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THE ECONOMICS OF NEW INFORMATION AND COMMUNICATION TECHNOLOGY

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1. INTRODUCTION

Information and communication technologies (ICT) may be considered as a clear exemplum of the salient features and ingredients of a path dependent and complex process based upon an array of complementary localized technological changes. Indeed the path conducing to the generation and adoption of ICT emerged out of a collective and interactive process induced by relevant changes in the economic environment, which stimulated the creative reaction of an array of learning agents based in a fertile context characterized by effective knowledge governance mechanisms and positive feedback magnified by local externalities.

2. DETERMINANTS

Since the late 60s of the XX century, twenty years after the World War II, the US experienced a progressive erosion of its economic and technological leadership. The combined effect of the convergent catching up of competing countries, the international diffusion of mass production and science-based technologies (Nelson and Wright, 1992) and the exhaustion of technological opportunities in the chemical and engineering technologies determined a strong decline of US international competitive advantage and a productivity slowdown (Griliches, 1980). The decline of performances induced a myriad of interdependent, sequential and creative efforts directed towards the introduction of complementary technological innovations based upon the exploitation of locally abundant production

factors, the favourable conditions of use and access to large knowledge commons and localized learning processes (Antonelli, 1999).

The main result of such efforts has been the creation of a new technological system with a strong skill bias. In the decades following their introduction, ICT have been considerably improved upon, and slowly put on the features of a general purpose technology (GPT), with a high degree of fungibility, i.e. usable in many different contexts, high levels of complementarities and considerable spillovers. Along with the improvements, the diffusion of ICT across US firms stemmed from a process of sequential creative adoptions (Lipsey et al, 2005). The skill-bias of ICT is the result of intentional efforts directed to the introduction of a technology able to take advantage of locally abundant factor, such as academic skills in the US economy (Acemoglu, 1998).

3. ONTOLOGY

ICT are a typical Schumpeterian gale of innovations characterised by the increasing convergence between and the integration of a variety of localized innovations, generated in a wide range of industries and firms. In particular, such technological convergence is driven by the introduction of a number of innovations such as Internet services, enhanced broadband fibre optics, ADSL, digital TV and UMTS opening up the possibility of integrating over the same means a variety of contents, services, technologies and applications (Fransman, 2002). As a result ICT, and the related technological knowledge, are both composite and fungible. ICT are the outcome of the recombination of a variety of knowledge modules which cannot be fully commanded internally by the firm and requires the coordination of technological complementarities within the broad ICT technological system (Antonelli, 1999).

The integration of the array of interdependent, localized and sequential innovations, characterized by substantial indivisibility has been shaped by the implementation of: a) economies of localized learning due to the increasing specialization in specific technological areas, the advantages of network externalities and the gains from knowledge externalities; b) qualified user-producer and business-academic interactions; c) organizational innovations such as standardization committees technological platforms, technological clubs and alliances to improve the dynamic coordination of the wide range of actors, products and technologies into a single working system and hence the complementarity, compatibility and interoperability of the variety of new localized technologies (David and Steinmueller, 1994; Shapiro and Varian, 1999; Antonelli, 2001).

4. EFFECTS

The effects of the introduction of ICT have been powerful. The U.S. economy has been facing a new surge in productivity since the 1995. The ICT industry plays a key role in this context, with the rapid technological developments in semiconductor industry. The persistent and steep decline in the price of semiconductors has actually been transmitted downwards in the value chain, affecting the user sectors, mostly the producer of telecommunication equipments and software (Jorgenson, 2001). The productivity gains stemming from ICT are hence due both to increase of efficiency in upstream industries, and to the flows of creative adoptions in downstream sectors. ICT produced not only relevant knowledge spillovers to the rest of the system. Because of intense competition, the new upstream industries were unable to retain the full stream of benefits stemming from the new technology engendering a flow of pecuniary externalities (David, 2001).

The new US technological leadership engendered a new international division of labour which reversed the situation of the 80s. The U.S. quickly became the main producers and users of ICT, while the rest of the advanced countries is engaged in creative adoptions to adapt the technology to the idiosyncratic conditions of their factor markets and industrial structures.

Because of the strong directional bias of ICT a clear digital divide is emerging between countries 'properly' endowed that have the 'right' amount of human capital and access to knowledge commons, and hence able to participate into the process of cumulative technological change and creative adoption, and countries that can, at best, adopt passively with lower chances to take advantage of the new opportunities for productivity growth. ICT are global in character because it brings about such increases in productivity and efficiency that its adoption is profitable in a great array of products and processes, and regions. Nevertheless, asymmetric effects stemming from the strong skill bias and the different endowments of human capital must be accounted for (Antonelli, 2003).

Since the early '90s the adoption of ICT made possible the emergence of global corporations based on distributed coordination processes selling worldwide customized products, manufactured and assembled in a variety of regions, while retaining in home countries skill-intensive activities. This trend is especially evident in the new service industry and in particular in the new knowledge-intensive-business-service sector (Dunning, 1993).

The specialization in new knowledge-based services that rely heavily on the quality and variety of advanced digital communication characterizes the transition to the new knowledge economy in advanced countries. ICT are increasingly relevant for a wide scope of knowledge services that range from entertainment to health and financial services to education and logistics. The advent of digital technologies changes the context in which knowledge-based services were traditionally supplied. ICT affect the condition of interaction in that they allow remote interaction between different actors, while in traditional services interaction, if any, implied physical proximity. ICT change the condition under which services are both delivered and used: interaction changes the way in which services are provided to final users. ICT are crucial also with regard to the way in which new knowledge services are utilised and contributed by final and intermediary users. Significantly enough, the development of open source software is the result of online interactions within the community of users, who create and implement new modules of the software (Von Hippel, 2005).

The complex nature of ICT, and the complementarity among different physical devices and platforms led to the identification of the notions of essential facility and economies of density. Their application to antitrust law led to the splitting of the Bell System. The separation between property and use rights is necessary when a facility, essential to other competitors, is owned by a natural monopolist. In this case the monopolist must provide reasonable access to the facility, if its duplication is not possible. Dedicated authorities have been established since the late 1980s to implement the right to interconnection, and mandatory access has become well established in antitrust law (Baumol and Sidak, 1994).

The introduction of ICT can be viewed as the cause and the consequence of the emergence of new financial institutions, like the venture capitalism and the related creation of markets dedicated to the transaction of knowledge-intensive property rights. Empirical evidence shows that the spread of VC has taken place during the 1970s and 1980s, in parallel with the ICT revolution. The wide scope for improvements and the large range of new technological opportunities engendered a strong increase in the birth of new high-tech companies based on VC to mitigate the traditional problems of credit rationing to innovative ventures. The strong demand for investment in ICT-based start-up favoured the development of the new VC industry (Gompers and Lerner, 2001).

5. CONCLUSIONS

In conclusion, the emergence and the evolution of the new ICT system can be seen as the result of the interplay between the strong idiosyncratic features of the context in which firms are embedded and the innovative strategies of the firms. Myopic firms characterised by irreversibility in their productive choices can face the mismatch between expectations and actual performances by means of creative reaction, building on their own localized learning processes, only when the structural characteristics of their environment are fertile and able to provide access to complementary knowledge commons. In those systems such as the US, and to a lesser extent the E.U., where human and technological capital, financial resources and high-skilled labour were abundant and accessible, firms could face the decline in performances of the late 70s and 80s with the introduction of an array of new technologies. The convergence between the localized efforts of a myriad of innovating firms led to the emergence of a radical innovation in a cumulative and self-reinforcing way. Where and when those systemic conditions are more difficult to find, such as in many developing countries, firms are more likely to be passive adopters of ICT, rather than innovators (Antonelli, 2007).

ICT represent a clear case of a path-dependent complex process based upon the complementarity of a myriad of localized technological changes. At each point in time the structure of the existing endowments, industries and regions and the networks of communication flows in place among innovative agents exert strong effects on their creative efforts so as to shape the direction and the rate of technological change. When effective knowledge governance mechanisms are in place, the result may be a sweeping gale of innovations (David, 2000 and 2001b).

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