Moreover, Keilbach (2002: 68-70) has calculated Gini coefficients of spatial concentration for German manufacturing and service industries on a relatively disaggegated basis, albeit with data of the 1987 working place census. This would help to find evidence for the dependence of localization or urbanization economies.

18 The sectoral reservation price functions can be expected to be more convex for services than for manufacturing firms, because manufacturing firms are not willing to pay the high rental prices in core centers as do urban disembodied services but are more transportation cost-sensitive than footloose disembodied services. As a result, the much steeper reservation price function of aggregate services intersects the less steep function of manufacturing twice, with urban services outperforming manufacturing in the core cities but manufacturing outperforming footloose services on the adjacent ring.

inner border to the core area and of either R&D or production sites of Schumpeter-immobile industries at the ring's outer border to the next service ring.

With respect to data availability, again the employment data base could be deployed. Although figures on employment for specific districts are presumably not available because of secrecy obligations, an aggregation over different types of regions or districts according to the regional classification scheme of the BBR might give some evidence on the spatial structural change. To be sure, such data are not published directly but hat to be compiled from internal data by the statistical office.

5. Conclusions

For the foreseeable future, empirical research on implications of the Internet on the spatial division of labor will have to rely either on data which have been compiled by specified surveys among affected firms or on proxy indicators which link Internet applications with the identified (and statistically documented) locations of firm sites or jobs in space.

While this task is easier to perform for firms of the New Economy proper — because numerous actual surveys on the locational choice of New Economy firms have been undertaken recently or are going to be published —, it is more difficult to trace the spatial impact of deploying B2B-E-commerce techniques in old-economy-firms. Both the palette of suppliers/customers can be expected to change because of increased locational competition as well as the geography of firms due to the potential for outsourcing of and co-operation in entrepreneurial functions qualifying for remote control. Empirical research would require comprehensive data bases on both phenomena. Alas, only a limited number of surveys exists on this issue. Among conceivable proxy indicators either indicators of affectedness of different types of locations could be deployed or indicators of the direction of Internet-driven structural change:

Different types of locations might be subject to B2B implications because of differences in ICT infrastructure quality or access costs, or because of sectoral differences in Internet utilization. While the infrastructure/access costs issue appears to be less important for Germany, the different qualification of branches for Internet transaction might render some information on affectedness due to actual sectoral patterns of

regions. However, in the course of the dissemination of Internet applications these differences are transitory and can be expected to disappear sooner or later.

Given the different impact of ICT on various entrepreneurial functions in the course of the value-added-chain (do they require face-to-face contact or not?) it is probably more fruitful to deploy existing data on changes in locational patterns of human capital and jobs with high qualifications as a proxy for the direction of Internet-driven structural change and to link changes of spatial job patterns of different types of locations with the potential for firms' reorganization permitted by B2B.

On this second avenue, the Bade approach of measuring human capital distribution by the number of jobs of selected skills could be combined with an analysis of potential changes of functional specialization of different types of cities according to the Duranton-Puga approach. While the Bade (2001) results suggest that all kinds of activities, not only production, are decentralized to more remote locations in Germany, somewhat less distinct results for management functions give the impression that a specialization of large agglomerations on face-to-face activities could be found for Germany, too, similar to the results of Duranton and Puga (2001) for the USA.

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Appendix

Table 1 — Internet Implementation in Firms of Various Industries in Western Europe

	Retail		Tourism		Chemical Industry		Furniture Industry		Mechanical and electrical engineering	
	Small firms[1]	Large firms[2]	Small firms[1]	Large firms[2]	Small firms[1]	Large firms[2]	Small firms[1]	Large firms[2]	Small firms[1]	Large firms[2]
LAN and Internet access penetration										
% of sites with LAN	51	94	49	88	62	87	41	98	84	95
% of PCs connected to a LAN	86	85	79	91	93	95	34	86	86	85
Presence of Internet access	74	85	73	87	75	99	61	92	89	100
% of PCs with Internet access	29	30	40	32	38	29	37	32	32	35
Website primary function										
Detailed product information	18	51	51	69	20	56	42	46	22	53
Customer service and support	12	34	23	46	36	38	38	43	12	50
Sales transaction	13	30	23	29	5	16	16	13	12	40
Online payment	5	3	4	8	2	1	—	—	2	10

[1]1 to 99 employees. — [2]More than 100 employees.

Source: EITO (2001).

Table 2 — Internet Implementation Maturity in Various Industries in Western Europe

	Furniture	Retail	Tourism	Chemical	Mechan./ el.engin.
Internal E-commerce organisation					
Supply Chain Management (SCM)	0.4	1.0	0.2	0.6	0.8
Enterprise Resource Planning (ERP)	0.6	0.4	0.2	0.8	1.0
Intranet	0.2	0.6	0.4	1.0	0.8
Extranet	0.2	0.4	0.6	1.0	0.8
Knowledge management	0.2	0.6	0.8	1.0	0.4
Data warehousing/ business intelligence	0.4	0.6	0.2	1.0	0.8

Table Continued on next page

Table 2 continued — Internet Implementation Maturity in Various Industries in Western Europe

External E-commerce organisations					
Customer Relationship Management (CMR)	0.2	0.8	1.0	0.6	0.4
Website	0.4	0.2	1.0	0.8	0.6
Sales transactions on website	0.2	0.6	1.0	0.4	0.8
Online payment	0.6	1.0	0.8	0.2	0.4
Customer service/ support on website	1.0	0.2	0.6	0.8	0.4
Internet-enabled call centre	0.8	0.4	0.6	1.0	0.2

Source: EITO (2001).

Table 3 — B2B e-commerce by industry sectors

	B2B e-commerce		
Industry	No use	Sporadic	Broad
Consumer goods industry	60.17	33.47	6.36
Chemical industry	47.70	44.25	8.05
Other basis goods industry	53.16	35.44	11.39
Mechanical engineering	51.24	36.04	12.72
Electrial engineering	40.00	44.39	15.61
Medical, precision and optical instruments	52.56	37.21	10.23
Motor manufacturing industry	51.11	36.44	12.44
Wholesale trade	52.94	33.99	13.07
Retail trade	64.40	26.18	9.42
Transport and post	53.65	33.85	12.50
Financial intermediation	49.09	40.45	10.45
Computer and telecommunications	32.84	40.67	26.49
Technical services	54.26	32.29	13.45
Other business services	58.33	31.37	10.29

Source: Bertschek and Fryses (2001).

Table 4 — B2B E-Commerce by Size Classes

Employees	B2B E-Commerce		
	No use	Sporadic	Broad
5-9	63.41	26.83	9.76
10-19	54.64	31.97	13.39
20-49	56.61	31.84	11.55
50-99	51.79	33.16	15.05
100-199	51.41	35.74	12.85
200-499	45.38	41.51	13.12
≥500	43.18	44.55	12.27

Source: Bertschek and Fryses (2001).

Table 5 — The Diminishing Sectoral Specialisation and Increasing Functional Specialisation of US Cities According to Duranton and Puga 2001

Local population[a]	Sectoral specialisation[b]			Functional specialisation in management against production[c]			
	1977	1987	1997	1950	1970	1980	1990
5,000,000 – 19,397,717	.375	.369	.348	+10.2%	+22.4%	+30.8%	+39.0%
1,500,000 – 4,999,999	.287	.275	.257	+ 0.3%	+16.7%	+21.7%	+25.7%
500,000 – 1,499,999	.352	.338	.324	–10.9%	–10.0%	– 5.0%	– 2.1%
250,000 – 499,999	.450	.409	.381	– 9.7%	– 9.7%	–10.9%	–14.2%
75,000 – 249,999	.499	.467	.432	– 2.1%	– 6.6%	–12,7%	–20.7%
67 – 75,000	.708	.692	.661	– 4.0%	–33.7%	–40.4%	–40.5%

[a]Population by Metropolitan Statistical Area/Consolidated Metropolitan Statistical Area (New England County Metropolitan Area in New England), or Non-metro Area. The same areas are included in each population class throughout the table, on the basis of area definitions and population data from the Decennial Census of 2000. [b]Median value for each population class of a Gini index comparing the local and national distributions of employment shares across 2-digit sic manufacturing sectors. If s_h and $\bar{s}_h$ are respectively the local and national shares of employment in sector *h* the Gini specialisation index is $\frac{1}{2}\sum_h \left| s_h - \bar{s}_h \right|$. Its value is close to one if a city is fully specialised in a sector that is very small at the national level and is equal to zero if local employment is dispersed across sectors in the same way as national employment. [c]Perentage difference from the national average in the number of executives and managers per production worker (occupied in precision, production, fabrication, or assembly).

Source: Duranton and Puga 2001