Has the European ICT sector a chance to be competitive?

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Abstract:

The ICT sector is featured by technical progress, convergence and *systems integration*. This leads to risks of monopolization regimes at the core with higher competition regimes at the periphery. Moreover, some specific component of the system may be essential for its evolution. In particular, networking to some extent creates the system, while software (notably operating systems) is the "glue" which holds it together.

In this context, the European ICT industry is potentially smashed between the cost advantages of Asian countries such as China, and the inventiveness and dynamism of the US industry. The way out of this difficult situation is to create in Europe the conditions of restoring knowledge accumulation. By concentrating on an ambitious project of open source software production in embarked and domestic systems, Europe could reach several objectives: to make freely accessible an essential facility of networks, to stimulate competition, to help reaching the Lisbon objectives and to restore the European competitiveness in ICT.

Keywords: Information and communications technologies, industrial policy, competition regimes, knowledge based society, open source.

To try to answer such a large question in twenty pages should be considered as particularly temerarious, if not completely foolish. But it is worth the challenge because such an industry is very fascinating, due to its huge degree of technical progress, its pervasiveness in our modern life, and its development potential which, more than fifty years after the birth of the transistor, seems as great as ever.

We construct our endeavor in two parts: first we analyze the main features of the ICT sector and try to explain how it evolves. In the second part we present a proposal for a European industrial policy which could cope with the challenges to European firms raised by the ICT evolution.

Section I: What is the ICT sector?

Basically, the ICT sector includes the manufacturing and services activities which rely on the use of Integrated Circuits (ICs) and more generally electronic components, for the purpose of communications and information processing. This definition seems fairly reasonable but still raises borders issues. Is, for example, the medical instrument industry (scanners, IRM, radiography apparatus, etc.), which largely relies on ICs, part of the ICT sector? We can argue that its main purpose is information processing, but we can also say that the objective is to cure patients, as much as the purpose of the motor vehicle (which by the way uses more and more electronic devices) is to transport persons or goods. By the way, it is estimated that cars, which included 1700 $ of electronics per vehicle in 2001, will see this number raise to 2700 $ by the year 2008[1].

Seen from an “electronic perspective”, the ICT sector includes, in a broad sense, “assemblers” and “integrators” which manufacture systems used by end users, or other manufacturers or service providers. To give an example, the German car equipment manufacturer Bosch, can be also considered as an “electronic integrator”, which relies heavily on ICs for its production. The pervasiveness of electronic components in general, suggests that there are many of those “electronic integrators and assemblers” in various areas of the economic activity (car and aircraft manufacturing, medical instruments, toys production, etc.). Another important point is that the share of microelectronics (in particular ICs) embedded in these devices and systems, raises constantly since the early 60s. This share was estimated globally at 5% in 1960, 10% in 1980, 20% in 2003. This applies particularly to DVDs, flat screen displays, digital cameras, decoders where ICs can represent 50% of the equipment value[2]. Another figure to keep in mind is that presently 6 billion of electronic devices are produced each year, with an average 10% decrease in prices[3].

The leverage effect of ICs and their pervasiveness in the economic activity, can also been understood with market figures: it is estimated that the world semiconductors market is worth 200 billion $ and 3 million job places, the electronic devices (objects or systems) markets 1000 billion $ and 18 million jobs, and the electronics related services 5000 billion $ and 100 million jobs[4]. The semiconductor industry thus influences directly or indirectly an economic activity which is 25 times larger. This leverage effect hence cannot be neglected.

[1] Dominique Lemoine (2004) “Bilan Electronique 2003” Anvar, Paris, June.
[2] Ibid.
[3] JP Dauvin (2003), “Assises de la Filière Electronique et Numérique” French Senate, Paris, 11th June.
[4] Groupements Professionnels de la Filière Electronique et Numérique (2004) « Livre Bleu : »

The figures also suggest that a key element for the ICT sector’s definition rests upon the distinction between manufacturing and services. The official definition of ICT includes both, but may not take into account all the electronic systems we have mentioned. According to the European Commission and following a consensus adopted by OECD countries, the ICT manufacturing sector is defined as follows: office, accounting and computing machinery (NACE 30.01 and 30.02), insulated wire and cable (NACE 31.3), electronic valves and tubes and other electronic components (NACE 32.1), television, radio transmitters and apparatus for telephony and telegraphy (NACE 32.2), television and radio receivers, sound or video recording or producing apparatus and associated goods (NACE 32.3), instruments and appliances for measuring, checking, testing, navigating and other purposes (NACE 33.2) industrial process equipment (NACE 33.3). In the ICT service sector instead, the Commission has put wholesale of electrical household appliances (NACE 51.43), wholesale of machinery, equipment and supplies (NACE 51.64), wholesale of other machinery used in industry, trade and navigation (NACE 51.65), telecommunications services (NACE 64.2) renting of office machinery and equipment including computers (NACE 71.33) computer and related activities (NACE 72).

In most cases we will limit ourselves to this OECD definition, and also emphasize the role of electronic components. Nonetheless without fully entering the intricacies of ICT related sectors (medical instruments, electronic military or civil apparatus, measuring and testing devices) we will give some account of their evolution as well, if necessary. With the narrow definition of OECD, the European ICT sector is given in table 1.

Table 1: European ICT sector (OECD definition)

	ICT Manufacturing				ICT Services		
	Number of enterprises	Number of Persons employed	Turnover EUR million	Value added EUR million	Number of Persons employed	Number of enterprises	Turnover EUR million
EU25	88 720	1 771 106	398 258	358 564	4 989 106	618 638	1 232 842
Belgium	1 904	25 875	6 560	11 445	145 370	15 896	50 467
Czech Republic	740	65 697	3 697	684	43 031	18 220	1 965
Denmark	1 174	21 662	3 279	7 816	116 235	10 435	28 470
Germany	20 135	355 099	85 130	64 061	776 997	49 647	208 863
Estonia	40	6 104	129	110	6 806	1 180	698
Greece	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Spain	3 484	66 177	14 390	24 727	406 810	41 885	87 518
France	16 818	297 665	74 329	51 365	760 679	71 701	194 196
Ireland	4 548	37 276	26 294	2 649	33 790	3 805	12 073
Italy	8 655	179 453	29 759	40 596	586 034	106 297	128 417
Cyprus	3	83	n.a	454	5 749	368	787
Latvia	10	675	12	532	16 672	1 316	1 521
Lithuania	110	10 575	307	396	19 588	1 613	1 453
Luxembourg	64	1 347	147	1 254	9 960	1 782	5 638
Hungary	1 080	74 626	7 954	2 232	74 560	20 411	7 597
Malta	173	3 297	1 214	63	2 512	691	204
Netherlands	1 398	66 178	4 853	16 622	343 849	29 105	100 959
Austria	2 841	38 781	9 136	8 098	109 140	12 123	30 327
Poland	1 479	75 405	5 184	2 911	n.a	25 275	7 603
Portugal	743	21 494	3 867	4 567	76 935	7 310	15 954
Slovenia	243	n.a	928	351	n.a	2 673	1 623
Slovak Republic	184	24 428	840	731	31 801	1 896	2 375
Finland	7 251	47 814	26 663	5 791	86 621	7 558	20 856
Sweden	992	82 016	19 550	13 362	221 014	34 372	47 859
United Kingdom	14 650	269 379	74 037	97 749	1 114 953	153 079	275 420

Source: *EUROSTAT, New Cronos 2003.*

We can observe that the service sector represents roughly 80% of the total sector. Noticeable is also the leadership of the UK in ICT services, both in terms of number of firms, personal and turnover. However, this may be due to statistical definitions on which no precision is given in the original source.

Section II : A complex sector

From an economic point of view, ICT is a very peculiar sector, because it exhibits a lot of features which make the unfolding of competitive forces particularly difficult to analyze and hard to predict (§1). Moreover the sector itself is subdivided in several sub-sectors, each of which exhibits specific elements of evolution (§2). Finally, there are linkages between each sub-sector. Taking as examples the Internet and GSM, we give evidence of how complex is the dynamics of this sector (§3).

§ 1 Features of the ICT sector as a whole.

Some key elements feature the economic evolution of this sector:

- Very *high* and very *predictable technological progress* in ICs (Moore’s Law). It gives the opportunity both to newcomers to quickly enter the market, and to entrenched leaders to keep their competitive advantage nearly indefinitely. In the theory of innovation, the first situation is referred to as “Schumpeter Mark I” while the second is nicknamed “Schumpeter Mark II” (see for example Nelson and Winter, 1982, Malerba and Orsenigo, 1996). Schumpeter Mark I is synonym of “innovation as creative destruction” while Schumpeter Mark II means “innovation as creative accumulation”. Whether the sector or some sub-sector of ICT industries evolves along the Mark I or the Mark II regime, is particularly important to know, not the least for antitrust motives. The evolution towards an innovation regime, Mark I or Mark II, may be due to specific technicalities; for example designing DRAMs is less complex than designing a microprocessors because it is the simple repetition of a basic motive; thus entry should be easier in this sub-sector. But other factors, for example on the demand side, may also influence the innovation regime.
- The service but even more the manufacturing ICT sector have been subject to *fluctuations* in their activity during the last years, and this may possibly come back in the future. To give an illustrative figure, the telecommunications equipment market has dropped from 120 to 60 billion $ within two years between 2000 and 2002. These fluctuations are not specific to ICT and reflect the presence of high sunk costs (R&D, infrastructure, marketing and advertisement expenditures). They give advantages to large incumbents which have “deep pockets” to go through temporary financial difficulties.
- The *systemic nature of innovation*; the latter, in order to be successful, may require the presence of complementary assets. For example, the failure of EMI, the inventor of the scanner, to be the market leader in the 70’s, is explained by the difficulty for this company to get access to decision makers in American hospitals and the Congress. This difficulty has allowed well entrenched competitors (in particular General Electric) to catch up and overcome EMI (Teece, 1986). In that case, Schumpeter Mark II may prevail on Mark I: incumbents controlling key complementary assets can maintain their position in front of innovative new entrants. Sometimes the complementary assets may even be “non market”, involving institutional mechanisms and rules. For example, the motor vehicle industry had a chance to develop in the beginning of the last century because public authorities built up roads with signaling panels, wrote Highway Code, certified driving licenses, etc. Hence the evolution towards Schumpeter Mark I or Mark II may be conditioned by the interrelatedness between market and institutional evolution.
- The *interplay,* as in many “high tech” industries, *between public and private research*, that is “open” and “protected” knowledge creation: For the latter to be successful, one needs to publicly subsidize “open” research, because both are complementary (for further details, see D. Foray, 2002). This case is another example of relationships between market and non market mechanisms, but upwards from the competition process, in the research and innovation phase. An outstanding example of such interplay is provided by *dual technologies,* that is technologies which are developed for military purposes (and paid for by the budget of a government) and later extended to civil uses, endowing the subcontractors with a strong competitive advantage. Examples abound of such technologies: computer reservation systems, Internet,

Teflon (in the material industry) are some of them. The USA are particularly strong at exploiting dual technologies.

- The key value of *user/ producer interactions* (Von Hippel, 1988), particularly in the early phases of the innovation process. This has led some authors in particular M. Porter (1990) to claim that one of the key factors for success is the proximity of manufacturers and users, namely a large home market. Dual technologies are an example of such interactions, but Internet and the evolution of computer science have strongly widened the scope of users promoted (or even created) innovations: the World Wide Web, Linux and LaTex, are well known examples of the users creativity.
- The importance of *networks effects*, particularly but not only in the communications sector. These effects may boost innovation, as we can see with Internet diffusion. On the other hand, network effects may sometimes delay it by protecting an older technology, as can be seen from the non diffusion of HDTV[5]. This phenomenon is well known in the economics of standards literature (see for example Katz and Shapiro, 1985, and also Rohlfs, 2001) and may lead to a Schumpeter Mark II instead of Mark I regime.
- Finally, in the manufacturing ICT sub-sector as a whole, the issue is raised *whether production plants can be maintained in industrialized countries*, in particular the European area. While this problem of foreign investment is not new, it has become a real issue with the quick development of India and China in the ICT related activities. To give some example, ICT’s share of imports and exports represented respectively 12.1% and 12.3 % of total manufacturing imports and exports of China in 1996. In 2003 the figures where respectively 26.8% for imports and 28.1% for exports[6]. China in 2003 represented 16% of the world production in electronic devices manufacturing, but this proportion may rise to 40% in 2010. For India, the share of exports accounted for by the computer service sector only, represented 20% of India’s exports in 2003[7]. This means that not only production but also research centers may be moved in Asia and Pacific area. This obviously has major consequences on the future of the European ICT sector and on an eventual European policy.

Thus, to use the dialect of mathematician economists, the ICT sector exhibits plenty of “non convexities”. The same mathematician economists would deduce from this observation that a market equilibrium, if it exists, may not be optimal. To put it in simpler terms, the competitive process will be difficult to understand, because it is highly dynamic and includes elements which generally are not part of competition. Moreover it is not sure that the competitive process will lead to a stable competitive equilibrium. Instead, some form of monopoly or oligopoly could emerge, because of the “non convexities” mentioned above. For example with Internet and the instant worldwide diffusion of information related services, network effects combined with sunk costs and user/ producer interactions, triggers a “winner takes all” effect, which, in the recent past, has benefited to companies such as e-Bay, Amazon or Google and Microsoft as well. Hence this global effect may either promote Schumpeter Mark I or Mark II innovation regimes. Finally one could say that a market equilibrium, whenever it exists, may be completely unfavorable to European firms or manpower. The question may be raised of the validity of a European policy in this sector, and of the contours to give to it.

[5] For a full and illuminating discussion of network effects, see Rohlfs (2001). A more theoretical perspective is provided by O. Shy (2001).
[6] See M Katsuno (2005)
[7] See S. Dutta (2004)

But the ICT sector is not an homogenous sector, on the contrary, and to fully understand it, one has to describe the features of the single sub-sectors.

§ 2 Specific competition regimes inside ICT

Actually, the above mentioned list of features does not apply to the single sub-sectors (computer and software manufacturing, communications equipment manufacturing and services, media equipment manufacturing, content production). Each of them is subject to what one of us calls a *competition regime* (Genthon, 2004). By this we mean that each sub-sector encompasses some of the features listed above, but may include other specificities as well. This makes the analysis even more difficult.

- With predictable technical progress (Moore’s Law), the *ICs industry* has had a competition regime which has evolved from a Schumpeter Mark I type of competition, towards Schumpeter Mark II. This stems from the fact that each generation of ICs requires the building up of new factories and the investments become higher and higher (two to three billions dollars a plant, one billion of R&D costs for each generation of semiconductor). Therefore there is, among manufacturers, a consensus about the so called “ITRS Roadmap”. ITRS is an international consortium of major players in ICs which conducts a collective thinking about future technologies and production methods. Innovation becomes common knowledge and the very source of competitive advantage relies in the degree of risk that each manufacturer is ready to take, in which product it specializes and to which privileged market it has access. In synthesis, the ICs industry becomes more and more a “cartelized” sector, where innovation, still the engine of growth for this activity, is monitored by a “club” of manufacturers which controls the development pace. This does not prevent price and production cycles, particularly in the DRAM segment, but at least reduces their amplitude.

Table 2: The ITRS “Road Map” for the next 15 years

First year of production	2004	2007	2010	2013	2016	2018
Minimal dimension DRAM (10^{-9} m) Microprocessor(10^{-9} m)	 90 37	 65 26	 45 18	 32 13	 22 9	 22 7
Alimentation (Volt)	0.9/1,2	0.8/1.1	0.7/1	0.6/0.9	0.6/0.85	0.5/0.7
Frequency (GHz)	4.1	9.2	15	22.9	39.6	53.2

Source: Lemoine (2004)

- The *computer manufacturing industry* has benefited from the downsizing of hardware, which now provides to billions of single users in a PC, a computing and storing power unbelievable for “mainframes” in the early 90s. The industry is now featured by vertical disintegration (Groves, 1997) and the so called “Wintel” paradigm, which dominates the PC industry: Windows operating system and Intel’s microprocessors feature most of PC’s worldwide[8]. Such domination is a consequence of a network effect which gives to an old technology a decisive advantage against any innovative

[8] Intel has a challenger, AMD, but still remains the market leader.

newcomer (a Schumpeter Mark II regime). In the core business of Microsoft, the operating system, there has been no challenger so far: UNIX, once supported by AT&T, Sun, or even Digital Equipment did not live to the expectations. The only challenger having emerged in the recent past, is the users promoted Linux, which by definition does not belong to any manufacturing company. To some extent, competition to Windows is thus "virtual". In the hardware segment, after the success of Dell relying on e-commerce, the market is stabilizing around a bunch of "Wintel" subcontractors. The withdrawal of IBM and the emergence of Chinese manufacturers is the revelation that industry becomes a "commodity" industry where PCs are produced at low cost in China or India. Distributors will thus establish commercial relationships with these low cost manufacturers in a form analog to those of major textile or clothing firms which get their products from the same producing areas.

- The *software industry* is again dominated by Microsoft in the domain of productivity applications (office "suites"), while there is a bit more of competition for company specific software, in particular ERP (Enterprise Resource Planning) where the market is split between the leader SAP and its main challenger, Oracle/ Peoplesoft. The same applies for e-commerce software, where there is no clear market leader, even not IBM. Generally speaking, the software industry is featured by high sunk costs (both of R&D and marketing) and low production costs. This leads to a few numbers of competitors, which have a capacity to innovate and market new products with high distribution and advertisement budgets. Therefore, a company like Microsoft, which holds a lot of cash (around 40 billion $) may be in position to sustain "wars of attrition" against competitors, provided its product development quality is not far below theirs. This attitude has been exemplified recently in several market segments such as browsers, or media interfaces for the Internet. Here again, Schumpeter Mark II has a strong probability to prevail, particularly because on the demand side, network effects rely on "ascending compatibility": the strength of the "installed based", gives advantage to the market leader. And monitoring a regular software renewal by end users, secures in the long run, revenues to this leader.
- The *communications services sector* has been featured by competition since the deregulation established at the end of the 90s in Europe and in most parts of the world, in the mid 80's in the US, Japan and the UK. Competition is tightly controlled by regulation authorities, since the previous monopolies still hold a dominant position in their market: The bulk of the infrastructure is their property, and access to it is an "essential facility" for their competitors. Moreover, in mobile telephony, competition is limited by the scarcity of radio frequencies and the large amount of investments that operators have to bear in order to install equipment[9]. Therefore, the operators have strong incentives to extract consumer surplus from mature technologies (such as GSM in Europe) before launching next generation systems. In the more traditional fixed network communications, telephony is today threatened by the emergence of Voice on IP (VoIP), potentially making their infrastructure (the switching equipment) and their tariff policy (time dependent tariffs) completely obsolete. Since fixed telephony still represents 45% of operators' revenues[10], the long term position of traditional operators may be really endangered and their size reduced, with further concentrations likely to occur in the short-medium term.
- The dynamics of the competition regime triggered by IP technology will lead to *integration* between access providers and infrastructure owners. In fact, the weakness of the sector has been revealed during the burst of the financial bubble: it has been

[9] Mobile Virtual Network Operators (MVNO) which have appeared recently,
[10] This figure is taken from the French market estimates.

originated by the absence of coordination between ISP (Internet Service Providers) and backbone operators. The latter invested heavily in fiber networks while the access providers could not deliver services accordingly, because at the same time they were caught in price wars and had no access to the technology (ADSL) which would have made the most of the access to fiber transport networks. As a result, many companies went bankrupt. The only successful exception to this vertical integration scheme in Europe is Tele 2. However this company earns mainly its profits from fixed telephony business, where margins are much higher than in Internet access segment, since tariffs are time dependant and the network has long been amortized. Moreover the control established by regulatory agencies makes it sure that access tariffs to the incumbent operator’s network are “fair” and benefit to competitors as well as to the service providers. However, with the likely decrease of fixed telephony due to VoIP, one can expect that Tele 2 will also invest heavily in capacity. In any case, telecommunications operators are presently prevented from evolving to a Schumpeter Mark II regime or at least to a “cartel” regime, thanks to the action of the regulators; otherwise all other factors would push in that direction.

- In the *telecommunications and network equipment manufacturing* sector, the impact of the bubble as well as the diffusion of mobiles and IP related technologies, have transformed the industry in depth. In the pre-internet era, the bulk of competitive advantage was an ability to transfer the advances in ICs and computing power into capabilities of equipments specifically designed for the telecommunications carriers needs. But the sudden diffusion of IP related technologies in particular during the bubble, has overwhelmed this competition regime. The key of competitive advantage is no longer good connections with operators, but an ability to sell quickly evolving equipments (the so called routers and fiber optics) to a host of rapidly expanding new entrants. Telecommunications manufacturers proved to be particularly slow to react to these new market conditions, and newcomers, in particular Cisco and to much lesser extent Newbridge, took the lead. The traditional telecommunications equipment manufacturers (Alcatel, Ericsson, NT, Lucent or Siemens) had to rely on the mobile market to maintain their profits, but there they had to struggle with aggressive outsiders such as Nokia, Motorola, Samsung which had invested earlier and in a more consistent way in this promising new business. As a result, we can say that the equipment manufacturing industry sector has evolved towards a Schumpeter Mark I, that is a more competitive regime.
- *Internet applications* have blossomed during the “Internet bubble” and some of them have survived the bubble burst. Some e-commerce applications such as online booking of transport tickets, or buying PCs on the Net, or second hand objects auctions, have really been successful. But the bulk of applications (80%) come from the market of business to business relationships. Although the “electronic marketplaces” such as Covisint have not been profitable, many business to business relationships which preexisted to the Internet diffusion, have been eased and their cost reduced through the use of Net. The latter has, in this context, to be seen in a broader perspective: it is only part of corporate digitization geared towards an efficient customer response. This diffusion of Internet applications in the business sector does not provide major upheaval in the software industry. The point is that business are heterogeneous and therefore local (geographical) factors as well as a good knowledge of and connection with the customer’s business are part of the competitive advantage and create local barriers to entry. Other characteristics of the software industry including sunk costs, are on the other hand still valid. It is thus no surprise to observe a concentration movement in this industry, which enables the companies to preserve their competitive

advantages linked to the demand side (specificities provided by local or customer’s business elements), while not losing ground on the supply factors (sunk costs).

The impression that results from this sketchy description of ICT sectors’ competition regimes, is rather mixed. There are common trends (e.g. technical progress in ICs, increased *connectivity* hence increased network effects) but each sub-sector seems to require a specific analysis. Some evolve towards a Schumpeter Mark I (consumer electronics, telecom-munications and computer manufacturing) while other move towards a strong (operating systems, application software) or a weak (telecommunications services, ICs) Schumpeter Mark II regime. It would be erroneous however to assume that these evolutions are independent, as we will see now.

§ 3 Dynamics of the ICT sector

To make the things even more complex, one has to notice that there are linkages between ICT sub-sectors, which influence their competition regimes. These linkages are likely to be increased in the future, exemplified by the buzzword “convergence. It is thus important to clarify this, because it is one of the key elements explaining the dynamics of ICT.

A- The issue of convergence

We have now communications capabilities in cars, computers, and possibly TV sets. We can retrieve information from the Internet with the help of a computer, a mobile telephone, a TV set, a digital assistant. We can look at films on TV or computer screens, in a car on a videogame station. Technology seems to bring convergence in usage of devices embedding similar electronic circuitry. We can thus speak of a genuine *technological convergence* as well as a convergence in usage (Rallet, 1996). But the impact of those broad trends on the evolution of firms and markets is far from clear.

As Greenstein and Khanna (1998) have put it, convergence may occur “in substitutes” or “in complements”. In the first case, the devices substitute each other in accomplishing the same task, as is the case for seeing a film on TV or a computer screen. Competition may thus be enlarged to a wider market: we may move towards Schumpeter Mark I. In the second case, the devices complement each other to provide better or new usage opportunities. Internet for example has been the outcome of complementarities between computers and telecommunications networks. However this complementarities may either lead to Schumpeter Mark II (because incumbents rely on their complementary assets to implement the innovations stemming from the convergence and therefore increase their market power), or to Schumpeter Mark I (because new entrants holding complementary assets, bite in the market shares of incumbents with new products).

Greenstein and Khanna moreover emphasize the point that some complementarities at the manufacturing level may lead to substituability at the usage level. For example interconnecting the mobile and fixed networks has enabled to provide new services to the consumer and help complementarities. But now some of them react by substituting the fixed telephone with a mobile one. This interplay between substituability and complementarities makes it difficult to predict how competition regimes will evolve. One simply knows that any perturbation in well established competition conditions (and technological convergence might be a big perturbation) leads to a new competition regime. But the features of it may be difficult to grasp.

In the case of ICT some factors favor Schumpeter Mark I while others help Schumpeter Mark II, as we have seen above. But institutional factors may also impinge on this evolution. Let’s think for example to mobile telephony: it is clear that the decision to open the market to three or even four competitors while retaining only one standard, was a political decision which has strongly helped the success of GSM in Europe in the 90’s.

The transition from one or several competition regimes to a completely new one may thus be influenced by a form of *institutional convergence*: if for example, media regulation is carried out in the same fashion as telecommunications regulation, the rules of the game might influence the media/ computer convergence. With this background in mind let’s examine now the linkages inside the ICT sector.

B- Patterns of linkages in the ICT sector

To begin with, ICs create naturally linkages because their constant increase in performance has to be exploited effectively. Hence assemblers and users of ICs have to embed each new generation of ICs as quickly and as effectively as possible. This happens now since the 50’s, and the linkages are well established. But technical progress in ICs means also that the latter become systems and assemblers buy them “off the shelf”. It is no longer advantageous to produce one’s own ICs, given the risks connected to their production. As a result, assemblers and integrators have divested from the business of ICs production: Motorola, Siemens, IBM are cases in point. But for new products, some collaboration or “quasi vertical integration” between IC producers and assemblers may be necessary.

Linkages downwards in the ICT value chain are much more puzzling. For example some of ICT sub-sectors have had or will have a dominant influence on the evolution of the sector as a whole[11]. This occurs simply because these sub-sectors have grown or are growing more quickly. They have thus influenced or will influence temporarily the evolution of other sub-sectors through complementarities and substitutability, while being hardly influenced by them. We will call them *current dominant segments*. As a result, linkages among ICT sub-sectors may not be symmetric.

For instance the *PC* has been in the 80’s the leading ICT product sold all around the world and has clearly been established as a *dominant segment*. Its diffusion has conditioned the evolution of the whole ICT sector, up to the mid 90’s. New applications and usages have appeared such as word-processors and spreadsheets, file transfers and workflows, local area networks, where Novell was once the market leader, Internet (that is, a very wide area network) which has enabled information retrieval[12] and written communication, etc. The PC has initially provided complementarities with telecommunications services, testified by the worldwide success of Internet. Nowadays however, the PC market seems, technologically speaking, to have reached a maturity stage, although it is still expanding in terms of market penetration. Its influence upon the whole ICT sector is thus being curbed.

[11] We leave aside the ICs the influence of which has always been there, but in rather predictable terms (see above § **)

[12] It is important to note that the attempts to bypass the PC in providing connectivity have failed. This was the gamble of Network PC promoted in the mid 90’s to avoid Microsoft’s licences.

In the mid 90’s *mobile telephony* has taken the lead, and for a time played the role of a dominant segment, at least in Europe. The evolution of digital systems towards “2.5G” (Edge, GPRS) and 3G (UMTS) provides new opportunities for market and usage expansion, while at the same time giving an impulsion to convergence with Internet. Hence the product and its derivatives will create some convergence on usage. Will it still be a dominant segment in the next years? The answer is probably no, because there are a lot of uncertainties surrounding the diffusion of 3G systems, partly due to economic conditions (the burst of the Internet bubble), partly due to institutional factors (the high price of auctioned frequencies). In any case, the diffusion of 3G mobile telephony will strengthen complementarities with networked computer services, in particular those linked with Internet. On the other hand, the continuous expansion of mobile services provides a further threat on fixed voice services. Here again, competition may be increased. A by-product of this may be “pervasive computing”, that is the systems which may be installed to enable people wearing electronic devices to be able, at any moment, to communicate, retrieve information conduct transactions and more generally interact with the “electronic environment” they go through. The features of this “pervasive computing” are still to be established. So we cannot say, for the moment, that it will constitute a dominant segment in its own right. But it might become one.

Since the beginning of this millennium, *consumer electronics* has a revival and offers new opportunities both for convergence as well as for extension of its usage. The success of videogame stations, digital cameras, home video and now terrestrial digital television provides a framework for home based ICT products in the context of leisure. It creates opportunities for complementarities *and* substituability with computers and networks. It also creates opportunities for manufacturing in low wage countries, in particular China, and broadens the scope for competition. Schumpeter Mark I competition regime may thus feature this evolution in the production of the electronics devices. On the other hand, Schumpeter Mark II may emerge because of the provision of connectivity to all these electronic devices. In fact one does not know yet how the “home area network” will work. So we don’t know yet if consumer electronics will be the next dominant segment, and if this happens, we don’t know whether this will favor Schumpeter Mark I or Schumpeter Mark II competition regimes.

On the whole, ICT has been experiencing at least three or four important life cycles since 1980, each of them having brought or bringing, during its initial phase, a more competitive competition regime. In the next future, there may be two candidates for being the future dominant segment, home systems associated with the development of consumer electronics and pervasive computing linked with the diffusion of mobile technology. The following table gives a nice picture summarizing the linkages within the ICT sector across time:

Table 3: Linkages in the ICT industry

	System Centric (1964-81)	PC Centric (1981-94)	Network Centric (1994-2005)	Content Centric (2005 -?)
Main users	Business	Professional	Consumer	Individual
Technology	ICs	Microprocessor	Bandwidth management	Embedded Software
“Laws”	Grosch	Moore	Metcalfe	
Network focus	Data center	LANs	“Best effort”	“seamless interconnection”
Supplier structure	Vertical integration	Horizontal integration	Competition and cooperation	?
Supplier leadership	US systems	US components	Carriers and access providers	Content providers

Source: adapted from Low(2000)

It is necessary to give some explanation about the “laws” stated in the table above. Robert Grosch stated that the computer power increases as the square of its cost. Moore’s Law has already been mentioned which claims that the ICs performance doubles every two years. Metcalfe’s law claims that the value of a network increases with the square of its connections. We could add to these “laws” that the size of information stored in digital form, which probably doubles every two years. The question mark in the supplier structure line means that industry could evolve towards more competition or monopolization.

The shift in demand conditions is to some extent linked to two basic features. Network effects and technological convergence in fact, have also brought *system complementarities*:

- Technologically, complementarities are obvious since they are grounded on *digitization*. The latter is the basis for technological convergence.
- From an usage point of view, the complementarities have been established with the advent and subsequent evolution of the Internet. The latter provides an interoperability platform for any exchange of information. Hence a very strong network effect has been unraveled.

Complementarities shape the evolution of ICT but do not preclude substitutability as we have seen. The latter is possible at the periphery, in the terminals and for some services (telephony and VoIP are a good example). Now, if consumer electronics becomes the next dominant segment, innovation will be featured by proprietary systems, hence substitutability with existing devices and more competition. Schumpeter Mark I will be part of the competition regime.

The same applies, to some extent, to pervasive computing. Embarked systems require specific and well conceived hardware and software, because of the technical constraints on energy provision, weight and robustness. Recently, several operating systems have been put on the market, such as Windows CE, Symbian, Palm OS, etc. This is a stimulus for innovation and competition, at least since no one has overwhelmed the others.

On the other hand, *systems integration* is particularly strong at the core (networks, servers) where interoperability is the key word. Therefore, the dynamics of ICT evolution provides both at the manufacturing and at the usage levels, real complementarities between the system components beyond their own life cycle. For example you cannot retrieve information from Internet on your digital assistant if you have not a physical connection to a wireless network (through Bluetooth, Wifi, Wimax or whatever standard is used). You cannot download a film on your computer if the server has no access to the digital database of a content providing firm (or peer!). The consequence is that *systems effects at the core interact with higher competition regimes at the periphery*. This integration is provided partly by IP protocols, but the more heterogeneous the services and the terminals, the more strain will be put on standard and protocols definition.

The systems approach may lead to recognize that some specific component of the system is particularly important for its evolution. Therefore, focusing on the control of this component might be enough to master many single value chains of the ICT sub-sectors. After all, it is thanks to its control of the PC’s operating system that Microsoft has been able to later be the key player in the production of generic software (office “suites”) as well as the conception of Internet browsers. The point is that networking creates need for a system, while software (in particular operating systems) is the “glue” which holds the system together.

In the case of “home systems” and consumer electronics, the network operating system may be the candidate for being the key component. Manufacturers have recognized while working on the so called UPnP (Universal Plug and Play) protocols. But there is yet no dominant design in the definition of home operating system. In the case of pervasive computing, the discussion sketched above on alternative embarked operating systems shows that this component is the keystone for embarked systems.

With these elements for understanding the evolution of the ICT sector, we can now open the discussion about a European ICT policy.

Section III: Designing a European ICT policy

In front of the complex ICT landscape presented in the foregoing section, the question may be raised whether designing a European policy makes sense. We have first to examine if the European situation requires such a policy (§1) and in front of a positive answer we will try to sketch its possible contour (§2).

§ 1 The European situation

The European situation is not particularly brilliant in the ICT sector, neither is it catastrophic. If we look at regional production and market statistics, we can indeed draw a mixed picture. Let’s consider first the electronics sector, namely the manufacturing side of ICT, plus other electronic systems (for car, aircraft and so on).

Table 4: Production in electronics sub-sectors

Total World	2002	2007	2002-03	2003-04	2002-07
Consumer electronics	204,6	271,0	4,5%	6,3%	5,8%
Computers	370,6	492,9	7,1%	6,3%	5,9%
Telecommunications	195,4	267,2	1,4%	8,5%	6,5%
Avionics, Space, Defence	89,3	109,4	-0,9%	3,7%	4,2%
Automotive	93,4	154,5	9,9%	12,2%	10,6%
Energy, Industry and Services	188,2	246,3	1,6%	5,0%	5,5%
TOTAL	1141,4	1541,3	4,4%	6,8%	6,2%

Source: DECISION - Nov. 2003

There are several distinct sectors which use ICs and that their evolution perspectives are quite similar. Consumer electronics, telecommunications and electronics (that is the three manufacturing sectors included in the OECD definition of ICT) represent 2/3 of total electronic devices manufacturing and this proportion could decrease to 60% by 2007. However the recent explosion of consumer electronics markets and the difficulties of car producers with electronics may lead to revise slightly this forecast.

In any case and because of the significant proportion of “non ICT” electronic devices in manufacturing, Europe is roughly at the level of North America both in terms of size and growth as the following table shows. In particular, growth of electronics manufacturing should be higher in the old than in the new continent. Such “good news” can be explained. In automotive industry and avionics, European firms are competing on a par basis with their American counterpart. And to do this, they embed more and more electronics into their products, which leads them to interact strongly with their suppliers. This user/ producer interaction is one of the key elements for competitiveness as Porter (1990) among others, has already shown. But the most striking feature of this table 5 is the extraordinary growth of China which should outperform Europe in market size in 2007 and North America in 2008.

Table 5: Production of the electronics sector by region

Production	2002	2007	2002-03	2003-04	2002-07
Europe	280,9	355,7	1,0%	5,7%	4,8%
North America	315,9	382,2	1,1%	4,2%	3,9%
China	186,3	360,8	21,5%	15,4%	14,1%
Japan	160,2	182,4	0,9%	2,3%	2,6%
Other Asia Pacific	154,0	187,0	-1,0%	4,8%	4,0%
Rest of the World	44,2	73,2	7,4%	10,6%	10,6%
TOTAL	1 141,4	1 541,3	4,4%	6,8%	6,2%

Source: DECISION - Nov. 2003

In terms of market size, North America remains the dominant market, and this means that its trade balance should be highly negative over the period. The European market, although growing quickly, will not catch up with North America before 2010, while the Chinese market could be comparable to both at that time. On the whole, we expect that China will, by the end of the present decade, be the major player in the electronics manufacturing sector defined in a broad sense. Europe, left behind by the big Asian country, will not be at a handicap compared to the US and Japan.

Table 6: Market for the electronic sector by region

Market	2002	2007	2002-03	2003-04	2002-07
Europe	328,7	410,6	2,3%	5,0%	4,5%
North America	399,5	487,7	2,7%	4,6%	4,1%
China	93,5	210,8	17,4%	22,5%	17,7%
Japan	137,4	163,2	1,9%	4,3%	3,5%
Other Asia Pacific	91,3	141,0	9,3%	8,7%	9,1%
Rest of the World	91,1	128,1	4,7%	5,8%	7,1%
TOTAL	1 141,4	1 541,3	4,4%	6,8%	6,2%

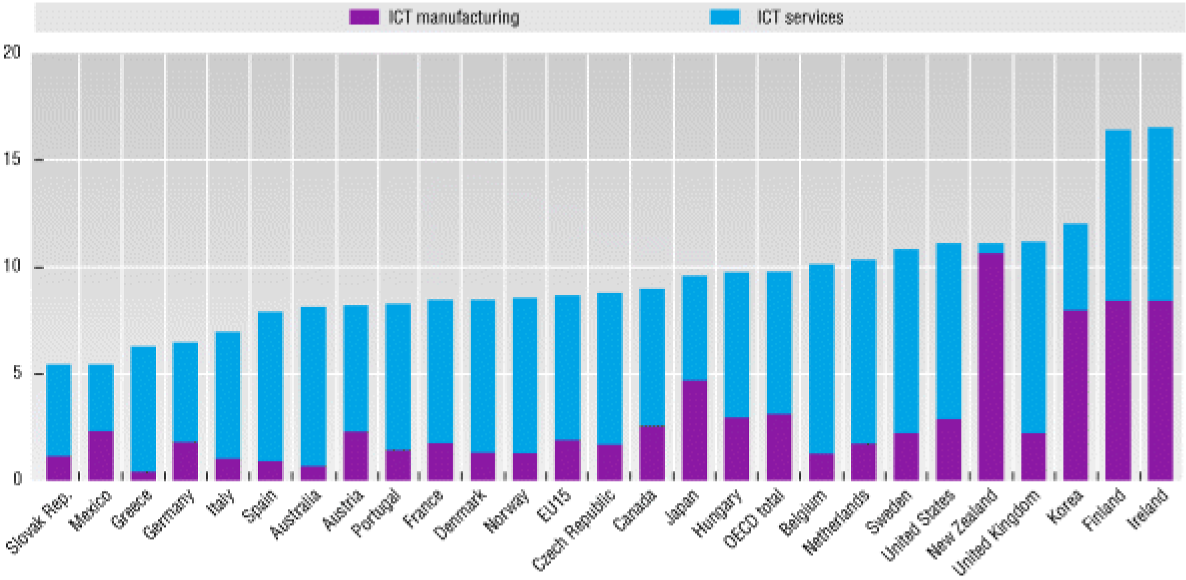
Source: DECISION - Nov. 2003

This table however, which focuses on the manufacturing sector only and broadens ICT to avionics and automotive sectors where Europe holds strong positions, might be somewhat misleading. We have to look to the service side, which is by far bigger than the manufacturing side (roughly four times). Hence the European position is more gloomy.

Picture 1 presents the share of the ICT sector’s value added in percentage of value added in the business sector. To some extent it measures the degree of specialization of the country in ICT. A couple of small countries, Ireland, Korea and Finland have this high degree of specialization. But EU 15 has reached an 8% figure, while the US is around 11%.

The emphasis put on the ICT sector is the result of a macroeconomic objective. The use ICT is considered as a part of a global strategy aiming at promoting new growth paths summarized by the concept of “Knowledge based Society”. The latter is supposed to rely on three pillars: innovation, use of ICT and education of manpower. Basically, this concept has been put forward and largely discussed within OECD. So if ICT is a component of the Knowledge Based Society, Europe lies behind the US in the way to this objective.

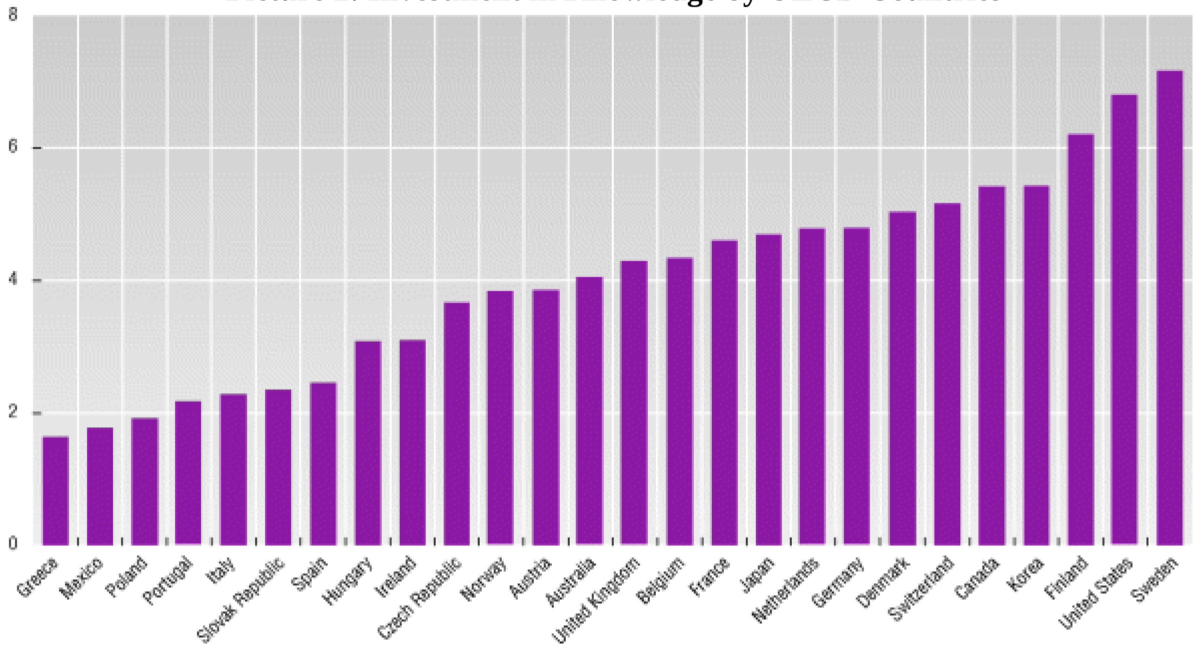
Picture 1: Share of the ICT sector in business sector’s value added in 2000



Source OECD Factbook 2005

On the other hand, the European Union has endorsed this target. In fact, the way towards the “Knowledge Based Society” is the very objective of the Lisbon agenda, and ICT, for the EU, plays a key role testified by the Commission’s “eEurope” Program. The figures of Picture 1 are thus not encouraging.

Picture 2: Investment in Knowledge by OECD Countries



Source OECD Factbook 2005.

Picture 2 confirms this, which presents a synthetic indicator of “investment in knowledge”[13]. This is defined as the sum of expenditure on R&D, on total higher education (public and private) and on software. The North American effort is matched by only a couple of European countries, typically Sweden and Finland and an Asian country, Korea. Most European countries in particular Germany, France and the UK, have an “effort” which is 30% lower than the American one. With respect to the OECD’s definition of “investment in knowledge” Europe spends only 4% of its GDP on such an investment, while the proportion is 7% in the US.

Even more concerning is the evolution of these expenses. For the sole R&D, the following table shows how much the European evolution is unsatisfactory.

Table 7: R&D expenses evolution

R&D expenses	1995	1998	2001
Europe (15)	124	143	175
Europe/US	88%	71%	56%
Europe/Japon	114%	138%	122%

Billions euros. *Source : OCDE*

[13] This includes expenses in R&D, software and higher education (University level).

If this table gives a bad picture of Europe for R&D, the situation is even worse if we look at R&D expenditures in the individual sectors. According to OECD, the volume of these expenditures of US private firms was in 1999 0.7 billion$ more than European ones in the pharmaceutical sector, 3.6 billion$ less in the automobile sector, 1.1 billion$ less in the chemical sector, but in excess of 7.3 billion$ in aerospace and, above all, of 28.7 billion$ in the ICT sector[14]. Several factors explain this overall gloomy situation:

- Economic factors: unfavorable macroeconomic conditions, but also network effects whereby leaders are likely to become leaders in the future. Then it becomes useless for a country to support its home industry if it has no chance to become a market leader.
- Institutional factors: absence of structural reforms leading to rigidities, difficulty of implementing systemic innovations due to the fragmentation of the European efforts, cultural factors, which, in some sense, are a form of long term institutional specificity.
- Sectoral factors: Europe does not lag behind in all the sub-sectors. We have several times emphasized the success of GSM, but the same does not apply to most of ICT products and services. In fact mobile telephony seems to be the only market segment where European firms, both in manufacturing and services, are world number one (Nokia for terminal manufacturing, Vodafone for mobile services). But it is well known that Asian manufacturers whether Korean (LG Electronics, Samsung), Japanese (Mitsubishi, Sharp) or even Chinese are catching up quickly, at least in the terminals segment.

The following table shows however that the situation has not worsened in all European countries.

Table 8: Evolution of the public expenditures in R&D in the ICT sector (100 in 1997)

Country	Index in 2003
Korea	233
Finland	185
USA	169
Spain	164
Italy	102
Germany	99
France	94
Netherlands	91

Source: CSTI on OECD data

Two things are remarkable in the table above. First, the countries which have had their public expenditures in R&D rising quickly, are those which are “catching up” to reach of technological capabilities similar to the most advanced countries (Korea, Finland, Spain). The second thing is that the USA are the only technological leader which increases the level of its public expenditures in proportion with the “catching up” countries. This means that there is a real challenge for Europe: will it be able to reduce the gap with the technological leader? Will it be in position to resist the overwhelming development of the Asian ICT sector?

§ 2 An industrial policy for Europe?

[14] See « Livre Bleu » (2004)

Because Europe’s position in ICT is not so good as one would wish, it is natural to think of a kind of “industrial policy”. The concept however is debatable and has been strongly debated[15]. An industrial policy is something which is not very popular at the EU’s level, for several reasons:

- First, this has been ignored by the “Founding Fathers” of the EU and therefore it is not in the Commission’s tradition
- Second, there always has been a divergence among European countries about the definition of such a policy. To take two countries generally considered as close one to the other on European issues: France’s governments have had, in the past, no shame in using the State’s power to help (French) private firms in well targeted sectors. German governments instead, prefer to speak about “Strukturpolitik”, namely policies designed to support any type of industries or firms. This help is furthermore often mandated to “Länder”.
- Third, the evolution of international trade and the globalization of companies make the objective of such a policy less and less obvious: Will it really help national firms or firms established on the nation’s territory?

However, in the case of ICT the urgency of public intervention at the European level is nowadays well acknowledged. For example, the “eEurope” program has been designed to target partly this objective. Focusing on an increase in the use of IT, it claims to indirectly boost the ICT manufacturing and service sectors. The same applies for the EU’s IST program which, within the 5th and 6th Research Framework Program, has been more concerned with an impact on the supply side. But if there is a consensus on the necessity for an intervention, its contour has still to be defined.

§ 3 The contour of a European industrial policy.

Let’s start from the evolution of ICT. The discussion of Section II suggests that a European industrial policy may have at least two options: a *systems approach*, similar to what has been done with GSM, or a *key component approach*, targeting a key element of ICT sub-sectors.

The former however is complex, difficult to implement in a community of 25 states, full of technological difficulties to solve, while uncertain in its perspectives. For example, if we compare GSM and UMTS for which this approach has been favored in both cases, we find very different results. In the first case it took eight years (from 1984 to 1992) to conceive the system, while in the second case the design period has been reduced to five years and as a result, the market introduction, imposed by a European Directive, has been too hasty. The end result is that ten years after the start of its conception, the UMTS still seems a gamble to most players involved in this business. Clearly, it is not that easy to define, from the outset, a system that will encounter a large success, be technologically flexible and improve the European manufacturing and service industries altogether. Moreover, interconnection becomes the rule in the IP world and designing an autonomous system which could be unfolded in the same way as GSM has been, seems nowadays less and less feasible.

We have seen that the consumer electronics and media content distribution could be the germ of a future “home based system”. But it is not yet clear which shape such system will have. In

[15] For a clear and comprehensive overview of industrial policy in the European context, see Pelkmans (2002)

particular, one does not know whether it will rely on proprietary systems. At the moment, most of domestic IT systems, having been designed by terminal equipment manufacturers, are proprietary. This explains in part why these systems have not yet really taken off. It might be the case that open protocols, IP based, will be established. There is the above mentioned example of UPnP already underway, which had been promoted by Microsoft (!) but gathers 300 of players including Sony or Intel. But as already said, at the moment the applications using this protocol have not yet been designed. Concentrating on a key component on the other hand leads in the present context to focus on software development, in particular in the area of operating systems, because it is the “glue” which holds the system together.

As said before, the markets have shifted away from PCs to mobile terminals and now consumer electronics and pervasive computing, while networking and interoperability are threading together these evolutions: demand for computers, mobile telephones, Internet access, digital TV, photo cameras, game station will share opportunities of interconnection, pervasive computing means that embarked terminal will interact with their digital environment, everywhere and every time. This will be guaranteed by at least two things:

- Interface standards and common exchange protocols
- Compatible operating systems.

In the present context, US firms or institutions dominate the evolution of these features: A private firm, Microsoft, masters or tries to master the whole chain of operating systems in PCs, mobile terminals, game stations (Xbox), Internet access. Similarly, US dominated standardization institutions like Internet’s IAB (Internet Advisory Board) and IETF (Internet Engineering Task Force) or Icann establish interface standards or common exchange protocols, or control access to scarce resources (domain names). Of course, there are differences between a private company, which owns proprietary standards, and Internet Protocols designed by IETF and IAB, which are open. But this domination simply reflects the greater competitiveness of the US firms in many software and hardware components, as well as the activity of US public institutions in standardization forums. This competitiveness is further increased by network effects underlying communications systems, and the systemic nature of innovations which are gradually embedded in existing complex systems and lead to “Schumpeter Mark II” innovation regimes. US institutions also help to strengthen US firms position by enforcing a very strong intellectual property rights regime, which has the consequence to preserve the interests of the incumbents and leaders.

Hence, to design a European policy that could reverse this trend does not seem very easy. It appears that given the present weaknesses of European firms both in terms of costs (vis-à-vis Asian firms) and inventiveness and system control (vis-à-vis US firms), Europe has no way to choose an original path. But there are few assets on which the European continent can rely. They are well known and have been identified by the European institutions when the “Lisbon Agenda” has been set up at the beginning of this millennium ([16]):

- Market size: After all it is a market of 380 million individuals, reasonably wealthy. This means that there is a potential for innovators to find customers locally and therefore to be helped in the design of their products.
- Collaboration between European firms and labs. There is a long tradition of such collaboration in many European countries. In Germany the Fraunhofer Institute, in

[16] See Dang Nguyen & Jolles (2005)

France the CEA (Commissariat à l’Energie Atomique) or Inria, in Italy the ENEA, and even at the European level the ECRC, are examples of public research centers which have long developed a tradition of cooperation with firms. While this is not exceptional when compared to the US and Japan, it means that public institutions can help in the process of knowledge accumulation and innovation.
- Education of manpower.
- Cultural tradition of knowledge distribution and sharing, mostly locally.

These trumps are not decisive however, since for most of these items Europe is superseded by the US as we have seen in §1 of this section. But in order for Europe to overcome its position of challenger in the race towards the Knowledge based Society, we can thread all these elements together and relate them to the open versus proprietary knowledge debate ([17]): If we let knowledge be “open” we encourage its dissemination. People having, by education or self apprenticeship, the capacity to assimilate this knowledge will be better off, and may even increase this “stock” of knowledge if they are inclined to do so. On the other hand, if knowledge is proprietary, people will have strong private incentives to accumulate this stock, but not to disseminate it. Obviously there is no clear cut answer to this debate, but we claim that the historical features of the European continent call for an institutional arrangement favoring the *open production of knowledge*. This would:

1. Enable European and non European firms to compete on a par basis. No restriction should be put on access to key complementary assets such as essential facilities, in particular intangible assets: software or knowledge in general.
2. Support projects and initiatives which make these facilities less dependent from restriction by the intellectual property rights owners. This applies in particular to the so called “open source software”, in particular Linux, which is gaining momentum and has already overcome the entry barrier created by critical mass[18]. Because Linux represents both an opportunity to establish in a sector (operating systems) where network effects and an installed base lead to monopolization, it brings a real opportunity for providing an alternative solution for embarked systems for example.
3. Stimulate producer/ user interactions, the importance of which has been emphasized when we discussed table 4 above. This could be done both locally and through inter-regional exchanges, but it has not always been the case. For example the European Commission has, in 2002-2003, launched the “Networks of Excellence” in R&D, the success of which has caught the Commission by surprise. Networks of several dozens of research institutions (private and public) have been set up, but the vision, assessment and evaluation of these networks in the context of the Research Framework Programs has still to be established. There is no mission assigned to these networks, the spill over effects of their activity in terms of “startup” creations, support of venture capital, etc are not really promoted and evaluated. In that respect, “free software” naturally encourages user/ producer interactions because the openness of the source code is a guarantee that anybody is potentially entitled to reveal the “bugs”[19].
4. A European Policy designed to favor “open” knowledge would also offer occasions for training young people in knowledge based activities and provide them with opportunities to make the most of their acquired knowledge through servicing and users and customers. There is a good chance that they will find customers, because

[17] Further elements on this debate can be found in D. Foray (2002) chap. 7.
[18] See for example Varian and Shapiro (2003)
[19] ibid.

there is locally an internal demand (residential but mainly business) in many parts of Europe.

Thus our vision of an industrial policy for ICT is that the European Union and its Member States should encourage the production and dissemination of open knowledge in general, with a strong emphasis on software, such as embedded and embarked operating systems. Those are the *key components* or *platform*s which enable connectivity between heterogeneous devices, helping innovators to design new and innovative services, while enabling the customer not to be captured by proprietary systems. Being accessible all across Europe, this knowledge capital could then be further exploited and enhanced locally by service firms, eventually creating jobs. The key point of our argument is that focussing on open interconnection platforms (or operating systems) has several advantages:

- As said before, European firms are in a challenger position and this strategy is well suited to a challenger: an incumbent has a strong interest to protect the source of its competitive advantage, while a challenger has to overcome a network and critical mass effect that benefits its main rival. This can be done essentially by making the source of this advantage shared with others in order to induce customers to move to a more competitive community of suppliers.
- From a public policy point of view, there are also two strong arguments: first, open knowledge will stimulate knowledge creation because many potential innovators will be able to exercise their talent from a common basis. Said in the words of section I, Schumpeter Mark I is supposed to be more effective, and encouraging open knowledge leads to Schumpeter Mark I: With a knowledge base similar across suppliers, each of them will be closely competitor with its neighbors. Hence it will have to construct its competitive advantage with different things such as complementary assets. In any case the “playing field” will be “level”.
- The second argument stems from the fact that an essential facility, a key interconnection platform, will be available without any restriction. Moreover, as emphasized by Varian and Shapiro, some open source software such as Linux has already reached a critical mass, thereby lowering the switching costs of users. Focussing for example on its implementation in embarked systems or in domestic networks, the market should thus develop easily if the corresponding products and services are adequate.

What then could be the contours of this industrial policy?

- First, guarantee that any software or program written with the European support in the framework of an “open source policy” is not protected by any property right. Instruments like the General Purpose License or any similar “copyleft” framework could be used for that purpose.
- Second, rely on the instruments already available in the present institutional arrangement. There is, at the Union’s level, the Framework Research Program, the Eureka initiatives which provide possibilities for joint public/ private partnerships and could help designers to write open source software for embarked operating systems. Specific actions in direction of small and medium enterprises could also enable them to serve customers on the basis of the “open” software freely available.
- Third, diffuse open source software in the e-government initiatives linked with the “eEurope” program.

- Fourth, encourage professors to teach, students to study and share open source software on a broad scale.
- Fifth, establish or support a certification body at the European level which could guarantee the quality of the software produced. In the creation of
- Sixth, invite specialty software producers and users to focus on applications that could be standardized in an open source framework. Consumer electronics and pervasive computing should represent an important target for such policy, for the reasons mentioned before: they are probably the future dominant sub-sectors in the decade to come. But whatever the market segment, the key point is to ensure that such software creates a critical mass of users that enables the market to develop freely.

Conclusion

In this paper we have tried to present the main trends of evolution of the ICT sector. Its dynamics, supported by a constant technical progress in ICs, compounded with “non convexities” such as network effects and high sunk costs, may either lead to a Schumpeter Mark I or Schumpeter Mark II competition regime. This means that in some segments, the market will be more competitive (Mark I), while in other it will be more monopolistic (Mark II). But a key trend is also the so called “convergence”. Digitization makes it cost effective to integrate different communications, information processing and entertainment systems and devices. Hence, Schumpeter Mark II grows at the core where software production dominates, while Schumpeter Mark I is established at the periphery.

In this context, the European ICT industry is potentially smashed between two forces. On one hand the cost advantages of Asian countries in particular China, threatens many of its ICT activities. On the other hand the inventiveness and dynamism of the US industry supported by powerful financing institutions, manpower flexibility and quality, and an active public R&D policy by the American government, leads to an increasing gap between the USA and Europe in ICT production and services. The way out of this very difficult situation is to create in Europe the conditions of restoring knowledge accumulation in a key sub-sector of ICT, that is software production. To do this, Europe can rely on its tradition of cooperation and knowledge sharing and on a set of institutions that have shown their ability to stimulate inter-regional cooperation.

By concentrating on an ambitious project of open source software production in embarked systems and domestic networks, Europe could reach several objectives: to make freely accessible an essential facility, to stimulate competition, to help reaching the Lisbon objectives and to restore the European competitiveness in ICT.

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