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Localized technological change, new information technology and the knowledge-based economy: The European evidence*

Cristiano Antonelli

Dipartimento di Economia, Laboratorio di Economia dell'Innovazione,
Università di Torino, Via S. Ottavio 20,
I-10214 Torino, Italy (e-mail: antonell@de.unito.it)

Abstract. This work analyzes the co-evolution of new information and communication technologies and the knowledge-intensive business industry. New information technology affects the actual conditions of information, its basic characteristics of appropriation and tradability, favouring the role of business services as forces of interaction between knowledge components in the generation of new technology. Empirical analyses, based on input/output statistics of the European economy in the second half of 1980's, demonstrate the existence of a correlation between the usage of business and communication services and confirm their high output elasticity.

Key words: Information technology – Knowledge-intensive business services – Input/output analysis

JEL-classification: 033; 047

1 Introduction

New information and communication technologies alter the very conditions of the access, retrieval, processing and communication of all types of information. Specifically, they increase the separability, tradability and transportability of information, thus favouring the commercial opportunities of knowledge-intensive business service firms. The increased activity

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of the latter and the related spread of new information technology should enhance the connectivity and receptivity of information networks and their agents, reconfiguring the position of service industries and making the knowledge-based service sector, as the mediator of increasing interactions between tacit and generic knowledge, central to the innovative capability and competitive advantage of an economic system (Antonelli, 1988, 1992).

Preliminary attempts to use percolation methodology in economics suggest an empirical ground upon which to test the basic working hypotheses (Antonelli, 1996a). Thus we can appreciate empirically, in assessing the capability of firms to generate technological innovations, the role of connections existing among agents in a network and the capacity of each agent to absorb new information.

2 New information and communication technologies and knowledge-intensive business services

The generation of new knowledge, in the form of technological change, results mainly from the interplay between generic knowledge (codified technological knowledge with a direct scientific content) and tacit knowledge (learning processes based on the specific experience of the innovator). In this context, research and development activities represent only one factor of the generation of new technological knowledge, which should rather be seen as a general process of the accumulation and capitalization of learning and experience dependent upon both internal and external circumstances and opportunities. The production of localized technological knowledge, whilst incorporating the top-down, deduction-from-fact process which is the basis of generic knowledge, is essentially a bottom-up process of induction from experience. Turning localized knowledge into successful innovation would thus appear to depend on a firm's capacity to appropriate learning opportunities, by means of both research and development and internal learning, and also by the systematic absorption of the specific scientific and technological externalities available in a firm's environment. In fact, the development of knowledge within an economy is strongly influenced by the network of relations among its firms and is seen to be systemic, with externalities, communication and interdependence playing crucial roles (Nelson, 1987; David, 1993; Antonelli, 1995).

Indeed localized knowledge, viewed as the result of a collective, interdependent undertaking, is heavily shaped by the availability of external knowledge precisely in terms of connectivity among agents and the receptivity of agents to external sources of information and competence. Thus the need, within effective innovation systems, for open and dynamic channels of information and communication between agents who are receptive to learning opportunities and well-connected to both the internal and external technological environment in terms of organization and cooperation (Lundvall, 1992; Nelson, 1993; David and Foray, 1995).

And it is here that knowledge-intensive business service firms, providing access to scientific and technological information dispersed in the system, are of central importance. In terms of connectivity and receptivity,

knowledge-intensive business services function as holders of proprietary 'quasi-generic' knowledge, implemented by the interactions with customers and the scientific community. Knowledge-intensive business services operate as an active interface between codified knowledge, stored in universities and the research laboratories of other firms, and its tacit counterpart, located within the daily practices of the firm (Gallouj, 1994).

The distribution and quality of knowledge-intensive business services have important effects on the economic system in terms of innovative capacity. An increase in the exchange of codified and tacit knowledge, made possible by the services of consultants and advisers, improves connectivity, with agents sharing learning experiences and creating learning opportunities. Improved business services, in terms of distribution, capillarity, competence and access, in turn improve the interaction between internal and external knowledge. In so doing they generate technological and organizational innovations and solutions specifically tailored to a firm's individual business environment. This increases the absorption capability of external knowledge and leads to a systematic reduction of the levels of vertical integration of the knowledge generation process. Consequently, receptivity is also increased by the systematic outsourcing of knowledge-intensive business services. The not-invented-here syndrome is moderated and the absorption of external knowledge is easier and faster (Miles et al., 1995; Den Hertog, 1995).

The diffusion of knowledge-intensive business services and the growth of the knowledge-intensive business service industry are deeply affected by the parallel diffusion and implementation of the new information and communication technological system. The effects of the new information and communication technologies on the very conditions of information, and ultimately its tradability or commercial potential, influence more and more the actual generation and organization of knowledge, both industrially and institutionally (Antonelli, 1988, 1992; Preissl, 1995).

The vertical integration structure of knowledge generation, within 'intra-muros' research and development laboratories characteristic since the Second World War, is being progressively and systematically replaced by the institutional creation of an information exchange market, based on real-time, on-line interaction between customers and knowledge producers. Customer accessibility and supplier competence, both enabled by systematic use of information and communication networks, are the major factors of evolution here. Firms requiring specific solutions or advice can access the competencies of knowledge-intensive business services, which are able to interface their own localized knowledge with the generic scientific and technological competencies available in the external environment, thereby enhancing their own technological capacity. The classic exchange of goods and coin is in this context represented by a process of market cooperation involving ex-ante contractual agreements, which enable the appropriation and distribution of knowledge and the supply of specific problem-solving competencies on demand.

Knowledge-intensive business service firms are the protagonists in this emerging market, serving as a dynamic source of "quasi-generic" knowledge and an interface between a firm's own tacit and implicit knowledge

and the generic knowledge available within the economy as a whole. Such a situation, as has been said, improves and increases connectivity and receptivity, as exchanges of tacit knowledge and localized competencies mean increased learning opportunities from the share of experience between the customers of knowledge firms. The beneficial effects are clearly circular: the greater the diffusion of computerized networks, the greater the volume of electronic communication, and thus the greater the exchange of tacit and generic knowledge, and vice versa.

The net result of such activity is increased specialization in the production of knowledge and the creation of a veritable knowledge economy. A comparison with the software market is telling, where on-line interaction exists with independent software houses (knowledge producers) and their packages (knowledge, competencies). What emerges is a highly individual interaction between the customer, in search of specific solutions or generic information to turn its own tacit know-how into localized knowledge and innovation, and the supplier. The penetration of new information and communication technologies encourage just such a trend, affecting the actual conditions of information in terms of its exchangeable parts, separating new information from the technical expertise used to generate it. New technologies provide an opportunity for business services providers to store and market knowledge, and for business services users to better access and purchase it.

Again the effects are reciprocal. The growth of direct, on-line, question-answer interactions creates more and more opportunities to generate new generic knowledge with increasingly wider applications. The dynamics of positive feedback has a positive influence in terms of both private and social efficiency. The increased activity is obviously economically beneficial to knowledge-intensive business firms (with respect to size and revenue), and at the same time improves the overall distribution of the knowledge exchanged through the accumulation of experience and increasing interactions. Customers are able to acquire the information needed, while at the same time the total amount of knowledge increases. The interdependent nature of this exchange system means that new information technologies and the feedback they generate contribute to the reduction of the wasteful duplication of costs, which occur due to the separation between the production and the (subsequent) absorption of knowledge. Knowledge not only becomes on-line, but also tailor-made[1].

Because of the strong and positive effects of the use of knowledge-intensive services provided to the rest of the economy, in terms of technological spillovers, the co-evolution of communication technologies

[1] The Arrovian trade-off is thus to some extent mitigated: the incentive for specialized firms to build competencies is apparent in the positive market signalling it provides; the assessment of competencies is possible in terms of reputation; and in such an institutional market there is little opportunity for customers to "steal" actual competencies. Moreover, the negative effects of intellectual property rights, with respect to other potential users, may be countered by mandated licencing of key technological information, generated in previous "telematic market" interactions, in turn increasing the socialization of this new specialized generation of knowledge.

and knowledge-intensive business services is likely to lead to the creation of a new strategic sector centered in the service industries, which is more and more capable of replacing the manufacturing sector (more specifically the electronic, machine-tool and chemical industries) as the providers of strategic inputs to the rest of the system[2]. The emergence of the knowledge-based economy and the co-evolution of communication technologies and knowledge-intensive business services seem to be two strictly intertwined aspects of a more general process of structural change.

The emergence of such a specialized industry for the production of knowledge, enabled by the diffusion of new information and communication technologies, ultimately affects the institutional generation of knowledge. Universities, and the academy in general, already face questions regarding the funding, efficiency and quality of research, as private business service firms doing the same work come to compete directly. The increasing compatibility of and comparability between universities and knowledge firms may equally have positive effects. The evaluation of such things as the quality of research and the efficiency of the labor force in a publicly-funded institution becomes more and more viable as that institution more and more resembles a private knowledge firm. In fact, this similarity may even affect the traditional distinctions between university and (knowledge) industry, the regulated interaction and cooperation of which could well increase overall efficiency. Pressures of budget cuts on academic institutions, on the one hand, and the threat of unfair competition between low-priced publicly-funded services and tax-paying ones on the other, are forces that will certainly bring about change. In Europe, the historical antagonism, or at least the lack of established communication and cooperation, between industry and the academy may well be bridged by knowledge firms acting as connectors and mediators in the exchange of technological information (Antonelli, 1998).

3 The empirical analysis

3.1 The hypotheses

New information and communication technologies affect the state of information itself, changing its divisibility and storage, its processing, transportation and communication, and consequently its accessibility and tradability. This in turn increases the market opportunities for knowledge-intensive business service firms. By means of new information technologies, these firms gain a greater command of the knowledge economy, building up connectivity and receptivity by establishing an interface between each member of the information network and the information itself. Hence communication and business services industries are becoming the new strategic sector providing key inputs to the rest of the economic system.

[2] For the notion of the strategic sector, and more specifically the role of the manufacturing sector as the engine of economic growth, see Cornwall (1976) and Kaldor (1966). For the notion of technological spillover, see Griliches (1979). It is interesting to note the strong complementarity between the notions of strategic sector and localized spillover.

Given this general analysis we expect to see a correlation and consequent co-evolution, in level and rate of growth, in the use of business and communication services. The quantity of business and communication services acquired by an industry can be measured on the basis of input/output statistics, providing data from which to estimate the co-evolution and actual output elasticities of these two key services (Antonelli, 1996b, 1997).

3.2 The use of input/output data

Input/output tables provide a rich data set from which we can extract the amount of services provided by the communication services industry and the business service industry to the rest of the economic system. Neither capital nor investment data, however, are made available by these statistics. Hence it is necessary to cross-check data from the input/output statistics with data from standard national account statistics, so that the amount of communication and business services purchased by each industry as intermediary inputs may be compared with figures on added-value, labor costs and capital (estimated from investments series) obtained from national accounts statistics. The matching of these two statistical sources is necessary in order to obtain data on investments, and hence capital, so as to estimate a production function (see Appendix I).

Tables 1–4 show the distribution of intensities of communication and business services calculated as the percentage share of communication and business services, respectively, to value added (C/VA and BS/VA) in the four countries. The data show that the value of communication services purchased by each industry accounts for a small percentage share of value added in all countries and sectors. The ratio C/VA ranges from (1ow) values in the proximity of 0.5% in most manufacturing industries to (high) values of 3% in many service sectors such as lodging and catering, credit and insurance, transport, trade and business services. The share of business services to value added (BS/VA) is everywhere much larger: it accounts for an average value of 15% in most sectors and countries[3].

More precisely, we see that, in Italy, the average ratio of communication services to value added increased from 1.48% in 1985 to 1.78% in 1988. In the same time interval the average ratio of business services to value added increased from 14.8% to 16.4%. In Germany the ratio of communication services to value added was 1.23% in 1986 and 1.39% in 1990, while the

[3] The ratios of business services and communication services as well as of any other intermediary input to value added should not be interpreted as an indicator of vertical integration. This is true for many reasons. First, the unit of analysis is the industry and not the firm; actually it is an industry made up of specialized units, into which data at the firm level are split. Second and most important, the extent to which a production process and the related product uses communication and business services as well as any other intermediary products is by no means associated with the amount of communication and business services purchased in the market place by a firm. Input-output tables show the levels at which a given production process requires some services. These services can be supplied internally, by other specialized units which belong to the same firm, but never by definition to the same industry, or externally by independent firms.

Table 1. The ratio of communication and business services to value added in Italy (1985 and 1983)

	Italy sectors	C/Va% (1988)	C/Va% (1985)	BS/Va% 1988	BS/Va% 1985
1	Agriculture	.030	.030	.750	.200
2	Energy	1.217	.777	1.352	1.084
3	Minerals	3.196	4.020	19.255	20.272
4	Clay & Glass	2.417	2.523	13.377	13.288
5	Chemicals	2.805	3.067	15.755	16.029
6	Metal products	2.504	2.214	18.121	15.677
7	Machinery	2.441	2.401	11.458	10.079
8	Precision & informatics	2.786	2.962	16.092	14.370
9	Electrical machinery	1.484	1.538	12.997	12.176
10	Motor vehicles	1.859	1.851	10.667	9.776
11	Ships & aeronautics	1.512	1.160	9.897	7.372
12	Meat & products	.773	.982	13.134	14.705
13	Milk & products	1.499	1.680	15.307	15.139
14	Other food industries	1.662	1.469	14.865	13.934
15	Drinks	1.232	1.287	17.036	14.567
16	Tobacco	.049	.145	3.816	6.934
17	Textiles & apparel	2.405	.240	16.011	14.051
18	Leather & shoes	1.426	1.424	14.578	12.865
19	Wood & furniture	2.144	2.055	18.070	15.243
20	Pulp, paper & printing	2.840	2.898	15.175	12.912
21	Rubber & plastics	1.767	1.564	9.410	8.243
22	Other manufacturing	2.242	2.404	19.931	20.127
23	Building	.511	.490	9.960	9.520
24	Repair & maintenance	2.950	2.410	33.186	33.237
25	Wholesale & retail	1.587	1.478	44.075	37.503
26	Lodging & catering	1.422	1.371	25.957	19.840
27	Inland transportation	.839	.241	19.065	12.082
28	Sea & air transportation	3.948	3.091	20.413	16.731
29	Other transportation	4.076	3.619	3.980	3.762
30	Communication services	3.464	2.614	27.945	37.590
31	Credit & insurance services	2.700	1.840	44.320	39.980
32	Business services	2.040	1.970	39.870	38.760

ratio of business services to value added increased from 14.9% to 15.5%. In the United Kingdom, the ratio of telecommunication services to value added actually declined from 1.12% to 1.02% in 1990, while the share of business services went up from 16.6% to 19.3%. Finally, in France, the share of communications to value added increased from 0.89% to 0.95%, and the ratio of business services to value added increased from 14.1% to 16.3%.

In assessing the evolution of shares of communication services, the sharp increase in the capability of transmission equipment in telecommunications due to the increasing share of data communication should be born in mind, resulting in an effective reduction of the hedonic prices for telecommunications services. The decline of telecommunications tariffs should also be considered.

Table 2. The ratio of communication and business services to value added in Germany (1986 and 1990)

	Germany sectors	C/Va 1986	C/Va 1990	BS/Va 1986	BS/Va 1990
1	01/Agricultural, forestry and fishing	.323	.339	4.035	3.919
2	06/Coal, petroleum and gas	.753	.801	7.983	10.413
3	13/Ferrous & non-ferrous products	.643	.719	15.021	20.511
4	15/Non-metallic and mineral products	.904	.874	17.405	21.970
5	17/Chemicals and parmaceuticals	1.367	1.486	21.183	24.675
6	19/Metal products	1.485	1.536	12.825	16.740
7	21/Machinery	1.755	2.185	14.703	22.656
8	23/Office equipment	2.087	1.909	28.391	30.597
9	25/Electrical machinery	.670	.674	10.959	15.048
10	28/Transport equipment	.476	.610	16.344	23.358
11	36/Food beverages and tobacco	.977	1.242	16.779	27.042
12	42/Textiles, clothing, leather and products	2.128	2.511	16.002	25.260
13	47/Paper and printing products	1.051	1.126	9.802	15.028
14	49/Rubber and plastic products	1.170	1.125	15.140	18.790
15	48/Other manufacturing industries	1.426	1.628	13.221	20.184
16	53/Building	1.363	1.566	13.226	18.780
17	56/Repair and wholesale & retail	2.278	1.992	10.829	11.839
18	59/Lodging and catering services	2.884	3.081	8.531	15.403
19	61/Domestic transportation	2.777	2.678	8.240	9.518
20	67/Communication	1.428	2.064	.171	.587
21	69a/Credit & insurance	1.983	1.709	17.538	19.422
22	74/Business services	.737	.746	9.806	14.087
23	86/Non market services	1.474	1.402	5.551	8.136

3.3 Evidence of the co-evolution of usage of business and communication services

New information and communication technologies profoundly affect the ability to access, retrieve, process and store information. The tradability, divisibility and transportability of information is greatly enhanced by new information technologies that make it possible to deliver a growing variety of services to a growing variety of remote users. Hence we expect to see a strong association between both the levels and the rates of growth of business services and communication services across the main sectors and industries of the European economy. More specifically, we hypothesize that the larger the usage intensity of communication services, the larger is the use of business services.

The first hypothesis can be easily specified as follows:

$$\text{BS/VA} = a + b(\text{C/VA}) \tag{1}$$

where C/VA measures the intensity of communication services purchased by each industry with respect to value added, and BS/VA the intensity of business services in 1988 for Italy and 1990 for the United Kingdom, Germany, and France.

Table 3. The ratio of communication and business services to value added in France (1986 and 1990)

	France sectors	C/Va 1990	C/Va 1986	BS/Va 1990	BS/Va 1986
1	01/Agricultural, forestry and fishing	.040	.030	1.618	1.649
2	06/Coal, petroleum and gas	.657	.629	13.260	8.615
3	13/Ferrous & non-ferrous products	1.606	1.309	4.774	3.121
4	15/Non-metallic and mineral products	.271	.252	13.917	10.160
5	17/Chemicals and parmaceuticals	2.400	1.952	20.764	18.964
6	19/Metal products	2.913	2.633	8.148	5.086
7	21/Machinery	1.618	1.394	47.382	38.350
8	23/Office equipment	2.981	2.743	19.705	15.618
9	25/Electrical machinery	1.441	1.281	21.048	17.778
10	28/Transport equipment	1.306	1.363	32.319	19.966
11	36/Food beverages and tobacco	1.056	.967	25.292	17.496
12	42/Textiles, clothing, leather and products	1.273	1.184	21.589	14.985
13	47/Paper and printing products	2.755	2.630	20.835	14.139
14	49/Rubber and plastic products	1.163	1.070	30.859	19.964
15	48/Other manufacturing industries	2.101	1.916	17.848	14.290
16	53/Building	.966	.861	37.306	25.640
17	56/Repair and wholesale & retail	1.737	1.655	6.180	4.192
18	59/Lodging and catering services	1.118	1.034	8.509	5.457
19	61/Inland transport	.998	.944	5.525	3.940
20	67/Maritime and sea transport	1.920	1.926	26.653	20.730
21	65/Auxiliary activities	.457	.413	5.844	4.219
22	67/Communication	2.652	2.183	2.617	2.829
23	69a/Credit & insurance	3.153	4.640	31.882	18.916
24	74/Business services	2.732	2.767	12.976	9.151
25	86/Non market services	1.459	1.430	4.687	4.169

The econometric test yields a strong positive result for all the countries:

$$\text{(2.1. ITALY) BS/VA} = 0.047 + \underset{(10.211)}{3.382}\text{(C/VA)}$$

$R^2 = 0.781; F = 104.258$; (t of Student between parentheses)

$$\text{(2.2. U.K.) BS/VA} = 0.247 + \underset{(8.211)}{2.885}\text{(C/VA)}$$

$R^2 = 0.881$; $F = 124.212$; (t of Student between parentheses)

$$\text{(2.3. DEU) BS/VA} = 0.168 + \underset{(9.901)}{3.312}\text{(C/VA)}$$

$R^2 = 0.741$; $F = 104.867$; (t of Student between parentheses)

$$\text{(2.4. FRA) BS/VA} = 0.297 + \underset{(12.311)}{2.966}\text{(C/VA)}$$

$R^2 = 0.901$; $F = 96.578$; (t of Student between parentheses)

Table 4. The ratio of communication and business services to value added in the U.K. (1984 and 1990)

	U.K. sectors	C/Va 1984	C/Va 1990	BS/Va 1984	BS/Va 1990
1	Coal mining	1.649	.481	7.113	9.183
2	Petroleum and gas	N.A.	N.A.	N.A.	N.A.
3	Metal ore mining	0	N.A.	16.667	N.A.
4	Other mining	.227	.980	5.000	4.314
5	Food products	.622	.667	8.609	10.099
6	Beverages	.879	.643	11.905	11.340
7	Tobacco	.467	.301	12.336	6.541
8	Textiles	.957	.863	4.858	9.391
9	Wearing apparel	.884	.916	3.978	6.947
10	Leather and products	1.071	1.000	3.571	12.333
11	Footwear	.577	.845	4.038	6.901
12	Wood products	1.624	1.333	7.094	10.278
13	Furniture, fixtures	1.176	1.059	8.162	11.451
14	Paper and products	1.045	.933	7.351	9.733
15	Printing, publishing	2.876	2.909	7.819	18.555
16	Industrial chemicals	.869	1.071	6.802	9.887
17	Other chem. products	.629	.635	7.614	7.904
18	Petroleum refineries	.305	.484	8.244	5.565
19	Rubber products	.980	.651	6.667	6.095
20	Plastic products nec	1.126	.931	7.117	9.113
21	Pottery, china, etc	1.132	1.098	6.038	6.585
22	Glass and products	.845	.769	7.042	7.436
23	Non-metal prod. nec	.748	.791	4.829	6.759
24	Iron and steel	.421	.265	4.142	7.263
25	Non-ferrous metals	.769	.577	5.983	10.705
26	Metal products	1.439	1.082	7.888	11.320
27	Machinery nec	1.357	1.068	6.776	9.674
28	Electrical machinery	1.153	1.214	6.886	10.335
29	Transport equipment	.653	.512	5.814	9.303
30	Professional goods	1.463	1.561	7.073	8.341
31	Other industries	4.043	1.218	8.723	7.756
32	Electricity, gas, steam	1.270	1.199	4.920	2.854
33	Water works and sup.	1.181	1.154	4.173	4.375

These results confirm that the levels of usage of communication and business services were strongly related in the European economy at the end of the eighties.

The second hypothesis suggests that not only the levels, but also the rates of growth in the intensities of communications services, lead to, or are significantly associated with, the growth in the intensity of business services. In fact the causal link can easily work both ways: the growth in the use of communication services makes it possible, because of the powerful effects of new information and communication technologies in terms of tradability, divisibility and transportability, to access a wider and more efficient market for business services. The adoption of new information and communication technologies induces firms to increase their demand for communication services, inducing them to rely more systematically on the usage of business services. This hypothesis can be specified as follows:

$$\log(BS_t/BS_{t-1}) = a + b\log(C_t/C_{t-1}) \quad (3)$$

where C_t, C_{t-1}, BS_t and BS_{t-1} are the natural logarithms of the rates of growth of use of communication and business services in each of the industries retained between the years 1985 and 1988 for Italy, 1984 and 1990 for the United Kingdom, 1986 and 1990 for Germany and France, respectively. The logarithmic specification of equation (3) makes it possible to read the outcome of the econometric test directly in terms of elasticity, so that b will measure the elasticity of the growth in the use of business services to the growth of communication services. The results of the econometric test are again very clear:

$$(4.1.\ \text{ITALY})\ \log(BS_t/BS_{t-1}) = -4.905 + 0.607\log(C_t/C_{t-1})$$
$$(8.819)$$
$$R^2 = 0.733;\ F = 77.771;\ (t \text{ of Student between parentheses})$$
$$(4.2.\ \text{U.K.})\ \log(BS_t/BS_{t-1}) = -3.705 + 0.789\log(C_t/C_{t-1})$$
$$(9.819)$$
$$R^2 = 0.739;\ F = 57.987;\ (t \text{ of Student between parentheses})$$
$$(4.3.\ \text{DEU})\ \log(BS_t/BS_{t-1}) = -9.905 + 0.753\log(C_t/C_{t-1})$$
$$(7.908)$$
$$R^2 = 0.813;\ F = 71.951;\ (t \text{ of Student between parentheses})$$
$$(4.4.\text{FRA})\ \log(BS_t/BS_{t-1}) = -6.535 + 0.831\log(C_t/C_{t-1})$$
$$(8.115)$$
$$R^2 = 0.782;\ F = 77.549;\ (t \text{ of Student between parentheses})$$

These results are important on two counts: first, they show that the econometric link between the growth in the usage of communication services and the growth in the usage of business services is statistically very strong. In fact, the two variables exhibit a strong correlation value. Second, and most important, the large estimated value of b, the elasticity parameter, in equations (4.1)–(4.4) suggests that the growth in the usage of business services is strongly stimulated by the growth in the usage of communication services.

3.4 The effects of the co-evolution of the usage of business and communication services: a simple accounting approach

Communication and business services industries are the new strategic sector of the emerging knowledge-based economy. Their products are key intermediary inputs to the rest of the economy. A small increase in their use makes it possible to increase significantly the output levels. Hence we expect to measure their strong and positive effects on the rest of the economic system by the empirical estimates of their output elasticity. An attempt to assess empirically the effects of the use of communications & business

services can be based on the standard production function, where "communication & business services" are specified as distinct production factors.

The hypothesis leads to the econometric specification of a production function for each of the four countries, where communication and business services, respectively[4], enter as specific production factors:

$$Y = a + b\,K + c\,L + d\,C \tag{5}$$

$$Y = a + b\,K + c\,L + d\,BS \tag{6}$$

where Y is the natural logarithm of value added for the sectors available in each country (see Tables 1-4) provided by national accounts statistics (OECD, 1993), K is the natural logarithm of capital stock (estimated from investments data found in national accounts statistics OECD, 1993), L is the natural logarithm of labor costs (provided by national accounts statistics OECD, 1993), and CBS is the flow of either the inputs of communications (C) or business services (BS) purchased by each industry (provided by input-output statistics[5]). Data for 1988 are used for Italy and for 1990 for the United Kingdom, Germany and France.

The OLS cross-section estimates of equation (5) for communication services provide satisfactory results:

$$\text{(5.1.ITALY)}\quad Y = 2.258 + 0.321K + 0.693L + 0.085C$$
$$(3.576)\quad (7.479)\quad (3.211)$$

$R^2 = 0.749$; $F = 47.162$; (t of Student between parentheses)

$$\text{(5.2.U.K.)}\quad Y = -4.281 + 0.354K + 0.349L + 0.208C$$
$$(5.483)\quad (3.956)\quad (2.34)$$

$R^2 = 0.953$; $F = 182.635$; (t of Student between parenthesis)

$$\text{(5.3.DEU)}\quad Y = 0.945 + 0.196K + 0.779L + 0.155C$$
$$(5.741)\quad (3.615)\quad (1.498)$$

$R^2 = 0.859$; $F = 24.162$; (t of Student between parentheses)

$$\text{(5.4.FRA)}\quad Y = 2.185 + 0.662K + 0.161L + 0.088C$$
$$(9.389)\quad (1.879)\quad (2.211)$$

$R^2 = 0.913$; $F = 73.162$; (t of Student between parentheses)

The OLS cross-section estimates of equation (6) for business services also provide satisfactory results:

$$\text{(6.1.ITALY)}\quad Y = 3.945 + 0.516K + 0.433L + 0.271BS$$
$$(3.489)\quad (7.279)\quad (3.611)$$

$R^2 = 0.749$; $F = 47.162$; (t of Student between parentheses)

[4] Because of the strong correlation between the diffusion of communication services and business services it is impossible to obtain reliable estimates of the joint effects of both. Hence we have specified two distinct regression equations, one for each group of services.

[5] See section 3.2. for a detailed discussion of data used.

$$(6.2.\text{U.K.})\ \text{Y} = -4.389 + \underset{(6.415)}{0.332\text{K}} + \underset{(5.479)}{0.473\text{L}} + \underset{(4.567)}{0.424\text{BS}}$$

$R^2 = 0.929$; $F = 154.342$; (t of Student between parentheses)

$$(6.3.\text{DEU})\ \text{Y} = 3.945 + \underset{(7.989)}{0.216\text{K}} + \underset{(6.429)}{0.473\text{L}} + \underset{(2.211)}{0.287\text{BS}}$$

$R^2 = 0.899$; $F = 231.162$; (t of Student between parentheses)

$$(6.4.\text{FRA})\ \text{Y} = 3.945 + \underset{(4.89)}{0.616\text{K}} + \underset{(3.422)}{0.273\text{L}} + \underset{(3.811)}{0.263\text{BS}}$$

$R^2 = 0.889$; $F = 76.890$; (t of Student between parentheses)

The most important result of this preliminary empirical analysis consists of the robust and persistent estimates of the output elasticities of communications and business services across four major European countries (see Appendix II for complementary estimates).

These estimates deserve some attention for three reasons:

1) the output elasticities so far estimated are very high and are close to the values of the two basic inputs of labor and capital. This result is all the more interesting when returns to scale are considered: in no case does the sum of output elasticities of the three factors considered exceed significantly unity. In Italy and Germany, the estimated output elasticity of communication services (0.085 and 0.155, respectively) is close to the output elasticity of capital. In France, the output elasticity of communication services is 0.088 against an output elasticity of labor of 0.161. In the United Kingdom, the estimated output elasticity reaches the highest value among the countries considered at 0.208 against an output elasticity of capital and labor of 0.354 and 0.349, respectively. When business service are included the results are even stronger. In Germany, Italy and France the estimated output elasticity of business services in 1990 was 0.28, 0.27 and 0.26, respectively. In the United Kingdom, the output elasticity of business services reached the 0.42 level. Although a direct comparison of the results across the four countries is impeded by the heterogeneity in the data (see section 3.2), it seems useful to note that the output elasticities of communication and business services reach the highest values in the UK, a country well ahead in the transition towards a knowledge-based economy; Germany ranks second, France third and Italy fourth. This ranking is consistent with OECD international statistics based upon other indicators concerning the role of intangible assets and knowledge-intensive inputs (see Foray and Lundvall, 1996; OECD, 1996).

2) The inclusion of communication services in the econometric equation has some negative, non negligible effects on the output elasticity of capital in all countries. The estimated output elasticity of labor declines when business services are accounted for. These two results deserve some attention in that they may supply some indirect and very preliminary evidence that communication services capture some of the output elasticity of capital

Table 5. A cross-European comparison of output elasticities and cost shares for communication and business services

	C/VA	dY/dC	BS/VA	dY/dBS
Italy	1.78%	0.085	16%	0.27
France	0.95%	0.088	16.9%	0.26
Germany	1.39%	0.155	15%	0.28
UK	1.02%	0.208	19.3%	0.28

and business services capture some of the output elasticity of labor. This in turn may suggest that the inclusion of communication and business services capture the efficiency of the portion of capital and labor more directly involved in the use of data communication and knowledge-intensive business activities, respectively.

3) The estimated output elasticities of both the communication and business services are much larger than the respective cost shares in all four countries (see Table 5). In Italy the estimated output elasticity of communication services is 0.085, against a cost share of 1.78%, i.e. almost five times larger. In Germany a similar discrepancy is found between a cost share of 1.39% and an estimated output elasticity of 0.155. In France the output elasticity of communication services is 0.088, against a cost share of 0.95%. In the United Kingdom the estimated output elasticity reaches the highest value among the countries considered at 0.208, against a ratio of telecommunication services to added value of 1.02%. In Italy the cost share of business services in 1990 was 16% and their estimated output elasticity 0.27. In France the cost share of business services was 16.9% and their output elasticity 0.26. In Germany the cost share of business services was 15% and their output elasticity 0.28. Finally, in the United Kingdom the cost share of business services was 19.3% and their output elasticity 0.42. Our interpretation is that, at the end of the 1980's, the usage of (tele)communication and business services was still in the early stages of the diffusion process. Only early adopters were able to make good use of the new technological and organizational opportunities. In these conditions the use of communication and business services is likely to yield a marginal output far larger than the share costs of the same services with respect to value added (see Table 5)[6]. Firms and hence industries that had been able to adopt new information and communication technologies more quickly, by means of these innovations, have been better able to appropriate the technological knowledge available in the new telematic environment. Moreover, they could implement it with the use of knowledge-intensive business services in order to experience a faster rate of growth. The discrepancy between estimated output elasticities and actual cost shares can be interpreted as an indicator of some systematic oscillation around long-run equilibrium trajectories. Estimated output elasticities can be considered

[6] The ratios of communication and business services to value added calculated in Tables 1–4 exclude naturally materials and other intermediary inputs and are fully consistent with our estimates of value added production functions.

as tentative proxies for the perspective levels of the cost shares of communication and business services. The discrepancy also confirms that, in all of Europe, the usage of communication and business services at the end of the 1980's was very productive, and a strong increase could be expected in the future[7].

4 Conclusion

Based on the growth of the new information technology system within the structure of the European economy, we are witnessing a new global division of labor, between OECD countries specializing in knowledge-intensive products on the one hand, and newly-industrialized countries concentrating on manufactured goods on the other. In such a situation, the competitiveness and innovative capacity of the European economy is increasingly seen to depend on the generation of the new information and communication technologies and, consequently, the function of the knowledge-intensive business service sector.

Localized technological innovations are the result of differing combinations of tacit and generic knowledge. Until now, the economic importance of generic (organized) scientific knowledge, and related research and development expenditures, has been exaggerated. Tacit knowledge, acquired by localized personal experience and individual learning processes, is also a major source of technological knowledge. In fact, many small firms generate significant innovations based solely on tacit localized knowledge; and many larger firms actually fail in the diffusion of innovative initiatives in unrelated activities because of a lack of tacit-learning appropriation opportunities. There is thus a basic need for innovation systems that encourage the accumulation of such tacit localized knowledge and enable its interaction with generic counterparts: in the generation of new technological innovations, firms rely on interactions between themselves and with academic and other research institutions, sharing learning opportunities and experience.

The innovative characteristics of the firm and its innovation system dictate the terms of communication and information exchange between firms, ultimately determining their innovative capabilities. We can identify three such 'topological' factors in particular: the individual resources designated to the accumulation and implementation of tacit knowledge, and thus the generation of innovation; receptivity to outside technological knowledge; and the connectivity and distribution network, in terms of knowledge, between firms. The quality of and accessibility to the information and communication technology infrastructure is also a significant factor in an economy's innovative potential.

Based on the advent of new communication and information technologies and their direct effects on the conditions of information, its

[7] As a matter of fact, the strong growth of the communication and business services industries in the four European economies in the 1990's confirms this intepretation.

appropriability and marketability, the knowledge-intensive business service industry can be portrayed as the new strategic sector of the knowledge-based economy. This is due to its key role as an interactive agent between tacit and generic knowledge components, intensifying the connectivity and receptivity of firms (ie. learning agents). This is consistent with the more general hypothesis that, because of the diffusion of new information and communication technologies, the knowledge-intensive business service industry is replacing the manufacturing industry as the engine of the accumulation of competences and knowledge in the knowledge-based economy.

Empirical analyses have demonstrated the co-evolution in the use of business and communication services in respect of the level and rate of increase. Moreover, our analyses show high output elasticity levels for business and communication services, far above actual cost shares. Such a discrepancy may be explained by significant time delays and heterogeneity among both firms and industries in the adoption of technological and organizational innovations made available by new information and communication systems. It is this introduction of new information and communication technologies that promotes the penetration of knowledge-intensive business service firms, and increases the access to new markets for disembodied knowledge. This process of structural change in turn feeds the diffusion and implementation of further innovations in new information and communication technological system.

We may conclude that the systematic use of communication and business services, and the associated creation of an operative information network, which enhances the communication intensity of a system, enable firms to capitalize on new technologies, improving general productive efficiency.

Appendix I: Matching input/output data with national accounts statistics

Matched data[8] were available in Italy for 32 sectors of the primary, manufacturing and service industries, for the 1985 and 1988; in the United Kingdom for 32 sectors of the primary and manufacturing industries only, in the years 1984 and 1990. German and French statistics were provided for 23 and 25 sectors, respectively, for the years 1986 and 1990. The classification of economic activities across countries considered differs all the more so when we try to maximize the number of observations (the number of industries). Hence the four countries examined cannot provide a homogeneous group of industries. Tables 6–9 indicate the conversion criteria from the input/output aggregation into the NACE classification, for Italy (Table 6), Germany (Table 7), France (Table 8) and the U.K. (Table 9).

[8] Data for Germany and France were made available by the MERIT Data Bank, whose support is gratefully acknolwedged. Data for Italy were found in ISTAT (1992a and b). Data for the United Kingdom were found in the Central Statistical Office (1995) and U.N. (1995). The help of Andera Panetta and Aldo Geuna in data collection and aggregation is acknowledged.

Table 6. Italy: Conversion from the Input/Output classification into the NACE

No	NACE	I/O compatible
1	011 − 030	01
2	111 + 120 − 17	07
3	211 − 224	09
4	231 − 248	13
5	25 − 26	15
6	311 + 312 + 313 + 314 + 315 + 316	17
7	321 + 322 + 323 + 324 + 325 + 326 + 327 + 328	21
8	33 + 371 + 372 + 373 + 374	23
9	341 + 342 + 343 + 344 + 345 + 346 + 347	25
10	351 + 352 + 353	27
11	361 + 362 + 363 + 364 + 365	29
12	412	31
13	413	33
14	411 + 414 + 415 + 416 + 417 + 418 + 419 + 420+ 421 + 422 + 423	35
15	424 + 425 + 427 + 428	37
16	429	39
17	431 + 432 + 434 + 435 + 436 + 437 + 438 + 439+ 453 + 454 + 455 + 456	41
18	441 + 442 + 451 + 452	43
19	46	45
20	47	47
21	48	49
22	491 + 492 + 493 + 494 + 495 + 496	51
23	505 − 509	53
24	620 + 671 + 672 + 673 + 675	55
25	61 + 63 + 64	57
26	661 + 662 + 664 + 665 + 667	59
27	710 + 72 + 730	61
28	741 + 742 + 750	63
29	761 + 762 + 763 + 764 + 771 + 772 + 773	65
30	790	67
31	811 + 812 + 813 + 820	69
32	83 + 84 + 84 + 85 + 93 + 94 + 95	74

Aggregation among these countries, morevover, differs in terms of the content of the service sector[9], and the communication sector. Communication services in the United Kingdom consist of only the telecommunication services, whilst in the other three countries they include mail and postal services as well. Consquently the four data sets cannot be easily compared and should be regarded as four different case studies.

[9] Business services in the United Kingdom include activities such as Legal services, Accountancy services, Other Professional services. Advertising, Computing services, Other business services, and the Renting of movables, respectively in rows 107-108-109-110-111-112-113. The definition of the business service sector for the other three countries is provided by the respective country tables.

Table 7. Germany: conversion from the input/output classification into the NACE

	Germany NACE-I/O sectors	Germany: input/ouput
1	01/Agricultural, forestry a...	C1 + C2
2	06/Coal, petroleum and gas	C3 − C10
3	13/Ferrous & non-ferrous...	C16 + C17
4	15/Non-metalic and miner...	C13 + C14 + C15
5	17/Chemicals and farmace...	C9
6	19/Metal products	C18 + C19 + C20 + C28
7	21/Machinery	C21
8	23/Office equipment	C22 + C27
9	25/Electrical machinery	C26
10	28/Transport equipment	C23 + C24 + C25
11	36/Food beverages and tob...	C38 + C39 + C40
12	42/Textiles, clothing, leath...	C35 − C37
13	47/Paper and printing prod...	C32 + C34
14	49/Rubber and Plastic prod...	C11 + C12
15	48/Other manufacturing in...	C29 − C31
16	53/Building	C41 − C42
17	56/Repair and wholesale & r...	C43 − C44
18	59/Lodging and catering se...	C52
19	61/Domestic transportation	C45 + C46 − C48(B24 − B25)
20	67/Communication	C47
21	69a/Credit & Insurance	C49 + C50
22	74/Business services	C55
23	86/Non commercial services	C56 + C57 − C58

Appendix II: Complementary estimates

In order to appreciate the influence of specific sectoral effects, pooled regressions, within the limits of available time span, have been tested.

The pooled OLS estimates of equation (5) for communication services for the years 1985 and 1988 for Italy, 1984 and 1990 for the U.K, 1986 and 1990 for Germany and France provide satisfactory results:

$$(7.1.\text{ITALY})\text{Y} = 3.945 + \underset{(7.479)}{0.516\text{K}} + \underset{(3.567)}{0.473\text{L}} + \underset{(2.765)}{0.113\text{C}} + \underset{(3.389)}{0.231\text{DUM4}}$$

$R^2 = 0.949$; $F = 137.192$; (t of Student between parentheses)

$$(7.2.\text{U.K.})\text{Y} = -4.415 + \underset{(6.411)}{0.327\text{K}} + \underset{(5.479)}{0.444\text{L}} + \underset{(2.11)}{0.327\text{C}} + \underset{(3.081)}{0.680\text{DUM7}}$$

$R^2 = 0.931$; $F = 155.362$; (t of Student between parentheses)

$$(7.3.\text{DEU})\text{Y} = 3.945 + \underset{(3.389)}{0.151\text{K}} + \underset{(7.479)}{0.78\text{L}} + \underset{(3.211)}{0.152\text{C}} + \underset{(3.786)}{0.596\text{DUM2}} - \underset{(4.732)}{0.314\text{DUM18}}$$

$R^2 = 0.949$; $F = 147.162$; (t of Student between parentheses)

Table 8. France: consversion from the input/output classification into the NACE

	France: NACE-I/O sectors	France: NACE
1	01/Agricultural, forestry ...	S01 + S02 + S03
2	06/Coal, petroleum and gas	S41 + S42 + S51 + ...
3	13/Ferrous & non-ferrous ...	S09 + S10 + S11 + ...
4	15/Non-metallic and mine...	S14 + S15 + S16
5	17/Chemicals and parmac...	S171 + S172 + S1...
6	19/Metal products	S20 + S21
7	21/Machinery	S22 + S23 + S24 + ...
8	23/Office equipment	S27 + S34
9	25/Electrical machinery	S28 + S291 + S29...
10	28/Transport equipment	S311 + S312 + S33
11	36/Food beverages and to...	S35 + S36 + S37 + ...
12	42/Textiles, clothing, leat...	S43 + S441 + S44...
13	47/Paper and printing pro...	S50 + S51
14	49/Rubber and plastic pro...	S52 + S53
15	48/Other manufacturing i...	S54 + S48 + S49
16	53/Building	S55
17	56/Repair and wholesale & ...	S65 + S66 + S57 + ...
18	59/Lodging and catering s...	S67
19	61/Inland transport	S68 + S691 + S69...
20	67/Maritime and sea tran...	S71 + S72
21	65/Auxiliary activities	S73 + S74
22	67/Communication	S75
23	69a/Credit & insurance	S88 + S89
24	74/Business services	S76 + S77 + S78 + ...
25	86/Non market services	S90 – S98

$$(7.4.\mathrm{FRA})\mathrm{Y} = \underset{}{3.945} + \underset{(3.389)}{0.716\mathrm{K}} + \underset{(7.479)}{0.173\mathrm{L}} + \underset{(3.012)}{0.113\mathrm{C}} + \underset{(2.553)}{0.467\mathrm{DUM7}}$$

$R^2 = 0.895$; $F = 87.042$; (t of Student between parentheses)

The pooled OLS estimates of equation (6) for business services, provide the following results:

$$(8.1.\mathrm{ITALY})\mathrm{Y} = \underset{}{3.945} + \underset{(7.479)}{0.516\mathrm{K}} + \underset{(3.567)}{0.473\mathrm{L}} + \underset{(2.765)}{0.273\mathrm{BS}} + \underset{(3.389)}{0.231\mathrm{DUM4}}$$

$R^2 = 0.945$; $F = 137.0192$; (t of Student between parentheses)

$$(8.2.\mathrm{U.K.})\mathrm{Y} = \underset{}{-4.41} + \underset{(6.411)}{0.32\mathrm{K}} + \underset{(5.479)}{0.444\mathrm{L}} + \underset{(2.11)}{0.327\mathrm{BS}} + \underset{(3.081)}{0.68\mathrm{DUM7}}$$

$R^2 = 0.931$; $F = 155.362$; (t of Student between parentheses)

$$(8.3.\mathrm{DEU})\ \mathrm{Y} = \underset{}{3.945} + \underset{(3.389)}{0.151\mathrm{K}} + \underset{(7.479)}{0.78\mathrm{L}} + \underset{(3.211)}{0.280\mathrm{BS}} + \underset{(3.786)}{0.596\mathrm{DUM2}} - \underset{(4.732)}{0.314\mathrm{DUM18}}$$

$R^2 = 0.949$; $F = 147.162$; (t of Student between parentheses)

Table 9. The U.K.: conversion from the input/output classification into the NACE

	U.K.sectors	Input/output classification	NACE/ CLIO classification
1	Coal mining	03	210
2	Petroleum and gas	04	220
3	Metal ore mining	09	230
4	Other mining	13	290
5	Food products	57 + 58 + 59 + 60 + 61 + 62 +63 + 64 + 65 + 66	311 + 312
6	Beverages	67 + 68	313
7	Tobacco	69	314
8	Textiles	70 + 71 + 72 + 73 + 74 + 75 + 79+	321
9	Wearing apparel	78	322
10	Leather and products	76	323
11	Footwear	77	324
12	Wood products	80	331
13	Furniture, fixtures	81	332
14	Paper and products	82 + 83	341
15	Printing, publishing	84	342
16	Industrial chemicals	19 + 20 + 21 + 22 + 23 + 24	351
17	Other chem. products	25 + 26 + 27 + 28	352
18	Petroleum refineries	85	353
19	Rubber products	85	355
20	Plastic products nec	86	356
21	Pottery, china, etc	18	361
22	Glass and products	17	362
23	Non-metal prod. nec	14 + 15 + 16	369
24	Iron and steel	10	371
25	Non-ferrous metals	11 + 12	372
26	Metal products	29 + 30 + 31 + 32 + 33	381
27	Machinery nec	34 + 35 + 36 + 37 + 38 + 39 + 40 +41 + 42 + 43	382
28	Electrical machinery	44 + 45 + 46 + 47 + 48 + 49 + 50 + 51	383
29	Transport equipment	52 + 53 + 54 + 55	384
30	Professional goods	56	385
31	Other industries	87	390
32	Electricity, gas, steam	06 + 07	410
33	Water works and sup.	08	420

$$(8.4.\text{FRA})\quad Y = 3.945 + 0.616K + 0.273L + 0.261BS + 0.467DUM7$$
$$(3.89)\quad (7.479)\quad (2.011)\quad (2.553)$$

$R^2 = 0.895$; $F = 87.042$; (t of Student between parentheses)

Pooled estimates make it possible to account for outliers and hence obtain more reliable measures of the relevant output elasticities. The results show a significant robustness of the estimates and confirm that the high values of the output elasticities for both communication and business services were not influenced by sectoral asymmetries.

Finally, in order to appreciate the twin effect of the usage of both communication and business services, an interactive variable was

introduced to measure the output elasticity of the combined usage of the two key services. The following equation has been specified:

$$Y = a + bK + cL + d(C + BS) \tag{9}$$

where all variables are specified as in the previous equations and (C + BS) is the natural logarithm of the sum of C and BS.

Pooled OLS tests have been conducted on the same data set as in equations 6.1. through 6.4, with the following results:

$$\begin{aligned}(9.1.\text{ITALY})\ Y = {} & 3.945 + 0.516K + 0.473L + 0.273(C + BS) \\ & \quad (7.479) \quad (3.567) \quad (2.765) \\ & + 0.231\text{DUM4} \\ & \quad (3.389)\end{aligned}$$

$R^2 = 0.899$; $F = 187.82$; (t of Student between parentheses)

$$\begin{aligned}(9.2.\text{U.K.})\ Y = {} & -4.41 + 0.32K + 0.444L + 0.327(C + BS) \\ & \quad (6.411) \quad (5.479) \quad (2.11) \\ & + 0.68\text{DUMMY7} \\ & \quad (3.123)\end{aligned}$$

$R^2 = 0.941$; $F = 173.390$; (t of Student between parentheses)

$$\begin{aligned}(9.3.\text{DEU})\ Y = {} & 3.945 + 0.151K + 0.78L + 0.292(C + BS) \\ & \quad (3.389) \quad (7.479) \quad (3.211) \\ & + 0.596\text{DUMMY2} - 0.314\text{DUMMY18} \\ & \quad (3.789) \qquad\qquad (4.732)\end{aligned}$$

$R^2 = 0.969$; $F = 149.621$; (t of Student between parentheses)

$$\begin{aligned}(9.4.\text{FRA})\ Y = {} & 3.945 + 0.616K + 0.273L + 0.273(C + BS) \\ & \quad (4.763) \quad (3.876) \quad (2.987) \\ & + 0.467\text{DUMMY7} \\ & \quad (2.257)\end{aligned}$$

$R^2 = 0.895$; $F = 87.042$; (t of Student between parentheses)

These results confirm once more the stability of the estimates. The estimated parameters of the output elasticity of new combined variable (C + BS) are in fact consistent with the estimated parameters of the output elasticity of each separate component, i.e. respectively C and BS in each country.

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