ICT, Clusters and Regional Cohesion: A Summary of Theoretical and Empirical Research

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NOTA DI LAVORO 58.2003

JUNE 2003

KNOW – Knowledge, Technology, Human Capital

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Summary

The question of the spatial impacts of the Information and Communication Technology (ICT) has animated the intellectual and policy debate for a long time. At the beginning of the 1990s the rise of the Internet brought a new surge of debate: it was argued that the Internet would free the economy from the constraints of geography (Cairncross, 1997) bringing about a more even economic landscape. This contrasts sharply with the popular view of, for example, Silicon Valley, a congested area where world-class ICT and high-tech industries cluster together.

In theory, geographical agglomeration of economic activities results as an equilibrium solution of a tension between centripetal and centrifugal forces.

The paper discusses how the use of ICT may alter the balance between centripetal and centrifugal forces and therefore the final equilibrium solution. It shows that, from a theoretical point of view, there are many counterbalancing effects and not unique answer. The question is therefore down to empirical research. Available empirical evidences are then reported and discussed. Finally, the implications for European policies are drawn.

This paper was firstly prepared within the framework of the European Commission IST project Digital Europe: e-business and sustainable development (www.digital-eu.org), contract IST-2000-28606. The authors gratefully acknowledge Vidhya Alakeson, Andrew Gillespie, Jeremy Millard, Carlo Carraro, Alessandro Lanza, Marzio Galeotti and Francesco Rullani for their useful comments. Special thanks go to Francesco Rullani for his help on the definition of the digital economy and useful discussions on IPR rules and Open Source communities.

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1. Introduction

Continuous technological progress in ICT – starting with the introduction of the transistor back in the 1940s – has speeded the codification, processing, storage and communication of an ever increasing mass of information. New technologies for data manipulation and storage allow growing amount of information to be compressed into tiny electronic space, therefore making the flow of information quicker, cheaper, and immediate.

These advances have introduced new methods of data transmission on private networks within a firm, on private networks between firms, and on the public network (Kolko, 2001).

Individuals can now communicate instantly with people never met, send everywhere on Earth the equivalent of information contained in a book in real time, listen to any type of music produced in the world. Businesses are able to create and maintain large, centralised databases and share this centralised knowledge-base with decentralised operational plants. Workers can work remotely from their offices. The authors of this paper seat now in three different Italian cities.

The scenario is one of great changes in transport and communication costs.

Over a century ago, Alfred Marshall (1890) wrote that "*Every cheapening of the means of communication alters the action of forces that tend to localise industries*".

What does it mean now? What are the consequences of these changes on the spatial organisation of economic activities?

This is the question we are concerned about in this paper.

The question has animated the intellectual and political debate for a long time. In 1964 Marshall McLuhan wrote that new technologies would lead to a 'dense symphony of nations', with activities leaving the centre and going to the periphery, to create a uniform 'global village'. In 1988 Bairoch suggested that one of the causes of urban sprawl (in his words the 'break up of cities') was the development of television. 'For decades recreation was a factor drawing people into the cities. But what today do average city dwellers do with their leisure time? They spend it in front of their television sets, watching more or less the same programs as the average dwellers in the country'.

The beginning of the 1990s, following the emergence of the Internet, saw a new surge of debate. It was suggested that the Internet would free the economy from the constraints of geography. The Internet was perceived to be 'everywhere, yet nowhere in particular' (Economist, Aug 2001). Since ICT products are 'disrespectful of physical distance and geographical barriers' (Quah, 2000), the digital revolution could bring about the 'death of distance' (Cairncross, 1997): as 'weightless' goods such as software, databases, electronic libraries and new media can be transported at no cost, and ICTs free workers to work anywhere, then the digital economy could promote development opportunities in more remote and economically disadvantaged areas. The impact would not only be felt in new industries, but also in those traditional industries that would benefit from improved access to world markets.

This view contrasts sharply with an opposite spatial manifestation of the digital revolution: the Silicon Valley model, where world-class ICT and high-tech industries are concentrated in a congested area. Here ICT appear to result in greater concentration and further advantage the position of more developed cities and regions. This view has inspired policy-makers around the world trying to imitate the success of Silicon Valley offering tax breaks, infrastructures and regulatory relief to high-tech firms in specific locations (Kolko, 2001).

In the theory, geographical agglomerations and regional imbalances results as a equilibrium solution of a tension between centripetal and centrifugal forces.

This paper analyses how ICT may alter the centripetal and centrifugal forces, and therefore the final equilibrium solution. Those effects are then discussed in the light of recent empirical evidences and used to induce implication for EU policy-making.

Section 1 frames the debate. Section 2 looks at the forces that shape economic geography: centrifugal (convergence) and centripetal (divergence) forces and discusses how centrifugal and centripetal forces are altered in the digital economy. Section 3 reviews the existing empirical evidences. Section 4 discusses relevant policy implications.

2. Some definitions

Scholars have developed a wide range of concepts to capture the essence of the economy-wide consequences resulting from the increased use of processed digital information and from the application of the Internet for delivering services (software programming, webpage maintanance) or transactions (delivering music, movies, documents).

Catchwords such as “digital economy”, “virtual economy”, “information economy”, “weightless economy” , “knowledge economy”, “network economy”, “e-conomy” or may be the most used “new economy” refers to different characteristic of this phenomenon.

In response to the diffusion of the Internet, people and media adopted the term *new economy* to capture the idea that ongoing changes would transform the social and economic system. The term emphasises exactly this dimension: “new” means we are facing something that wasn’t there before.

Other scholars use the expression the *weightless economy* to describe the revolution, “replacing” the term “new” with “weightless”. They identify the shift from a *weighty* economy (made up of cars, stones, cement) to a *weightless economy* (made up of ideas, knowledge, software) as the key fact of the revolution (Quah, 1996).

Others, coming from different fields (sociology, economics, and anthropology) focused on the “networking” features of the revolution. ICT made possible and profitable (not only in economic terms) a new organisational model, which soon became one of the most important symbols of the revolution. The term *net economy* tries to capture this dimension (Castells, 1996).

Some authors have emphasised the *knowledge* dimension of some of these phenomena. The idea is that the possibility to digitalise a huge amount of information can increase knowledge profitability, production, use and diffusion. For example, the Open Source Software community is composed mostly by people who never met each other in person, but who share information, create debates and build a social environment in which they learn together and from each other[1]. These elements, combined with the increasing importance of knowledge as consumption good and as a production factor, represent the *knowledge economy* dimension (FEEM, 2003).

[1] For an overview of Open Source Community environment, see Torvalds, Diamond, 2001; Raymond, 2000; Free Software Foundation, 2001; for the economical aspects see Harhoff D., Henkel J., von Hippel E., 2000; Lerner, Tirole, 2000; Dalle, Jullien, 2000; Weber S., 2000; and eventually Himanen, Torvalds, Castells, 2001; Berra, Meo, 2001 (in Italian) for a sociological approach.

Albeit trying to capture different characteristics, most of these definitions are used as synonyms. "The weightless economy [is] also described as the knowledge economy, the intangible economy, the immaterial economy or simply the new economy" (Quah, 1998). Danny Quah's statement illustrates how the different definitions overlap each other.

Kling and Lamb (2000) suggest to use the term *information economy* to include all informational goods and services like publishing, research, legal and insurance services, entertaining and teaching in all of its forms, and the term *internet economy* to address (only) the good and services whose development, production, sale, or provision is critically dependent upon digital technologies. Finally, they associate the term *new economy* to the possible consequences of the information economy and the digital economy, namely high growth, low inflation, and low unemployment (Piazolo, 2001).

We will follow Piazolo (2001) and adopt a wider definition of *digital economy*, embracing the characteristics of both the information and the internet economy.

We will define *digital economy* as "an economy where both final output and intermediate input increasingly consist of information and where the modern (digital) ICT increasingly provide world-wide immediate access to any information made available. These new technologies might have the potential to enable an increase in the productivity of conventional business practices, but also facilitate the establishment of new processes and products. Consequently, the evolution of the digital economy should not be considered as being restricted to the information sector, but as a far reaching process that might alter and extend the products and production processes within the whole economy" (Piazolo, 2001, p 30).

We will therefore take into account three different manifestation of the rise of the digital economy.

Firstly, we will consider the growth of ICT sectors themselves, as defined by the OECD, 2002. ICT-producing sectors account now for between 3-5% of GDP in major industrialised countries (OECD, 2002). ICT sectors have been often studied as a manifestation of the digital economy in the simplification *ICT sectors=digital economy*. However, they include a wide range of industries, ranging from manufacturing industries (personal computers, data processing machines, telecommunication equipments including televisions and telephones), whose characteristics are probably not different from traditional manufacturing, to services (such as software development), whose products can be taken as representative of the *weightless and knowledge based economy*. Although important they might be to the digital economy, the study of their locational dynamics should be generalised with great care.

Secondly, we will discuss the development of new products and services. The developments in ICT industries have generated a range of new opportunities for economic activities, in the form of new products and services, involved in the creation, manipulation or distribution of digital content (Gillespie et al, 2001). Gillespie et al, 2001, mention *Multimedia* industries (associated with CD-Roms and standalone interactive software), *New Media* industries (focused on multi-user interactive information services based on the Internet) and *dot.com* activity (focused on transactional capacity of the Internet). Those are the sectors often associated in the business vulgate with the label of *new economy.* They represent a minor part of the GDP in industrialised countries. However, they represent a key driver of change at local level in many cases.

Finally, we will address the impact on the traditional sectors. The potential impact of the adoption of ICT on traditional sectors of the economy is wide-ranging. Firstly, in some industries the digitalisation of products allows infinite replicability of the product and disrespect of geographical distance in its delivery (music, e-book, insurances). This effect captures most of what Quah (2001) refers to as the *weightless* economy. Secondly, digitalisation and Internet offer immediate advertisement everywhere and facilitate worldwide relationships with clients: traditional firms in peripheral regions may have immediate access to world markets. Finally, last but not least, the increased capacity in data management at the firm level might allow an internal reorganisation of the firm, towards a different spatial structure (Gillespie et al, 2001).

However, before going into the details of the relationships between the rise of the digital economy and the spatial organisation of economic activities, some important clarifications need to be made concerning the relationships between the concept of *digital* economy as adopted above and those of *knowledge* economy and *weightless* economy.

OECD defines a *knowledge economy* as "directly based on the production, distribution and use of knowledge and information" (OECD, 1996). As defined, the knowledge economy is not directly related to ICT, and not necessarily new. "Economies have been knowledge-based for over 5,000 years. Sumerians in the Mesopotamian river basin began carving cuneiform financial records onto clay tablets 5,000 years ago. During the first Industrial Revolution, deploying spinning Jennies and steam engines significantly boosted economic performance. Such machines were the physical embodiment of new knowledge" (Quah, 1998). However, steam engines or clay tablets are physical objects, their use is limited by geographical and physical constraints. They embody knowledge, but they are not knowledge. Quah (1998) argues that the real novelty is in the fact that the "new" products, such as software, databases, electronic libraries, new media, videos, broadcasting do not just embody knowledge; they are knowledge and behave as such (Arrow, 1962). They represent what he calls the *weightless economy:* an economy whose products are not-excludible, infinitely replicable and transportable costlessly through space, like knowledge in Arrow (1962).

Nevertheless, it is important to stress that knowledge is a farther reaching concept than information: while it is possible to translate a piece of information into bits, this is not true for every kind of knowledge. "Knowledge represents the capacities or capabilities of an individual or a social group [...] associated with meaning and understanding, as well as the abilities to organise, interpret and assess information" (Cohendet, Stainmueller, 2000), while information is "knowledge reduced to messages that can be transmitted to decision agent" (Dasgupta, David, 1994). Moreover, "the value of information is also dependent on the recipient's prior knowledge. If we have no previous knowledge of a particular subject, it's usually difficult if not impossible to make sense of data related to that subject. Conversely, the more we know about a subject, the better able we are to evaluate and use new data about it" (Burton-Jones A. C., 1999). While information represents the mere datum, knowledge represents the meaning of that datum, and the force that can create new meanings and structures, new ideas and strategies to use it in a valuable way. Therefore, it is possible to transform into bit strings only the *codifiable* knowledge, while *tacit* knowledge, embodied in practices, people or networks of relationships cannot[2].

The distinction is important here: new technologies allows codified knowledge to travel quicker and cheaper, but tacit knowledge remains localised, embedded into people, local practices, network of relationships. The final result in terms of localisation patterns of knowledge-intensive industry will therefore depend on the share of knowledge becoming codified with respect to the knowledge remaining tacit. This ratio is not given *a priori*: it depends on the relative costs and benefits of codifying knowledge and therefore on available technologies and institutions. Internet and the Intellectual Property Right system are important determinants of

[2] For more on the codification of knowledge see Polany, 1966; Ancorì, Bureth, Cohendet, 2000; Cohendet, Stainmueller, 2000; Malerba F., Orsenigo L., 2000.

this ratio. We discuss these issues in the next section where we look at how the new technologies affect dispersion and agglomeration forces.

3. Dispersion and agglomeration of economic activities

The economic literature has explained the type of agglomeration patterns that characterise the spatial distribution of economic activity in space (such as the EU's strong and enduring divide between a rich core and a much poorer periphery), in terms of a balance between some centrifugal and centripetal forces.

Agglomeration results from some form of increasing returns that cause cumulative causation mechanisms to set in and lock development processes. In fact, of the sheer notion of "location decision" by a firm contains an implicit assumption of increasing returns (i.e., of costly duplication of the firm's production process in different places). Under constant returns to scale, firms do not need to locate anywhere: they can disperse arbitrarily fine operations plants everywhere on the territory. It is only when there are increasing returns that a few large operation plants work better than many small ones. This is precisely what raises the location question: where should the few plants be located? (Quah, 2001c).

Marshall (1890) has described the three main *centripetal* forces (Marshallian triad) that are at the base of the existence of agglomeration. We briefly summarise them below following Krugman (1998):

- Market-size effect (demand and cost linkages, also called backward and forward linkages). A local concentration creates a large local market that in turn creates both '*demand linkages'* - sites close to large markets are preferred location for the production of goods - and *'cost linkages'* - the local production of intermediate goods lowers the production costs of other producers;
- Thick labour markets. A local concentration supports the creation of a thick labour market, where employees and employers are readily matched;
- Pure external economies. A local concentration creates information spillovers benefiting all firms in the agglomeration ('The mysteries of the trade become no mystery, but are, as it were, in the air' (Marshall, 1890). Besides, it is easier to monitor and manage activities in an established centre where firms know and can benchmark each other performances (Venables, 2001).

If only centripetal forces were at work, the final result would be a unique agglomeration of economic activity. Opposing to that and limiting the otherwise indefinite possibility of growing of the agglomeration are the *centrifugal forces,* all of them involving some form of costly transportation or congestion costs. The set of *centrifugal forces* is more difficult to complete. Krugman (1998) suggests the following useful classification:

- Immobile factors. Immobile factors (land, natural resources, and, to some extent, labour) slow down the process of agglomeration, both on the *demand* side (industries have to go where factor owners are) and on the *supply* side (industries have to go where factors themselves are);
- Land rents. Concentration of economic activity drives up the cost of land and disincentivates further concentration. This explains, for example, why most of the land-consuming manufacturing activities have left the urban areas;
- Pure external diseconomies. Concentration of economic activities and concentration of population are likely to lead to increased traffic, congestion, pollution and crime.

The digital economy is dramatically reducing transport and communications costs. It has therefore the potential to alter the current equilibrium of centrifugal and centripetal forces, and to re-design the existing economic landscape. The final effect is not self-evident. In what follows we discuss some examples of possible channels through which those effects can come about (the main reference is Venables, 2001).

- ***Search and matching costs***: identifying a potential trading partner.

  It seems likely that new technologies, internet, e-mails, mobile phones in particular, would significantly reduce the search and matching costs of finding a partner. What does this imply in terms of centrifugal/centripetal forces? Firstly, as the costs of searching and matching are reduced, the demand and cost linkages are weakened. Secondly, the thick labour market effect is also weakened. Both of these effects tend to weaken centripetal forces and therefore to increase centrifugal. Nevertheless, the requirement to be located close to customers/buyers still exists and often, if the Internet appears to be a necessary condition to acquire information, it is not sufficient to conclude a trade.

- ***Direct shipping costs:*** moving inputs and outputs.

  As activities are codified and digitised, they can be moved costlessly through space[3].Transport costs of many economic (intangible) goods are reduced to zero. Industries such as accounting, advertising, management consulting, and other services are increasingly able to substitute in-person delivery to customers with electronic delivery. The consequence on agglomeration effects is not straightforward. Two counterbalancing effects can be identified. On the one hand, the relevance of demand and costs linkages is reduced and being close to suppliers and customers become less important: one of the main centripetal forces is reduced. On the other hand, the need to be close to dispersed customers and immobile factors is reduced, consequently reducing one of the main centrifugal costs.

- ***Control and management costs***: monitoring and management

  Outsourcing and FDI (foreign direct investment) have seen a rapid growth in recent years. They involve a fragmentation of the structure of the firm, which means that production and administration can be split into geographically and organisationally different units. This implies that particular stages of the production process can be moved to lower cost locations (labour intensive products to low wages economies, land intensive products to low rent regions, etc.). To be able to achieve this, it requires an efficient management between the different fragments of the firm. New technologies have facilitated this[4]. The consequence on agglomeration effects is not straightforward: on the one hand, the possibility of "conversational"[5] transaction might be enough to create and increase relations between two firms and not necessarily require closeness. On the other hand, the need for face-to-face contact will tend to maintain or expand industrial clusters/regions.

- ***Cost of time in transit***: shipping to and communication with distant locations

  Digital economy is often perceived as "speed". The question is how a time-saving technology might influence the location of production by changing the value of time. Venables (2001) shows that when the marginal value of time (cost of delay) is negative (i.e. time-saving technical improvement increases the value of further reduction of time), the firm moves its production factories closer to the market to exploit the advantage of the more rapid market information. This is the normal case that arises because of discounting, but also

[3] They are also typically subject to very large productivity increases and price reductions.
[4] Venables, 2001, mentions Dell Computers as a good example of the use of new technologies to outsource, order and gett components from suppliers at short notice.
[5] Learmer and Storper (2000)

the case of the suppliers of intermediate goods, that use new technologies to make it easier to detect faults and therefore move production closer and cut delivery times (so that fewer faulty items are in the delivery chain). This effect tends to weaken centrifugal forces and increases concentration.

- ***Costs of personal interactions***: knowledge spillovers

  It can be argued that personal interaction and knowledge spillovers become easier with the rise of the digital economy and less dependent on geographic proximity: with Internet it is possible to compare written draft of papers, pictures, diagrams, and exchange ideas in a way that was simply impossible by fax and telephone. This effect alone would weaken one of the centripetal forces and therefore foster agglomeration.

  However, the final result also depends on the ratio of tacit to codified knowledge. This ratio is not given *a priori*: it depends on the relative costs and benefits of codifying knowledge and therefore on available technologies and institutions. The Internet and the Intellectual Property Right (IPR) system are important determinants of this ratio.

  The Internet (as well as cheaper telecommunications in general) makes the transmission of codified knowledge cheaper but does not change anything regarding tacit knowledge. Consequently, the rising of the Internet increases incentive to codify knowledge (and then to transmit it). At the same time, however, the resources saved on the transmission of codified knowledge could be used to generate more tacit knowledge. Hence the evolution of the ratio tacit/codified knowledge could decrease as well as increase. The first case would mean a greater diffusion of knowledge across space whereas the second one means increased concentration of knowledge (Duranton and Charlot, 2003a/b).

  The IPR system limits the possibility of codified knowledge to travel and be exchanged. Stringent IPR rules keep relatively more knowledge in the tacit state. More tenuous rules favour the codification and exchange of knowledge. The clustering of Silicon Valley versus the dispersal of the Open Source community would be the spatial manifestation of these differences.

  Digital outputs are generally characterised by more tenuous IPR rules than intellectual assets generated by R&D: the first are generally protected by copyrights and the second by patents (Quah, 2001c). We can then infer that the digital industries - such as the software, or multimedia industries - have stronger incentives to codify and exchange knowledge than more traditional patent-protected high-tech industries.

- ***Costs of commuting***: moving within the agglomeration

  Bairoch (1988) argues that in a typical city of 100,000 persons (assuming a reasonable density of 100 inhab. per Km^2, one can walk from any part of the city to its centre in a 10-15 minutes, which can be taken as negligible. On the contrary, in a city of 1m people, the same task can take up to one hour. In a large city, land is a scarce resource: commuting and shopping costs become strong brakes on urban growth. Teleworking, teleshopping, improved management of traffic through the use of ICT are likely to reduce commuting and shopping costs and therefore weaken one of the main limits to the growth of urban agglomerations.

- ***Costs of replicating the products.*** Infinite expandibility.

  ICT outputs have typycally little physical manifestation. Therefore, they can be transported almost costlessy through space with potential important consequences for location choices, as discussed above. However, this is not the only feature of intangible ICT outputs.

Intangible ICT outputs are, unlike haircut, *non-rival* or *infinitely expansible* (Quah, 2001c). Computer sofware, or music, or a film can be located on a satellite server and be accessed by an infinite number of customers. Its use by a customer does not detract anything from the use of the next customer. Therefore "ICT output behaves like knowledge (Arrow, 1962) or intellectuall assets more generally. It is not just that scientific knowledge is an input in ICT production, but ICT output itself acts like knowledge" (Quah, 2001c, p 86). This feature of ICT outputs strenghten increasing returns in production, which are at the base of agglomeration forces.

- ***Costs of relocation***: changing location

  Not only products can be moved costlessly through space. Firms are becoming more and more footloose. Sunk costs of moving operations to a different country (or region) are reduced. The change in relocation costs does not affect directly any of the convergence and divergence forces. However, it affects the thresholds at which firms may decide to move locations in response to a change in the balance between the convergence and divergence forces. This effect has important consequences for policy: the ability of national governments to raise tax revenues and their ability to use those funds to foster regional development and cohesion is challenged, as the tax base is increasingly footloose.

The following table summarises the results of this brief analysis of the effects of knowledge-based weightless economy on centrifugal and centripetal forces. The first column identifies the category of cost affected, the second column describes the effect on centripetal or centrifugal forces, the third column gives a summary explanation for the effect. The last column identifies the geographical level at which the effect is likely to happen (global, national, regional, urban o cluster level)

Table 1 How the digital economy changes centrifugal and centripetal forces

Costs affected by the rise of the digital economy	***Effect on centrifugal and centripetal forces***	***Explanation***	***Geographical level***
Reduction in search and matching costs	Strengthen centrifugal forces	Reduction of costs of searching and finding a trading partners	Regional/cluster/urban
Reduction in direct shipping costs	Strengthen centrifugal forces	No need to locate close to producers or other ICT firms as transport costs fall	Country/regional
	Strengthen centripetal forces	No need to follow dispersed customers	Country
Costs of personal interactions: relative roles of codified and tacit knowledge	Strengthen centrifugal forces	It becomes easier to exchange and transfer codified knowledge	Regional/cluster
	Strengthen centripetal forces	The ratio of tacit to codified knowledge might increase.	Cluster/urban
Reduction in control and management costs	Weaken or do not change centripetal forces	ICT is not a necessary and sufficient condition in itself, it also requires face-to-face contact	Global/country
Increase in the cost of time in transit	Strengthen centripetal forces	The marginal value of time increases: the desire to be closer to the market increases	Cluster
Reduction in the costs of commuting	Strengthen centrifugal forces	One of the major limits to urban growth in industrial cities is weakened	Urban

Reduction in the costs of replicating a product	Strengthen centripetal forces	Increase the degree of increasing returns	Global
Reduction in the costs of relocation	Weaken lock-in effects	Increase the possibility of relocating once the conditions are changed	Global/country

The discussion above shows that the increasing use of ICT in business has many counterbalancing effects on centrifugal and centripetal forces. Therefore, the question of the final spatial impact of ICT has not a definite answer at the theoretical level and thus it must be addressed at the empirical level. In the next Section we report and discuss available evidences.

4. Empirical evidences

Relevant empirical contributions can be classified into three strands: firstly, those looking at very specific impacts of the adoption of ICT on industrial locational patterns; secondly, those looking at the spatial patterns of 'new' industries (producing ICT or using ICT to produce, manipulate or commercialise digital content) and finally those enlarging the scope of research to assess the overall impact of ICT adoption in new and traditional industries. They are discussed in turn below.

4.1 Some specific impacts of ICT on industrial locational patterns

A first strand of empirical studies looks at some specific impacts of ICT on locational structure of traditional industries.

Hummels (2000) tries to assess to what extent transport costs have actually decreased. He uses US data on shipments by air and sea and estimates the implicit value of time saved by using air transport. He finds that this value is quite high and that the cost of an extra day's travel is around 0.3% of the value shipped (of imports as a whole), implying that transports costs have fallen much more through time than what is suggested by looking at freight charges alone.

Klier (1999) finds that 70-80% of suppliers of the US automobile industry are located within one day drive of the assembly plant. He also finds evidence that the concentration of supplier plants around assembly plants has increased since 1980 with the introduction of just-in-time production methods. This is consistent with the theoretical prediction that the increase of the cost of time makes location of production more prone to be closer to producers (Venables, 2001).

Kolko (2001) studies how ICT has changed the internal organisation of the firm. The hypothesis here is that ICT, lowering the management and control costs, would allow a more dispersed organisation of the firm, for example by allowing back-office operations to be separated from control and strategic functions (as discussed by Gillespie et al, 2001 or Sassen, 1991). He finds no evidence of a positive correlation between the average distance of an establishment from its headquarters and the ICT-intensity of an industry. The only significant effect comes from the growth rate of the industry: faster growing industries tend to exhibit an increasing average distance from headquarters.

This first group provides in-depth analyses of specific centripetal and centrifugal effects at work. It is interesting to know that empirical research confirms our *a-priori* of a dramatic reduction in transport cost. Overall, the other two studies seem to suggest that, if anything, the increasing use of ICT would lead to increased industrial geographical concentration: while the centripetal time-effect discussed by Venables (2001) is confirmed, the hypothesis of a internal spatial reorganisation of companies towards a more dispersed spatial structure (Sassen, 1991) seems to vanish in front of empirical research.

However, the focus of those studies is too specific to allow for any generalisation. As discussed in Section 3, the range of effects to be taken into consideration is wide and many of those effects counterbalance each other. Section 4.2 and 4.3 below discusses some of the studies trying to reach more general conclusions.

4.2 Spatial patterns in "new" industries: more evidences for the Silicon Valley model

A bigger number of studies have looked at the spatial organisation of either ICT industries themselves or those "new" industries that use new technologies intensively to produce, manipulate or distribute digital content (see Section 2) with the objective of understanding how the future economic landscapes will look like.

There is ample agreement that the ICT and digital industries are geographically concentrated.

Le Blanc (2000) uses US data and finds that the most recent and fast-growing industries – Internet on-line services and software – exhibit a higher level of geographical concentration than four other industries[6] which, on the contrary, shows roughly similar concentration measures. His research would tend to conclude that agglomeration forces are stronger in the Internet and software industries. Similar findings are reported by other researchers looking at a a wide variety of industries and locations. Cooke (2002) discusses the formation and life of a wide variety of "knowledge" clusters: from biotech companies in Cambridge, UK, Germany or San Diego, US, to advanced opto-eletronics cluster in St Asaph, Wales; to the ICT cluster in Oulu, Finland. Quah (2001a) documents that successful regional cluster tend to cross national borders within the EU. Scott (1996, 1997, 1998) drawing on trade directories and official data has studied the locational patterns of the multimedia industry in South California. He finds evidence of a strong spatial pattern in the industry: entertainment activities cluster in Los Angeles while business-oriented activities cluster in San Francisco. Sandberg (1998) has noted a similar concentration in Sweden, around Stockholm. Zook (2000) has used Internet registration data to provide maps of "dot.com" addresses across the US. He finds that "dot.com" activity is spread widely but unevenly across and within US city regions. Gillespie *et al* (2001) use trade directories to map the regional patterns of firms in the "New Media" subsectors (games, web-based advertising, etc.) showing that such activities are predominantly concentrated in four locations quite close to each other: London, the M4 Corridor, East Sussex and the M11 Corridor. Dodge and Kitchen (2000) obtain a similar picture using registered addresses of owners of domain name space in the UK. Similarly, Bonaccorsi *et al* (2002) find that domain names are more spatially concentrated across Italian provinces than income or population.

The foregoing empirical evidence has often been used to generalise (Cooke, 2002; Gillespie *et al*, 2001) and argue that new technologies will further reinforce existing regional imbalances: "The e-economy maps on to the existing geography of economic and social division." (Christie and Hepworth, 2001, p 141).

However, there are reasons to believe that some further analysis is needed before drawing such general conclusions. For example, Koski at al. (2000) and Quah (2001b) suggest that while it is correct to say that the production of ICT manufacturing is increasingly concentrated in certain countries, trade of ICT products is more evenly distributed, pointing out the need for enlarging the scope of research to a wider range of indicators of ICT specialisation.

[6] The other sectors being cable, telecom, data processing and computer systems.

Moreover, the scope of the analysis should be enlarged to include traditional as well as ICT and digital industries. Indeed, clustering does not characterise only ICT and digital industries. It is also a feature of some traditional industries. It implies that the intensive use of ICT is not the only characteristic driving industrial agglomeration or dispersion. Other factors (intensive use of skilled labour, growth profile) are likely to play a role and should be controlled for before any general conclusion is drawn.

Finally, "new" and "old" clusters do not necessarily map each other. Clustering of "new" industries may or may not lead to a reinforcement of the traditional regional imbalances.

Section 4.3 below discusses the studies looking at these last two issues.

4.3 The impact of ICT on the spatial organisation of new and traditional activities: challenging earlier conclusions

The main objection to the Christie and Hepworth-type of conclusions comes from the fact that clustering does not only characterise ICT and digital industries. It is also a feature of some traditional industries. In Midelfart et al (2001), most concentrated industries include textiles, clothing or footwear. Krugman (1991) describes geographic concentration in activities as diverse as carpet manufacturing, jewellery production, or the rubber processing industries. Devereux *et al* (1999) finds that low-tech industries are the most concentrated in the UK. In fact, the degree of clustering in one industry depends on a multiplicity of characteristics of the industry, ICT-intensity being just one of them. Using local industry growth regressions (estimated across across US SMSA[7]), Kolko (2001) finds that regional geographical divergence[8] patterns of industries are explained by two factors: the industry's intensity in highly-skilled labour and its growth profile. The relative intensity of ICT (measured by the fraction of employees in the industry using a computer at work for either electronic mail, communication, or both) does not appear to be a significant factor. He argues that there is nothing specific to ICT and digital industries, and that other industries with similar skills and growth profiles would also be similarly concentrated. He concludes that clusters are relatively less likely to remain for the Internet and ICT related activities and that the landscape will tend to be progressively less agglomerated. Those results are broadly confirmed by FEEM (2003), which carries out an econometric analysis of localisation patterns of 82 industries across 103 Italian provinces.

It is also important to stress that even if ICT and "new" industries clustered, this would not automatically lead to a reinforcement of the traditional regional imbalances, such as the core-periphery European regional divide. If ICT and "new" activities clustered in the periphery, this would rather contribute to the creation of a "multicentric Europe" as envisaged in the European Spatial Development Perspective (EC, 1999). There is some evidence suggesting that the latter might actually be the case: some peripheral EU countries such as Finland, Ireland and Sweden are the most specialised in ICT in the EU, with respect to a variety of measures of ICT specialisation, such as the share of ICT in the total manufacturing exports, in gross value added, and in R&D (OECD, 2000; Koski at al., 2000). Supporting evidence is also given in FEEM (2003) showing that ICT-intensity of industry is not significant in explaining the tendency of a

[7] Standard Statistical Metropolitan Areas.

[8] Divergence is defined as the tendency of an industry to grow where it is already over-represented. Concentration at a point in time and divergence over time are distinct, although related concepts. Concentration is the extent to which an industry's employment (or production) is clustered in a small number of places; divergence is the extent to which an industry's employment grow faster where it is already over-represented. Changes in industrial concentration over time can be decomposed into divergence and random shocks (Kolko, 2001, p 1, and 2).

industry to locate close to the Italian economic core (measured by provinces' economic potential[9]).

Section 5 below discusses the implication for European policy of those findings

5. Implications for European policy

The issues discussed in this paper are relevant for two strategic objectives of the European Union.

Firstly, the European Union is committed to achieving *regional cohesion* (EC Treaty, Art 158). The European Spatial Development Perspective (EC, 1999) has qualified further this objective, indicating the attainment of a "multi-centric Europe" as the key feature of a "spatially balanced" Europe.

Secondly, the adoption of the Lisbon strategy set the strategic objective for Europe to become "the most competitive *knowledge-based economy* in the world". The contemporaneous launch of the e-Europe Action plan recognises that ICT plays an essential role in the transformation. In this sense, the Lisbon documents reflect the definitional debate summarised in Section 2 with the rise of the knowledge-based economy compounding two parallel but distinct shifts: a shift towards a more ICT-intensive economy and a shift towards a more knowledge-intensive economy.

Regional cohesion in a knowledge-based economy

Research results show the existence of both complementarities and trade-offs between the two objectives. On the one hand, as far as the ICT-dimension of the change is concerned, the empirical evidence seems to show that the increasing use of ICT in the economy will lead to greater dispersion of economic activity, i.e. less regional disparities. This would suggest that policies fostering the adoption of ICT by industries and regions (such as the e-Europe Action Plan, launched by the Lisbon Council itself) would indeed favour a more geographically cohesive Europe.

On the other hand, there is evidence that the parallel shift towards more knowledge- and skill-intensive activities might counterbalance this dispersion effect. This effect points out a potential important trade-off in European policies: the shift towards the knowledge-based European economy envisaged in Lisbon might result in less regional cohesion.

Cohesion policies in a knowledge-based economy

Two additional points concern the elaboration of policies for fostering long-term growth at regional level.

First, research results suggest that regional policies aimed at attracting low-skill functions (such as call centres) in ICT-intensive industries are likely to fail in creating new clusters, as agglomeration forces for ICT-intensive, low-skill activities are weak (Kolko, 2001). In this sense, "high-IT industries are unlikely to offer poorer countries long-term sustainable economic growth" (Kolko, 2001, p 18), as poorer countries and regions have stronger comparative advantage in low-skilled rather than high-skilled labour. Policies should be rather aimed at

[9] The economic potential of a region is given by the weigthed average of the GDP of the region and GDP of surrounding regions, with weights inversely related to the distance. Economic potential of EU NUTS 3 regions have been calculated by Copus (1997) and Schürmann and Talaat (2000).

improving the local education and research system in peripheral regions. The case of Oulu in Finland shows that this strategy might indeed be, in some cases, successful (Cooke, 2002).

Second, successful concentrations of "new" activities are achieved at a finer level of policy-making than national states and often propagate across national boundaries within the EU (Quah, 2001c). Policy might therefore need to be developed at regional and local rather than national level.

Mono- versus multi-centric Europe: open questions

Two final considerations concern future research.

First, we discussed how an eventual clustering of ICT and "new" industries does not automatically lead to a reinforcement of the traditional regional imbalances, such as the core-periphery divide characterising the European economic landscape. If ICT and "new" activities cluster in the periphery, this would rather contribute to the creation of a "multi-centric Europe" as envisaged in the European Spatial Development Perspective (EC, 1999). There is some evidence suggesting that this might actually be the case: some peripheral EU countries such as Finland, Ireland and Sweden are the most specialised in ICT in the EU, with respect to a variety of measures of ICT specialisation, such as the share of ICT in the total manufacturing exports, in gross value added, and in R&D (OECD, 2000; Koski at al., 2000). Supporting evidence is also given in FEEM (2003) who carry out an econometric analysis of localisation patterns of 82 industries across 103 Italian provinces showing that ICT-intensity of industry is not significant in explaining the tendency of an industry to locate close to the Italian economic core. However, results are still tentative and more research is needed.

Second, and related, we discussed how the Internet and the IPR rules are important factors in determining the share of codified-global to tacit-localised knowledge and their potential consequences on localisation. However, theoretical and empirical analysis is still at a early stage. We think this is an interesting area for new research.

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(l) This paper was presented at the Workshop "Growth, Environmental Policies and Sustainability" organised by the Fondazione Eni Enrico Mattei, Venice, June 1, 2001

(li) This paper was presented at the Fourth Toulouse Conference on Environment and Resource Economics on "Property Rights, Institutions and Management of Environmental and Natural Resources", organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE, Toulouse, May 3-4, 2001

(lii) This paper was presented at the International Conference on "Economic Valuation of Environmental Goods", organised by Fondazione Eni Enrico Mattei in cooperation with CORILA, Venice, May 11, 2001

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(liv) This paper was presented at the Seventh Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Venice, Italy, January 11-12, 2002

(lv) This paper was presented at the First Workshop of the Concerted Action on Tradable Emission Permits (CATEP) organised by the Fondazione Eni Enrico Mattei, Venice, Italy, December 3-4, 2001

(lvi) This paper was presented at the ESF EURESCO Conference on Environmental Policy in a Global Economy "The International Dimension of Environmental Policy", organised with the collaboration of the Fondazione Eni Enrico Mattei , Acquafredda di Maratea, October 6-11, 2001

(lvii) This paper was presented at the First Workshop of "CFEWE – Carbon Flows between Eastern and Western Europe", organised by the Fondazione Eni Enrico Mattei and Zentrum fur Europaische Integrationsforschung (ZEI), Milan, July 5-6, 2001

(lviii) This paper was presented at the Workshop on "Game Practice and the Environment", jointly organised by Università del Piemonte Orientale and Fondazione Eni Enrico Mattei, Alessandria, April 12-13, 2002

(lix) This paper was presented at the ENGIME Workshop on "Mapping Diversity", Leuven, May 16-17, 2002
(lx) This paper was presented at the EuroConference on "Auctions and Market Design: Theory, Evidence and Applications", organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002
(lxi) This paper was presented at the Eighth Meeting of the Coalition Theory Network organised by the GREQAM, Aix-en-Provence, France, January 24-25, 2003

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