serie ad
WP-AD 2012-21

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Versión: diciembre 2012 / Version: December 2012

Edita / Published by:
Instituto Valenciano de Investigaciones Económicas, S.A.
C/ Guardia Civil, 22 esc. 2 1º - 46020 Valencia (Spain)

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ICT technologies in Europe: A study of technological diffusion and economic growth under network theory

Ana Salomé García and María Rosalía Vicente*

Abstract

The sector of Information and Communication Technologies is one of the key instruments for the development of an economy. The literature emphasizes its capacity for both increasing productivity and generating new sources of income and wealth (Jorgenson, 2001; Colecchia and Schereyer, 2002; among others). Traditionally studies on the ICT sector have focused on the analysis of its economic impact, but not on its capacity as a "bridge" of information and knowledge flows across the economic network. Following Burt's approach (1992) about structural holes, the organization of the economic network defines where and for whom new opportunities lie. The structural hole methodology allows to analyze the capacity of the ICT sector as an enabler of technological diffusion and innovation. Our results show that the European ICT sector not only is important for its intermediary role in the flow of information across the economic network, but also for its low level of dependency on other sectors.

Keywords: Information and Communication Technologies (ICT); diffusion; innovation; networks; information and knowledge flows.

JEL classification numbers: C67, O14.

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1. Introduction

Over the last decade a large number of studies have tried to unveil the role of Information and Communication Technologies (ICT) in economic development and productivity growth (Brynjolffson and Hitt, 2000; Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000, 2002; Colecchia and Schreyer, 2002; for a recent survey see Kretschmer, 2012). The potential of ICT relies in the fact that they are "general purpose technologies" (Bresnahan and Trajtenberg, 1995) whose main features are their fast path of technological improvement, their "pervasiveness" across the full economy and their role as innovation-enablers.

Thus, ICT facilitate the creation of new knowledge and its faster diffusion through more efficient processes of information transmission (both within and between firms) (Kretschmer, 2012), the development of closer links between customers, suppliers and collaborative partners and the reduction of geographical barriers (Friedman, 2005). All these have lead to an increasingly networked economy in which information is a key economic factor (Castells, 2000).

Within this context, this paper analyzes the extent to which the ICT sector acts as a "bridge" that facilitates the spread of "relevant" information and knowledge across the productive sectors of the economic network. In order to assess the relevance of information flows between sectors, this paper follows Burt's approach on structural holes (Burt, 1992) in the framework of input-output (IO) methodology and network theory. To authors' knowledge this is the first time to apply such approach to evaluate the role of the ICT sector in the economy, since previous research have relied on growth accounting exercises and econometric estimations of the production function (ICTNET, 2011). Empirical evidence is drawn from data on input-output tables for the European Union over the period 2000-2007.

2. Methodology: Structural holes

Following Burt's approach (1992), the organization of the economic network defines where new opportunities lie and who can benefit from it. Proximity and connection imply different intermediation degrees that can create advantages of access, time and exclusivity for certain sectors.

In this sense, inter-sector relationships do not provide the same information and the same opportunities. If each productive relation puts the sector in contact with the same sectors through other linkages, it is more likely that the information generated in the network will be less varied than when the network is sparse. Thus, we can say that these productive relations are "redundant" as they involve the same sectors and then supply the same information. New

ideas and opportunities are around the "bridge relationships" that connect branches of different sector groups. Hence, this kind of non-redundant links allows obtaining benefits: sectors, which operate as bridges, make possible the flow of varied information and facilitate the diffusion of ideas, knowledge and innovation. Therefore, the economic structure can create opportunities for certain sectors in these areas called structural holes. In sum, a structural hole is "a relationship of non-redundancy between two nodes" (Burt, 1992).

The presence of structural holes in "real economic" networks is far from unusual (García, Morillas and Ramos, 2010). In fact, this concept can be applied to identify the points of fragmentation in the production process. Economists have largely studied fragmentation processes (also called vertical specialization slicing-up the value chain, or outsourcing, among others) (Humphrey and Schmitz 2002; Jones and Kierzkowski 2005) and have found two key elements in them: the current trends to lowering service-link costs and the increase in the scale of production (Jones and Kierzkowski 2005). As Hummels et al. (2001) point out; there are various reasons for this vertical tendency "*one possibility is that technological shocks have led to the fragmentation of production. These shocks may include changes in production technique such as an increase in the number of production stages or shocks that make it easier to separate existing stages of production. A second possibility is that reductions in the cost of moving goods have driven the increase in vertical specialization*". The concept of structural holes has been successfully applied in input-output field with the aim of study fragmentation activities and innovation diffusion (Garcia et al., 2010).

The determination of structural holes is based on the level of non-redudant relations. The relative indicator of the diversity in network connections is called efficiency (Burt, 1992) and can be calculated as the difference in relative terms between network size $\left(N_i\right)$ and level of redundancy $\left(R_{i(j)}\right)$:

$$E_i = \frac{TE_i}{N_i} = \frac{N_i - \sum_j R_{i(j)}}{N_i}\ ;\ q \neq i, j \qquad (1)$$

$$0 \leq E_i < 1$$

where the knowledge obtained by a sector *i* is described as redundant if this sector *i* has an important relation—in terms of quantity—with another sector *q*, which simultaneously maintains relevant productive transactions with sector *j*. A sector i evaluate the extent to which a sector j is redundant with your other sectoral contacts. Given this, the indicator of redundancy can be written as (Burt 1992; Borgatti, 1997):

$$R_{i(j)} = \sum_{q} p_{iq} m_{jq} \qquad (2)$$

where p_{iq} shows the proportion of economic direct relations between sectors I and q with respect the sum of i's relations and m_{jq} represents the marginal intensity of linkage sector j's relation with sector *q*.

Efficiency values (E_i) near to one indicate a high level of efficiency, that is, a high number of non-redundant contacts, whereas numbers close to zero point out a high degree of redundancy and therefore a low level of efficiency in the capacity for information access.

Complementary to the efficiency study it is interesting to analyze the degree of dependence between sectors. If a high-efficiency sector strongly depends on other, the benefits of information transmission can be limited since the economic difficulties of the latter can influence the former. In order to take account of the restrictions in the network, the following aggregated constraint index can be used (Burt, 1992):

$$C_i = \sum_{j} c_{ij} \qquad (3)$$

where

$$c_{ij} = \left(p^{*}_{ij} + \sum_{q} p^{*}_{iq} p^{*}_{qj} \right)^2 ; \; q \neq i, j \qquad (4)$$

p^{*}_{ij} is the proportional strength of i relationship with j, p^{*}_{iq} the weight of the relationship of sector i with respect to q and p^{*}_{qj} the weight of the relationship of sector q with respect to j. The first term of sum describe the direct efforts to establish the relationships between sectors i and j. The second term the undirected efforts described above (U_i). .

Network constraints vary along the following three network dimensions: size, density and hierarchy. Constraints are high if a sector "has few links and those flows are connected to one another either directly (as in a dense network) or through a central and mutual contact (as in a hierarchical network)" (Burt, 1998). The hierarchy degree (H_i)- the extent to which the redundancy can be traced to a single contact in the network- is measured by the Coleman-Theil inequality index (Burt, 1992).

3. European ICT Sector

The described methodology has been applied to the analysis of the ICT sector in the European Union. The statistical information comes from the last input-output tables published by Eurostat and refers to the years 2000, 2005 and 2007. This methodology allows analyzing the capacity of the economy for technological diffusion, for enhancing innovation and creating new market opportunities.

Hence, on the basis of input-output tables, we approach the extent to which the ICT sector is a key element for economic growth. Its role is compared with that of the rest of the industries, identifying differences in European technological capacities.

In order to make these cross-country comparisons, it is essential to work with a homogeneous and widely accepted definition of the ICT sector. In this paper, the definition of ICT sector follows the international standards set, for the first time, by the Organization of Economic Cooperation and Development (OECD) in 1998. Such 1998 definition was subject to review in 2002 with minor changes. Table nº 1 shows ICT sector definition (2002), based on the ISIC Rev. 3 classification of activities (OECD, 2003).

A new definition of the ICT sector was agreed in 2007 in order to update the exhaustive list of ICT activities on the basis of the ISIC Rev. classification 4 (OECD, 2011).

Table nº 1. The ICT sector definition

Manufacturing
3000 – Office, accounting and computing machinery
3130 – Insulated wire and cable
3210 – Electronic valves and tubes and other electronic components
3220 – Television and radio transmitters and apparatus for line telephony and line telegraphy
3230 – Television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
3312 – Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment
3313 – Industrial process equipment
Services
5151 – Wholesale of computers, computer peripheral equipment and software
5152 - Wholesale of electronic and telecommunications parts and equipment
6420 - Telecommunications
7123 - Renting of office machinery and equipment (including computers)
72 - Computer and related activities.

Source: OECD (2003).

The 2002 definition is used in this paper given that the classification of activities in the available input-output tables relies on ISIC Rev. 3 classification. In particular, the following the ICT activities are considered: Office, accounting and computing machinery, Electrical machinery and apparatus, Radio, television and communication equipment, Medical precision and optical instruments, Wholesaling of machinery, equipment and supplies, Renting of office machinery and equipment, Computer and related activities.

Table nº 2 shows the results on the levels of efficiency and dependence for the ICT sector (See annex for non ICT sectors).

Table nº2. Structural holes ICT sectors

	2007				2005				2000			
	Ei	**Ci**	**Hi**	**Ui**	**Ei**	**Ci**	**Hi**	**Ui**	**Ei**	**Ci**	**Hi**	**Ui**
Office, accounting and computing machinery	0.779	0.176	0.388	0.993	0.776	0.174	0.382	0.993	0.782	0.174	0.383	0.988
Electrical machinery and apparatus	0.797	0.168	0.337	0.968	0.798	0.166	0.329	0.969	0.807	0.16	0.319	0.964
Radio, television and communication equipment	0.806	0.157	0.32	0.981	0.808	0.158	0.322	0.98	0.807	0.157	0.321	0.971
Medical, precision and optical instruments	0.812	0.153	0.303	0.982	0.815	0.153	0.307	0.982	0.82	0.148	0.287	0.981
Wholesaling of machinery, equipment and supplies	0.81	0.132	0.292	0.927	0.809	0.132	0.299	0.924	0.814	0.128	0.287	0.919
Telecommunications	0.778	0.172	0.4	0.967	0.78	0.171	0.392	0.963	0.787	0.163	0.37	0.963
Renting of office machinery and equipment	0.784	0.153	0.333	0.981	0.786	0.151	0.324	0.982	0.787	0.15	0.322	0.982
Computer and related activities	0.755	0.189	0.451	0.968	0.757	0.19	0.442	0.969	0.763	0.182	0.427	0.972
MEAN ICT SECTORS	**0.790**	**0.163**	**0.353**	**0.971**	**0.791**	**0.162**	**0.350**	**0.970**	**0.796**	**0.158**	**0.340**	**0.968**
MEAN NON ICT SECTORS	**0.798**	**0.215**	**0.434**	**0.933**	**0.794**	**0.219**	**0.433**	**0.935**	**0.803**	**0.211**	**0.432**	**0.931**

Note: As defined in the previous section, E_i stands for Efficiency Index, C_i, for Constraint Index, H_i for Hierarchy Degree and U_i for Direct and Indirect Efforts to establish links.

In general, the European Union presents high levels of efficiency (note that the efficiency index, E_i, is around 0.8, very close to 1) in the access to diverse information due to the existence of non-redundant relations and structural holes across the economic network. Over the period 2000-2007, the levels of efficiency have decreased while constraints have slightly increased. Such result suggests that the European market is a mature one with high levels of innovation diffusion.

In the ICT sector, the mean efficiency score is similar to that observed for the rest of the economy. While this result implies that nowadays the intermediary role of the ICT sector does not differ much from that of the other productive sectors; results on the constraint index indicate that the ICT sector has fewer restrictions than the rest of the productive industries. Hence, the ICT sector is able to generate a network, that does not concentrate on single contacts (hierarchy), but has a large size with intermediate or/and undirected relations. In this sense, the undirected flows of the ICT sector are higher than those of the rest of the economy. Low hierarchy and large undirected relations suggest that ICT industries are key in the spread of "relevant" information and knowledge in the European economic network. Furthermore, it indicates that many industries get information from them. In addition, low constraints allow to establish diffusion processes quite independently from other sectors.

Within the ICT sector, the braches with the highest efficiency levels and the lowest constraints are wholesaling of machinery, equipment and supplies and medical, precision and optical instruments. As the European Commission states (2011) "these firms are reshaping their product portfolio, specializing and favoring lighter asset strategies, in particular by relying on leading-edge foundries capacities". In contrast, computer and related activities is the branch with the lowest efficiency and the highest constraints. Such a result might be explained by the heterogeneity in the activities and firm's size: "Alongside multinational companies supplying consulting services, IT outsourcing services, business and non-business application software, there are thousands of software and computer services companies being mostly active on a national or local scale" (European Commission, 2011).

The non ICT sectors have more constraints, meaning fewer structural holes (Burt, 1992) compared to the ICT sector. A high level of constraints suggests that there are dense sector groups with high dependences. Hence, the non ICT sectors are strongly interconnected, and the impact of indirect relationships is moderated by the number of direct linkages.

All these imply that negative shocks in the economy have a limited impact over the European ICT sector compared to other economic sectors. Figures nº 1 and 2 show the scatter plots between the constraint index and two measures of the economic output (gross value added and production, in Mio. EUR. current prices).

Figure nº 1 shows the following negative linear relationship in the ICT sector: as the constraint index increases, the gross value added and/or production decreases via a fuzzy-firm linear rule. The variation in the economic output explained by constraints in the ICT sector is between 20% and 40%.

Figure nº 2 also shows a negative non linear relationship in the non ICT sectors: as the constraint index increases, the gross value added and/or production decreases at a non-constant rate, reaching a value of zero for medium/ high values of the constraint index. The variation in the economic output explained by constraints in the non ICT sectors is quite low (between 9% and 18%).

Overall, results show that the ICT sector not only has a strong capacity of growth but also its relational structure facilitates the development of the European economy without strong dependencies. This result is extremely important in the current economic crisis since it provides some key evidence for policy makers to design industrial policies aimed at overcoming economic difficulties.

Figure nº 1. Effects of Constraints over main economic indicators. ICT sectors

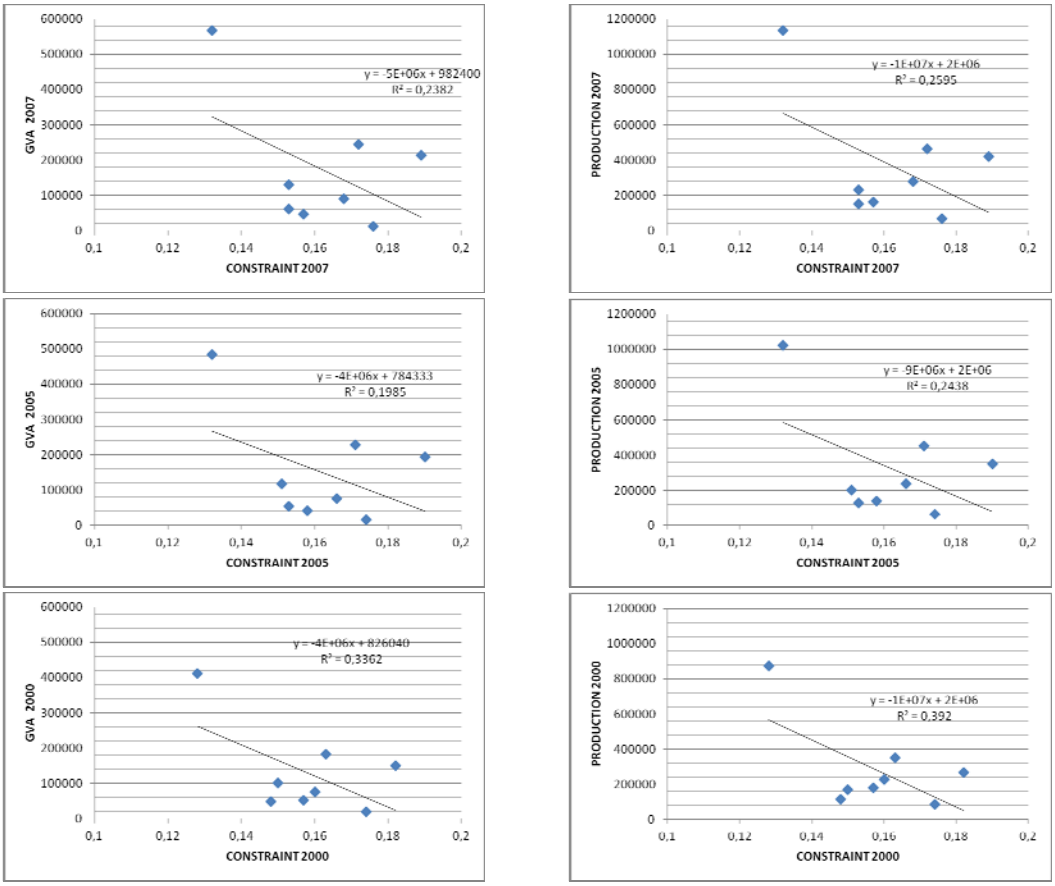
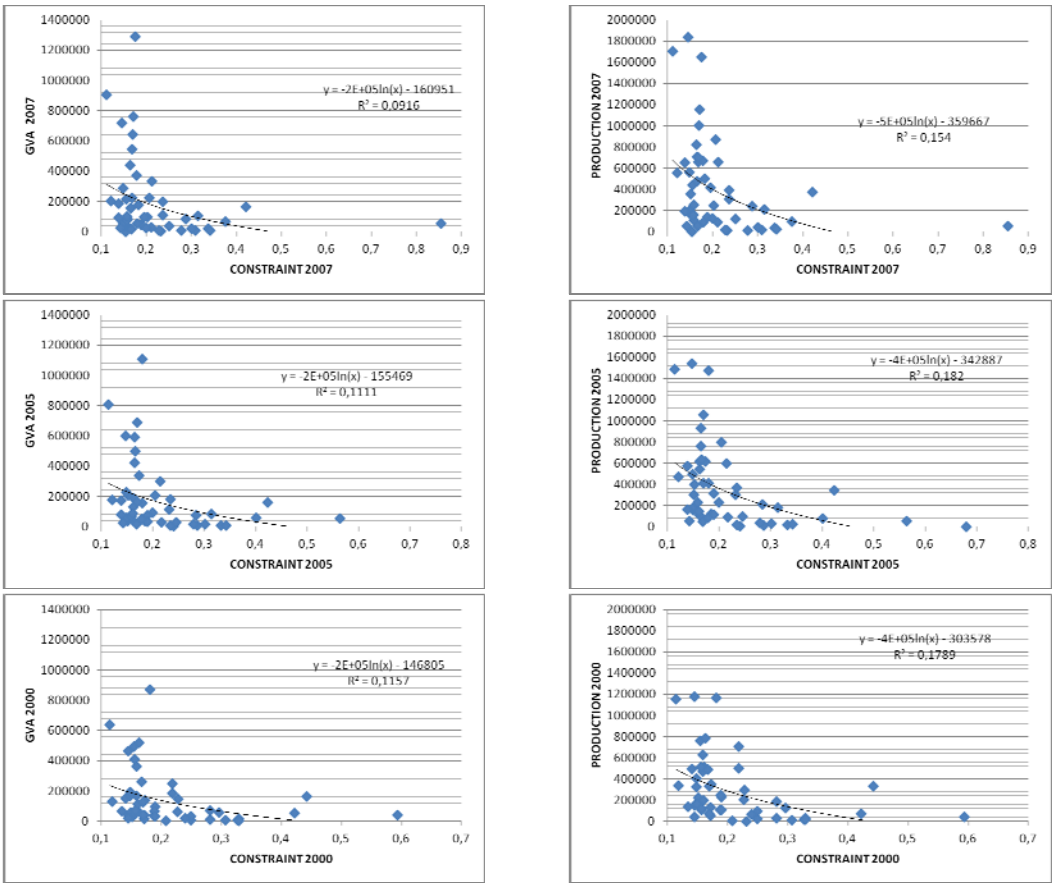


Figure nº 2. Effects of Constraints over main economic indicators. Non- ICT sectors



4. Conclusions

The economic structure is a vehicle for inducing cooperation and facilitating the process of innovation, technology diffusion and economic development. The relationships that industries establish within the economic network determine the potential advantages to gain from technological discontinuities (Utterback 1994). Obviously not all the linkages have the same importance in the spread of new ideas and opportunities. "The structural positions associated with the highest return lie *between* not *within* dense regions of relationships" (Walker, Kogut and Shan, 1997). These holes represent opportunities for broker information flows among firms or sectors (García et al., 2010). This paper presents a novel perspective on the ICT sector by using the structural holes concept. This methodology is based on the connections established in the economic network and their proximity, and thus allows to unveil the complexity, strength and weakness of the ICT structure.

Results show that the European ICT sector has a high level of efficiency with low dependences. The presence of structural holes in the network of contacts established by the ICT sector implies that this sector has access to diverse information. In contrast, the non ICT

sectors tend to generate more homogenous information through their linkages and with larger dependences on other sectors. Therefore, the ICT sector is the main economic activity able to access to new potentially valuable resources and has advantages related information-exclusivity. Hence, this sector has the capacity to foster technological diffusion and innovation across the European Union. Regarding constraints, the low results obtained for the ICT sector indicate that negative shocks in the economy have a limited impact over this sector compared to the rest of industries. In fact, previous studies by the OECD (Mickoleit et al., 2009) and the European Commission (2011) have shown that the European ICT sector weather the crisis better than the rest of the economy.

The high efficiency levels of the ICT sector, in general, together with other services sectors, emphasize their role both as links between production blocks and as a the key in the fragmentation of productive chains. This fact might related to the changes driven by globalization and innovations in manufacturing patterns, such as JIT (Just-in-Time Delivery) and new business opportunities linked to telematics. The current patterns of production/distribution has been built by a competitive edge around the development of subcontracting systems, the exploration of modulation techniques, and the implementation of efficient vertical value chains (Hummels et al. 2001; Humphrey and Schmitz 2002; Jones and Kierzkowski 2005).

References

Bernstein, J., Mohnen, P. (1998): "International R&D spillovers between U.S. and Japanese R&D intensive sectors", *Journal of International Economics*, 44, pp. 315-338

Borgatti, S.P. (1997): "Structural holes: unpacking Burt's redundancy measures", *Connections*, 20, pp. 35–38.

Bresnahan, T. and Trajtenberg, M. (1995): "General purpose technologies: Engines of growth?", *Journal of Econometrics*, 65, 83-108.

Brynjolfsson. E., Hitt, L.N. (2000): "Beyond computation: Information technology, organizational transformation and business performance", *The Journal of Economics Perspective*, 14, pp. 23-48.

Burt, R.S (1992): *Structural holes*, Cambridge University Press, Cambridge.

Cronin, F.J., Colleran, E.K., Parker, E.B. and Gold, M.A. (1991): "Telecommunications Infrastructure and Economic Growth: An Analysis of Causality", *Telecommunications Policy*, 15(6), pp. 529–535.

Dietzenbacher, E.; Romero, I. (2007): "Production Chains in an Interregional Framework: Identification by Means of Average Propagations Lengths", *International Regional Science Review*, 30, pp. 362-383.

Dutta, A. (2001): "Telecommunications and Economic Activity: An analysis of Granger Causality", *Journal of Management Information Systems*, 17, 4, pp. 71-95.

European Commission (2011): *Digital Agenda Scoreboard 2011. The European ICT industry at the crossroad: economic crisis and innovation*, in http://ec.europa.eu/information_society/digital-agenda/scoreboard/docs/pillar/research_innovation.pdf

Friedman, T. (2005): *The World is Flat*, New York: Farrar, Strauss and Giroux.

García Muñiz, A.S., Morillas, A., Ramos, C. (2010): "Spanish and European innovation diffusion: a structural hole approach in the input-output approach", *The Annals of International Regional Science*, 44, 1, pp. 147-165.

Hummels D, Ishii J, Yi K (2001): "The nature and growth of vertical specialization in world trade", *Journal of International Economy*, 54, 1, pp. 75–96.

Humphrey, J., Schmitz H. (2002): “How does insertion in global value chains affect upgrading industrial clusters?”, Regional Studies, 36, 9, pp.1017–1027.

Jones, R.W.; Kierzkowski, H. (2005): “International fragmentation and the new economic geography”, *North American Journal Economy Finance*, 16, pp.1–10.

Jorgenson, D.; Stiroh, K. (1999): “Information technology and growth", *American Economic Review*, 89, 2, pp. 109-115.

Kretschmer, T. (2012), "Information and Communication Technologies and Productivity Growth: A Survey of the Literature", OECD Digital Economy Papers, No. 195, OECD Publishing. doi: 10.1787/5k9bh3jllgs7-en

Mickoleit, A.; Reimsbach-Kounatze, C.; Serra-Vallejo, C.; Graham Vickery, G.; Wunsch-Vincent, S. (2009): "The Impact of the Crisis on ICTs and their Role in the Recovery," *OECD Digital Economy Papers*, 163, OECD Publishing.

OECD (2003): A Proposed Classification of ICT Goods, OECD Working Party on Indicators for the Information Society, Paris.

OECD (2011): Guide to Measuring the Information Society, OECD, Paris.

Utterback, J.M. (1994): *Mastering the dynamics of innovation*, Harvard Business School Press, Boston.

Uzzi, B. (1996): “The sources and consequences of embeddedness for the economic performance of organizations: the network effect”, *American Sociology Review*, 61, pp. 674–698.

Walker, G.; Kogut, B.; Shan, W. (1997): “Social capital, structural holes and the formation of an industry network”, *Organization Science*, 8, 2, pp.109-125.

Annex

Table A1. Structural holes Non ICT sectors

	2007				2005				2000			
	E_i	C_i	H_i	U_i	E_i	C_i	H_i	U_i	E_i	C_i	H_i	U_i
Agriculture. hunting	0.808	0.421	0.773	0.826	0.807	0.423	0.774	0.826	0.806	0.442	0.794	0.799
Forestry. logging	0.887	0.337	0.657	0.952	0.884	0.301	0.615	0.963	0.891	0.329	0.632	0.957
Fish and other fishing	0.831	0.277	0.54	0.981	0.832	0.286	0.557	0.981	0.827	0.307	0.578	0.98
Coal and lignite; peat	0.809	0.309	0.651	0.987	0.818	0.332	0.685	0.985	0.823	0.327	0.689	0.98
Crude petroleum and natural gas	0.835	0.376	0.664	0.914	0.838	0.401	0.687	0.912	0.852	0.422	0.72	0.893
Uranium and thorium ores	0.795	0.154	0.135	0.517	0.498	0.68	0.329	0.637	0.794	0.231	0.291	0.577
Metal ores	0.818	0.232	0.474	0.995	0.826	0.24	0.483	0.995	0.825	0.208	0.411	0.996
Other mining and quarrying	0.797	0.3	0.575	0.984	0.8	0.279	0.55	0.985	0.798	0.281	0.556	0.985
Food products and beverages	0.824	0.206	0.514	0.773	0.826	0.205	0.514	0.771	0.829	0.218	0.558	0.744
Tobacco products	0.73	0.228	0.456	0.987	0.721	0.234	0.469	0.987	0.737	0.249	0.472	0.988
Textiles	0.827	0.159	0.351	0.94	0.83	0.162	0.363	0.935	0.831	0.171	0.398	0.914
Wearing apparel; furs	0.818	0.211	0.482	0.944	0.819	0.217	0.495	0.939	0.829	0.249	0.565	0.92
Leather products	0.798	0.167	0.355	0.995	0.797	0.168	0.355	0.995	0.798	0.171	0.364	0.994
Wood and products of wood and cork	0.807	0.188	0.44	0.928	0.806	0.185	0.428	0.939	0.812	0.187	0.437	0.931
Pulp. paper and paper products	0.812	0.149	0.319	0.973	0.811	0.15	0.322	0.973	0.813	0.151	0.329	0.968
Printed matter and recorded media	0.746	0.202	0.48	0.968	0.747	0.2	0.47	0.968	0.756	0.19	0.445	0.963
Coke. refined petroleum	0.824	0.151	0.327	0.907	0.826	0.151	0.334	0.901	0.83	0.151	0.341	0.886
Chemicals. chemical products	0.811	0.139	0.307	0.941	0.811	0.139	0.309	0.942	0.809	0.14	0.316	0.941
Rubber and plastic products	0.798	0.159	0.328	0.963	0.8	0.158	0.328	0.963	0.799	0.16	0.335	0.961
Other non-metallic mineral products	0.756	0.287	0.645	0.931	0.756	0.284	0.639	0.933	0.758	0.281	0.638	0.933
Basic metals	0.821	0.195	0.441	0.909	0.824	0.19	0.425	0.913	0.822	0.188	0.418	0.921
Fabricated metal products. except machinery and equipment	0.804	0.183	0.406	0.907	0.806	0.179	0.392	0.914	0.809	0.173	0.381	0.918
Machinery and equipment n.e.c.	0.796	0.168	0.364	0.943	0.8	0.162	0.348	0.946	0.802	0.159	0.341	0.947
Motor vehicles. trailers and semi-trailers	0.812	0.165	0.328	0.943	0.814	0.162	0.323	0.94	0.811	0.161	0.321	0.943
Other transport equipment	0.817	0.149	0.295	0.98	0.82	0.148	0.294	0.98	0.825	0.145	0.288	0.977
Furniture; other manufactured goods n.e.c.	0.807	0.15	0.306	0.973	0.807	0.148	0.302	0.973	0.81	0.149	0.311	0.969
Secondary raw materials	0.823	0.342	0.648	0.98	0.83	0.343	0.654	0.977	0.829	0.329	0.639	0.98
Electrical energy. gas. steam and hot water	0.834	0.121	0.245	0.94	0.834	0.121	0.24	0.945	0.838	0.118	0.23	0.945
Collected and purified water. distribution services of water	0.807	0.143	0.282	0.995	0.81	0.142	0.274	0.995	0.807	0.145	0.29	0.996
Construction work	0.805	0.145	0.344	0.871	0.805	0.147	0.347	0.873	0.81	0.145	0.345	0.869
Trade. maintenance and repair services	0.794	0.155	0.331	0.964	0.799	0.152	0.321	0.965	0.804	0.148	0.31	0.967
Retail trade services.	0.779	0.164	0.376	0.957	0.78	0.165	0.373	0.959	0.785	0.159	0.361	0.962
Hotel and restaurant services	0.78	0.212	0.463	0.942	0.782	0.214	0.471	0.941	0.784	0.218	0.482	0.939
Land transport; transport via pipeline services	0.815	0.149	0.34	0.936	0.815	0.148	0.336	0.936	0.814	0.148	0.339	0.939
Water transport services	0.818	0.251	0.556	0.97	0.818	0.246	0.547	0.973	0.829	0.24	0.545	0.978

Table A1. Structural holes Non ICT sectors *(cont.)*

	2007				2005				2000			
	E_i	C_i	H_i	U_i	E_i	C_i	H_i	U_i	E_i	C_i	H_i	U_i
Air transport services	0.822	0.199	0.446	0.967	0.822	0.19	0.428	0.972	0.82	0.19	0.433	0.967
Domporting and auxiliary transport services; travel agency services	0.799	0.166	0.389	0.906	0.796	0.17	0.399	0.912	0.797	0.169	0.396	0.914
Financial intermediation	0.789	0.178	0.407	0.925	0.79	0.173	0.396	0.922	0.791	0.167	0.389	0.932
Insurance and pension funding services.	0.779	0.237	0.501	0.916	0.781	0.232	0.489	0.917	0.781	0.227	0.482	0.924
Services auxiliary to financial intermediation	0.83	0.315	0.576	0.892	0.823	0.314	0.573	0.899	0.825	0.296	0.55	0.912
Real estate services	0.778	0.175	0.402	0.924	0.774	0.18	0.412	0.92	0.772	0.181	0.419	0.922
Research and development services	0.813	0.139	0.283	0.982	0.818	0.138	0.279	0.981	0.822	0.134	0.263	0.982
Other business services	0.846	0.111	0.229	0.874	0.845	0.114	0.239	0.877	0.842	0.114	0.244	0.883
Public administration and defence services; compulsory social security services	0.777	0.17	0.404	0.965	0.785	0.165	0.383	0.963	0.794	0.154	0.347	0.965
Education services	0.782	0.168	0.373	0.984	0.783	0.166	0.355	0.984	0.795	0.155	0.326	0.985
Health and social work services	0.777	0.171	0.381	0.965	0.776	0.17	0.372	0.965	0.783	0.163	0.349	0.969
Sewage and refuse disposal services. sanitation and similar services	0.787	0.157	0.342	0.987	0.787	0.159	0.346	0.987	0.786	0.156	0.339	0.988
Membership organisation services n.e.c.	0.776	0.18	0.411	0.994	0.779	0.178	0.399	0.994	0.783	0.169	0.378	0.994
Recreational. cultural and sporting services	0.724	0.237	0.569	0.975	0.724	0.234	0.555	0.975	0.73	0.228	0.545	0.976
Other services	0.778	0.157	0.364	0.993	0.774	0.161	0.374	0.993	0.78	0.156	0.356	0.993
Private households with employed persons	0.606	0.854	0.855	0.705	0.662	0.564	0.706	0.648	0.663	0.593	0.727	0.624
MEAN	0.798	0.215	0.434	0.933	0.794	0.219	0.433	0.935	0.803	0.211	0.432	0.931

Note: As defined in the previous section, E_i stands for Efficiency Index, C_i, for Constraint Index, H_i for Hierarchy Degree and U_i for Direct and Indirect Efforts to establish links.

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