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# The ICT Revolution

## Productivity Differences and the Digital Divide

A Report for the Fondazione Rodolfo Debenedetti in Association with The William Davidson Institute

Edited by
Daniel Cohen,
Pietro Garibaldi, and
Stefano Scarpetta

THE WILLIAM DAVIDSON INSTITUTE
AT THE UNIVERSITY OF MICHIGAN BUSINESS SCHOOL

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*Edited by*

*DANIEL COHEN*
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*with*

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# *Acknowledgements*

Both studies (Parts I and II) were originally prepared for the fourth European conference of the Fondazione Rodolfo Debenedetti, which was held in Catania in June 2002. This book draws much on the discussion in Catania, which involved a qualified audience of academicians, professional economists, representatives of unions and employers associations, industrialists, and policy-makers.

Needless to say, we are very much indebted to all those who attended that conference and contributed actively to the discussion. In particular, we wish to express our gratitude to Lucio Stanca, Italian Minister of Innovation and Technologies, who opened the conference with an insightful speech on the ongoing policy initiatives in the area of ICT investments, and to Pasquale Pistorio, President of STMicroelectronics, who illustrated to the audience how the ICT miracle in the Catania area came about in the first place. Finally, Renato Soru, President and CEO of Tiscali Corporation added some very interesting remarks on the ICT revolution seen by a successful entrepreneur.

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# *List of Abbreviations*

| | |
|---|---|
| B2B | business to business |
| B2C | business to consumer |
| BERD | business expenditure in R&D |
| BI | Balassa index |
| CAD/CAM | Computer aided design and manufacturing |
| C2C | consumer to consumer |
| CB | Caribbean Basin |
| CDs | compact discs |
| DMOs | destination management organizations |
| EAF | East African Flowers |
| ECR | Efficient Consumer Response |
| EDI | electronic data interchange |
| EPL | employment protection legislation |
| F2F | fact-to-face |
| FHK | Foster, Haltiwanger, and Krizan |
| GDP | gross domestic product |
| GDS | global distribution system |
| GR | Griliches and Regev |
| ICT | information and communication technology |
| IPRs | intellectual property rights |
| ISIC | International Standard Industry Classification |
| ISM | industry-sponsored marketplace |
| ISO | International Standard Organization |
| IT | information technology |
| LM | labour market |
| MFP | multifactor productivity |
| OBNMs | Original Brand Name Manufacturers |
| OECD | Organization for Economic Cooperation and Development |
| OEMs | Original Equipment Manufacturers |
| PAP | de Particulier à Particulier |
| PC | personal computer |
| PMR | product market regulation |
| SCAA | Specialty Coffee Association of America |
| SMEs | small- and medium-sized enterprises |
| SSI | small-scale industry |
| STPI | Software Technology Parks of India |
| TFA | Tele Flower Auction |
| T&T | travel and tourism |
| TV | Television |

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# *Introduction*

## TAKING STOCK OF THE ICT REVOLUTION

Over the nineties, the information and communication technology (ICT) took center stage in economic analysis, attracting a great deal of attention by economists and policy makers. Many observers attributed the pick up in output and productivity growth, observed in few countries, to the ICT revolution. Further, the emergence of the digital economy and the explosion of the internet spread the idea that the basic functioning of most markets may change for good, with far reaching consequences on the world distribution of income, and on economic distance between the advanced and developing countries.

What lies behind the idea that the spread of ICT could be a "revolution" for our economies and for our daily life? The reason is that the spread of ICT could be considered akin to the diffusion of a "general purpose technology", a technology with wide scope for improvement and elaboration; with applicability across a broad range of uses; with potential for use in a wide variety of products and processes; and with strong complementarities with existing or potential new technologies. The ICT revolution actually started almost three decades ago in the mid-seventies. At that time, the emergence of the microprocessor and the diffusion of the personal computer, with their immediate possibility of distributed information storage and processing, set the stage for a dramatic change. The new technology emerged in the world economy when a remarkable slowdown in productivity growth was taking place.

Indeed, recent estimates of the growth of computer stocks and the flow of services are consistent with the view that in the mid seventies the US economy was in the early phase of the deployment of ICT. Figures developed by Jorgenson and Stiroh (1995) reveal that in 1979, when computers had not yet evolved beyond their limited role in information processing, machinery and computer equipment were providing only 0.56 percent of the total flow of real services from the (non-residential) producer of durable equipment stock. But these measures rose at 4.9 percent in 1985, and had ballooned to 13.8 percent by 1990, and 18.4 percent few years after that.

Historically, a comparable period of diffusion of a general purpose technology took place in the 1920s, with the emergence of the dynamo and the electrification of the industrial economy (David and Wright, 1999). Indeed, the transmission of power in the form of electricity revolutionized industrial production, through a process that required much more than substitution of a new productive input for an older alternative. The electrification of the industrial economy made possible significant fixed-capital savings while simultaneously increasing labor productivity. Interestingly, the extent of computerization that

had been achieved in the US economy by the late 1980s was roughly comparable with the degree to which the American manufacturing sector had become electrified at the beginning of the twentieth century. When the historical comparison is narrowed more appropriately to the diffusion of secondary motors, the growth rate for 1899–1914 is almost precisely the same as that for the ratio of computer equipment services to all producers durable equipment services in the US. In the case of the emergence of dynamo, history has already unfolded itself, and we now know that the pick up in productivity growth that took place in the twenties can largely and confidently be attributed to the slow diffusion of the new general purpose technology.

For the case of ICT, history has not yet completely unfolded. All one can do at this stage is to seriously take stock of the ongoing revolution. This is the aim of this project. Throughout the book, we aim at understanding what the ICT revolution implied for productivity growth across countries, as well as for the functioning of the world markets.

Specifically, there are three key research questions that the book addresses. First, does the ICT revolution contributed to the recent widening in growth disparities across the OECD? Second, why have some countries better able to harness the potential of this technology, while others have lagged behind? Third, are internet and the ICT revolution going to reduce economic distance between industrial and developing countries? These are fundamentally difficult questions. Nevertheless, this book provides an answer to each of them, and in this brief introduction, we offer a short sketch of the main logic behind the three answers.

As in previous volumes for the Fondazione Rodolfo Debenedetti, the book assembles contributions from two teams of leading economists of the field. Part One is the contribution of a team co-ordinated by Stefano Scarpetta and included Eric Bartelsman, Andrea Bassanini, John Haltiwanger, Ronald Jarmin, Stefano Scarpetta and Thorsten Schank. It focuses on the contribution that the ICT revolution has made in the advanced countries for output and productivity growth at the macro, industry and firm level. Part two of the book is the contribution of a team co-ordinated by Daniel Cohen and included Bruno Amable, Philippe Askenazy, Andrea Goldstein and David O'Connor. It assesses whether or not the digital economy will result in a more competitive and more equal world. The book includes also insightful comments by Alan Krueger and Robert Gordon, who discuss the first half of the book, and by Jan Svejnar and John Martin, who discuss the second half of the book. Finally, Gosta Esping-Andersen and Paul Geroski present their views on what they have learned from the book and what more remains to be analysed.

## *I: Does the ICT revolution contributed to the recent widening in growth disparities across the OECD?*

If a new general technology becomes available, sooner or later it must have an impact on the growth process. And changes in the productivity process should

be reflected in the growth data. In this respect, a natural starting point of our long inquiry is the analysis of aggregate output and productivity performance. Macro data clearly point to widening disparities in growth performance across the OECD countries, even using series that attempt to control for differences in the business cycle position of countries. Thus, convergence in output per capita and productivity levels can no longer be taken for granted by macro economists, not even for OECD countries that supposedly share common technologies. Indeed, significant growth divergence occurred in the 1990s across OECD countries. This is not only because the U.S., the country that was already at the productivity frontier in many industries, pulled ahead of the others, but also because some smaller economies have been able to significantly boost their economic performance (e.g. Australia, Canada, Ireland, the Netherlands).

The evidence provided in the book suggests that some of these disparities are due to "traditional economy factors" including differences in labour utilisation. But there also are important "new" factors behind them. Some countries, including the United States, have developed a sizeable ICT-production industry which has experienced over the past decade an extraordinary productivity growth. Moreover, a number of countries, whether or not with sizeable ICT industry, invested a lot in ICT equipment and this has also contributed to boost output and productivity. As often argued, ICT equipment also allows changes in work practices and could potentially lead to a faster pace of technological progress. One way to measure technological progress is by calculating the residual growth of output once the contribution of the growth of factor inputs is taken into account. This measure, often referred to as multifactor productivity, shows some interesting cross-country variation. In particular, after a prolonged period of downward trend, multifactor productivity growth accelerated in some countries, including all of those that have a sizeable ICT production industry and have adopted ICT equipment at a fast pace. And the way in which the acceleration in multifactor productivity took place appears consistent with the view of a slow diffusion of this general purpose technology. The acceleration was initially linked to productivity gains of the ICT producing industries, and was later followed by intensive productivity gains in ICT-using industries.

But the adoption of new technology interacts with a churning process at the industry level, which involves substantial rates of firm entry, firm expansion and contraction, as well as inevitable and often efficient exit of obsolete firms. Interestingly, when the book looks inside this complex churning process, it finds that a relatively stronger contribution to productivity growth in ICT-related industries came from the entry of new firms.

A careful examination of the macro, sectoral and firm turnover data, provides the tools for answer to yes to our first key question: the ICT revolution contributed to the recent widening in growth disparities across the OECD. The way in which the multifactor productivity growth picked up is consistent with a slow ICT adoption story, while the above average productivity gains of

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industries producing and extensively using ICT equipments suggests that, beyond the complex turnover process, ICT related industries did significantly contribute to push up productivity in a selected number of countries, such as United States, Canada, Ireland, Finland and Australia.

## *II. The Role of "Market Experimentation"*

But how did it happen that some countries, and notably the United States, were better equipped to adopt the new general purpose technology? What was so different and so special about them? This is our second key question, and the book draws on firm and establishment level data in search for an answer. The key idea in this respect is simple, albeit original and provocative. It is "*market experimentation*". As the report edited by Stefano Scarpetta shows, market experimentation refers to four interrelated features of firm behaviour in the United States compared to Europe. First, U.S. firms enter the market with a relatively smaller size than their European counterparts. Second, new entrants in the U.S. have on average a lower productivity relative to that of the incumbents. Third, there is greater dispersion of productivity growth amongst new entrants in U.S. than in Europe, and this dispersion tends to decline with the age of firms in the U.S. but not in Europe. Fourth, those U.S. firms who successfully enter and survive in the market, experience much stronger employment expansion relative to their European counterparts. All in all, these findings suggest that on average entrepreneurs enter each market in the U.S. with a relatively small size, test the market and, if successful expand rapidly to reach the minimum efficient scale. Those with poor productivity outcomes fail rapidly, clearing resources for others to test the market with alternative projects. Note that these findings do not come from ad hoc observations, but are obtained from a harmonized data set of firm level data for 10 OECD economies: Canada, Denmark, France, Finland, Germany, Italy, the Netherlands, Portugal, the United Kingdom and the United States.

To further test the market experimentation hypothesis, the book looks at new and original establishment level data for the U.S. and Germany. It finds that new entrants are much more heterogeneous in the U.S. than in Germany in many respects: in the level of productivity, in the skill mix of the labour force, in the degree of internet access and in the returns to investment in high technologies. All these features of new establishments are consistent with the idea of greater market experimentation in the US as compared with Germany.

Obviously, the regulatory and institutional environment and different degrees of market competitions within countries do play a role in shaping the different outcomes across industries and across countries. The book uses a new set of OECD indicators of product and labour market regulations to test whether such regulatory variables have a significant impact on sectoral multi-factor productivity and on R&D intensity, where the latter is used to proxy for the intensity of innovation. The results suggest that stringent regulatory

settings in the product markets adversely affect multifactor productivity growth and R&D, even though their impact depends also on specific technological and market conditions, such as industry distance from the technological frontier. But the way in which those cross country regressions should be read is in close connection to the evidence on market experimentation. It appears that certain regulatory environments, and strict product market regulation in particular, reduce the degree of market experimentation by firms, which in turn reduces the system ability to adopt new technologies, whenever they become available. While it is not obvious that a system that facilitates market experimentation is more efficient at all times, since too much churning can lead to waste of resources and high adjustment costs for all those involved, it appears that in periods of fervid technological innovation, such as those that followed the ICT revolution, an institutional system "experimentation-friendly" may allow a quicker adoption and diffusion of new technologies, with enhancing effects on productivity.

## *III: ICT, the digital economy and productivity differences between advanced and developing economies*

The first part of the book makes the case that the availability of ICT technologies was not per se a factor leading to faster convergence across industrialized countries. If anything, the ICT revolution made productivity performance across countries more heterogeneous, not least because cross-country differences in policy and institutional settings created different incentives to adopt ICT. Those findings challenge to the naïve view of the internet and the ICT revolution. Such view suggests that a fast movement toward a digital economy could create the conditions for a much more competitive world, a world that would equalize business opportunities within countries and, perhaps more importantly, across advanced and developing economies. With respect to developing countries, the view is that ICT access would lower barriers to entry of firms based in developing countries into the markets of advanced economies. This phenomenon should happen for both intermediate markets(business to business), as well as for final goods markets(business to consumer). The second part of the book argues that these equalizing forces of the ICT revolution, albeit not irrelevant, are not sufficient for reducing significantly disparities across countries, since other important features work in opposite directions. In other words, internet and the ICT revolution are not the great equalizers, and economic distance between industrial and developing countries is not going to be reduced across the board.

More specifically, there are three features of the ICT revolution that make the equalizing potential so difficult to realize in practice. The first is the fact that information is quite often not digitizable, since most business transactions require face to face (F2F) interactions. ICT equipments can certainly increase the speed at which different types of business transactions are executed, but

rarely are complex transactions closed without physical connections. Relatedly, only a small fraction of the goods and services traded internationally (software, audio and video clips, books and other documents, etc...) can be fully digitized so that delivery is possible via the internet or some other communications medium. These constraints can have a major impact on the ability of developing country based firms to penetrate into the more advanced markets. An interesting case study in this respect is the world market for cut flowers, where South African exporters pay high transportation costs for sending their flowers first to trading auctions in Amsterdam, whence they are re-shipped to the final destination, which can be anywhere in the world. Flowers can be thought as an experience good for which an online image is not an adequate substitute.

The second ICT obstacle to a cross country equalization of opportunities has to do with the inherent complexity of digitally based business transactions. In practice, digital transactions are often accompanied by sophisticated side transactions. Indeed, when concluding business on line, buyers and sellers have to deal with many third parties, which specialize in technical dimensions in support of the main transaction, such as the security of the financial deal, the security of the delivery, as well as certification of what is exchanged. In other words, the Internet quite often raises the complexity of a given transaction. Consider the case of buying a book. The casual buyer goes to the bookshop, pays for instance in cash and leaves the shop carrying his book. Buying on line is more complex. The transaction now depends on a number of intermediate products which involves logistics, security of transaction, security of delivery. Paradoxically, suppliers of these products/services may see their role and their rents increased, rather than decreased, by the emergence of the digital economy. In addition, the faceless nature of digital transactions requires high levels of truth, to which brand and reputation contribute importantly. Whereas the internet technology can lower barriers to entry into certain markets, reputational costs tend to restore them. Thus, the report shows that the complementary demands placed on internet-using firms (for on-time delivery, transactions security, etc...), the limited digitizability of many commodities (hence the continued importance of traditional infrastructural and regulatory constraints), and the reputation costs of online business are important factors in explaining why producers from developing countries find ICT of limited use thus far in penetrating into the brand markets of advanced economies.

The third obstacle to cross country equalization refers to the agglomeration forces inherent in an ICT based economy. This is partly a story of increasing returns to scale, as suggested by two obvious examples: the Silicon Valley in California and the Bangalore software industry in India, the latter being an obvious success case in the developing world. But the ICT revolution is more than increasing returns to scale. A key new development in business organization, just in time production, has been greatly facilitated by ICT diffusion,

e.g., in inventory and supply chain management. But delivering goods just in time imposes a constraint on the location of suppliers, who cannot be too far from consumers. One implication is that, according to a common rule of thumb, suppliers need to be within a 24 hours truck journey from the client, and in the car industry case we actually observe suppliers that co-locate with assemblers.

In terms of economic development policy, it seems that ICT in general, and the internet in particular, have changed "very little". Indeed, the policy and institutional constraints on growth emphasized by the existing development literature largely dominate the possible benefits linked to ICT adoption. In this respect, the main policy conclusion is that institutional and governance obstacles to development are still relevant in a digital world. But the book shows that for specific entrepreneurs and sectors, the impact of ICT could be relatively important. In these cases, gradually diminishing trade and other policy distortions become a necessary step for exploiting the positive effects of the ICT revolution.

In all the industries analysed, ICT and internet are affecting the forms of production and exchange, the nature of corporate behaviour, and the terms of competition. But in light of the forces analysed above, it is not clear whether the new distribution of costs and profits is unquestionably supportive of the development process. The Bangalore example shows that, provided some basic requirements are met—such as a relatively abundant and well-educated workforce and reliable telecommunications and electricity supplies—the transmission in digital form of codifiable and storable information from remote locations via computer networks is straightforward. The situation is much more complicated for production-supporting activities that make intensive use of information that requires complex, repeated face-to-face interaction for effective communication. Furthermore, e-business readiness depend on key governance dimensions—such as consumer protection, security of transactions, privacy of records and intellectual property protection—that remain weak in much of the developing world. As a result, the full exploitation of the new technology by developing countries, whatever its eventual impact, is further delayed by these institutional constraints.

*Daniel Cohen, Pietro Garibaldi, Stefano Scarpetta*

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