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Accounting for the Impact of Information and Communication Technologies on Total Factor Productivity: Towards an Endogenous Growth Approach

(Executive Summary)

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Executive Summary

The renewed Lisbon strategy puts special emphasis on the role Information and Communication Technologies (ICT) could play in meeting the challenges of boosting growth, competitiveness and cohesion throughout the EU. In particular, the i-2010 objectives to promote the information society and the diffusion of ICT to strengthen the competitiveness of the EU economy have translated into concrete policy proposals in a number of EU policy initiatives. In parallel to these policy developments, extensive research has provided evidence regarding the positive impact of ICT on growth and productivity. It has shown the EU's relative deficit in this respect, in comparison to the US. Although ICT adoption and productivity impact has been especially vigorous in certain Member States (e.g. Ireland, Finland), this effect has still not materialized in most EU countries, see van Ark and Inklaar (2005).

There is a thus growing awareness in both policy and academic circles that relatively low ICT diffusion is partly responsible for the EU productivity deficit. Up until now, however, economists have essentially looked at the impact of ICT on productivity and growth in a neoclassical framework where ICT is assumed to be equivalent to other types of capital. Here, the amount of money invested in ICT is linked to productivity growth in a given economy. This framework of analysis is far too restrictive in the case of ICT, however. There are a number of reasons for this. In particular, ICT diffusion radically changes the way information flows. ICT diffusion also promotes interaction between economic agents though network effects. This means that the economic behaviour of a particular firm, industry or country, cannot be understood properly without considering the specific context within which its activity takes place. These two features tend to support the view that the deployment of ICT does not face the same constraints as traditional physical production factors. Hence the neoclassic framework is necessarily limited for an analysis of the impact of ICT on productivity. Importantly, from a policy perspective, the existence of interactions and spillovers in ICT diffusion suggests that the productivity impact of ICT may require ICT diffusion to attain a certain level (or critical mass) and that it must be accompanied by measures fostering knowledge creation and diffusion. These issues have been largely discussed in endogenous-growth theories (often termed "new growth theories"), although not in the context of macroeconomic analysis of ICT diffusion and productivity. This literature has tended to focus attention on identifying possible interactions, i.e. spillovers, in productivity and innovation dynamics. Up to now, however, these views have rarely been connected with the information society. Significantly, the existence of spillovers in ICT adoption suggests the possibility that ICT investment can be lower in a given country than the optimum from an economic viewpoint.

The current study provides a review of the literature on the impact of ICT on economic growth and productivity. It also contributes to the discussion on extending the neoclassical growth framework to incorporate elements of endogenous growth theories, in order to take this impact into account. **Sections 2 and 3** provide an overview of the traditional growth accounting framework rooted in growth analysis. This contribution and the many studies that have followed, have led to the conclusion that the drivers of productivity growth were largely unknown and embodied in Total Factor Productivity (TFP), i.e. the residual term explaining productivity growth once production factors such as labour, capital and intermediate materials, are accounted for. This highly unsatisfactory conclusion gave rise to new directions in research. For instance, Arrow (1962) launched the idea of a "learning device" incorporating the knowledge aspect of capital. Romer's (1990) extension of the Sollow's framework

introduced elements such as R&D expenditure and human capital accumulation. R&D, in particular, shares the characteristics of a public good in that the effect of private R&D expenditure of a given firm often spills over to other firms. For instance, a company which invents a new product or introduces new production methods thanks to its own research effort may expect its competitors to try to benefit and/or mimic the technological advances related to the corresponding innovation. This type of interaction in research and innovation activity is usually termed "research spillovers". It follows that, in presence of such spillovers, the social return from firm-level R&D may not be fully internalized in private agents' behaviour. The resulting situation, when considering the economy as a whole, is that the overall level of R&D may be lower than the optimum. Similarly to the R&D case just described, while the benefits of using ICT in terms of productivity are potentially large, the resulting aggregate use of ICT maybe too low to boost productivity significantly in a given economy. The presence of spillovers in ICT use may thus deter greater levels of ICT diffusion and, consequently, result in lower macroeconomic productivity and growth than what could be potentially achieved if these spillovers were taken into account.

Section 4 discusses the way ICT spillovers can be embodied in a traditional production function framework and discusses the impact of ICT on productivity growth when ICT-related spillovers are taken into account. This section also discusses possible interactions between ICT and elements such as human capital and R&D. Within this framework, ICT, seen as a product, is characterised by fast technological change and, as stated above, is likely to influence both the accumulation and transmission of knowledge. Hence, the relationship between ICT and productivity growth is likely to be more complex than, say, when considering traditional production factors. ICT is a general-purpose technology which means that the scope of application is wide, as are the variety of uses, and the number of potential improvements is high. Therefore, ICT takes time to implement, but it is also likely to lead to knowledge spillovers, faster diffusion and production of knowledge which are seen as decisive elements in generating long-term growth. It follows that, one would naturally think, ICT, human capital accumulation and research activity would interact in favour of greater innovative capability and higher productivity levels. Furthermore, the network-character of ICT suggests that the contribution of ICT capital to output as a direct factor of production exceeds its contribution to growth as measured simply by the variation in the ICT capital stock. The empirical results provided in this study show that ICT capital stock have indeed provided a significant contribution to productivity growth in a number of OECD economies with a 10% increase in ICT capital stock contributing to 1.3% annual average increase in productivity growth.

Section 5 summarizes the main lessons and findings of the study and addresses policy implications. In particular, the study provides arguments and empirical support for the idea that policies favouring ICT investment can create large economic benefits, due to the existence of large potential spillovers related to ICT diffusion. Because of the existence of network and spillovers effects, these benefits can hardly be directly perceived by individual firms taking investment decisions. However, these findings do not necessarily mean that higher ICT investment will yield greater productivity and growth levels. Indeed, existing microeconomic evidence suggests that the positive impact of ICT investment usually observed at the macroeconomic level is not systematic. The micro-literature tends to suggest that ICT investment is just one condition for greater productivity growth, and that much more is needed. A large number of microeconomic studies have shown that aspects such as skills, changes in business organisation and an innovation-friendly environment are all important components for promoting the effective impact of ICT adoption on economic efficiency, see

for instance, Bertschek and Kaiser (2004) and Aubert et al. (2006). While these elements are not considered in this paper, the results and arguments provided here show that the context in which ICT diffuse conditions to a great extent the impact of ICT on productivity growth at a the macroeconomic level. From a policy perspective, the question arises as to how the economy's structural features and framework conditions (including institutions) could influence the adoption and expected impact of ICT on economic development. In particular, considering the Lisbon strategy, better working factors and product (and services) markets must be facilitated in order to favour the emergence of innovative forms of economic activities (new businesses, new products and services, new production organization processes, new markets, etc.) and adoption of new technologies (among which ICT is prominent).