

Distributed Enterprise, Intelligent Automation and Industrial Benchmarking – Putting ICT technology into practice *

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1. The leading role of ICTs in the emerging information society

The last 25 years, fundamental changes have taken place in the way corporations create wealth and increase competitiveness. Driven by major technological developments especially in the area of Information and Communication Technologies (ICTs), major business areas in telecommunications, software, consumer electronics and content provision are converging to create more value for their customers. This process of convergence is having profound implications for the economy and completely new economic sectors emerge and new economic players come into existence. New activities are organised on a global scale either directly or indirectly through networks of linkages between economic and business actors. What is emerging can be described as the creation of a “single digital space” where information is held and communicated in digital form, accessible from anywhere by anyone, at any time, using any device – television, mobile phones, computers or whatever.

Today, the level of investment in ICTs is considered to be a major driver for the successful development of high-tech industrial and service activities. Indeed, many aspects of business is changing, roles of public authorities are being revisited and users are confronted with an array of new or improved products and services generated by novel developments in ICTs. With the emergence of new products such as mobile phones, computers, digital TV, fibre optic net-

works – and new services – mobile including communications, computer networking, Internet connections, audio-visual, ICTs nowadays permeate all aspects of business, of work and of leisure. To illustrate this, last year European consumers and businesses spent more on ICT products and services than on cars, steel and aeroplanes combined [1,4]. In fact, ICT industries have become one of the largest and fastest growing sectors world-wide. ICT industries create new jobs, new opportunities, new products and new services, and drive economic growth and enhance competitiveness of the whole industrial fabric.

ICT is not only transforming the economic landscape, but also acts as an economic and social catalyst to bring profound changes in work and leisure patterns, and is consequently an engine of significant importance in society. The information revolution is just beginning and the pace of change directly influenced by the large diffusion of ICT will probably accelerate further [3].

1.1. ICTs and production industries

In the past, companies succeeded by virtue of a unique single technology or outstanding production technology. The advent of the digital economy has forced companies to rethink the relationship between business performance and the deployment of information technology, between organisation and production processes, and, e.g., between business culture, people and infrastructure. Furthermore, the opening of national economies to world market forces has created an environment of global competition, in which increasing customer demands and other market dynamics have dramatically increased the importance of the

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role of information and communication as a factor of productivity.

The corporate value chain is fundamentally being re-designed. Core activities of production, consumption and distribution, as well as their components – capital, labour, raw materials, management and information technology – are (re-)organised along broader geographical lines to optimise the effective use of skilled labour and technology, and to gain access to markets. This resulted in global production networks that stimulate growth and led to the emergence of new industries. Today, to be competitive, organisations need to operate at a global level, and to co-operate with many partners and other stakeholders at a regional and local level. It is increasingly rare to identify finished goods in which a large part of the value is added by just one single enterprise. New products and services are likely to emerge from new enhanced networks of user-supplier partnerships in which the effective development and rapid take-up of technological innovation is taking place. Companies that under-invest in ICT will soon lack the capabilities to compete in a networked business environment, where speed, flexibility and quality of information sharing are critical.

Nowadays, successful companies concentrate on their core business, peripheral activities are outsourced, business networks are established and service provision is integrated with production of physical goods. At the same time, corporate executives are having to master new, often radical, approaches to allocation of resources, whereby the key determinants of competitive performance are grounded more in the creative use of intellectual capital – R&D, design, know-how, flexible organisation structures and brands – than in natural resources, machinery or financial capital [2].

Within this context, business operations, large and small, rely more and more on advanced and cost-efficient communication and information infrastructures. All business operations can be improved using advanced ICT from strategic management; market and product planning; product design; manufacturing process design; production planning; production operations and control (including quality control); logistics with just-in-time distribution and control to customer support services (marketing and sales). Examples to illustrate the above include:

- *ICTs and the networked business*: Effective operations of companies, including user-suppliers connections, require seamless distributed operations that are only possible through reliable communication infrastructures and services. Information

technology systems enable the management of additional complexities of co-operation between partners in a supply network or within a virtual enterprise. This type of networked business structure offers new levels of efficiency and flexibility. ICT systems help minimise overheads of co-operation and drastically reduce transaction costs.

- *ICTs and the structure and culture of companies*: Efficient ICT products and services and integrated ICT solutions operating in an increasingly time-compressed environment are essential for businesses to enable new structures and new strategies for innovation, agility, team working and information dissemination within their companies. They equally facilitate implementation of new flexible working practices and increased training and learning for the entire personnel.
- *ICTs and innovation in production*: New technologies and business strategies are radically changing the way that products and services are designed, prototyped, created and marketed as well as the production manufacturing environment. Advanced applications and software platforms can accommodate and integrate evolving customers' needs and heterogeneous business processing environments and increase flexibility in the design and manufacturing processes necessary to master the introduction of short innovation cycles and to be timely to the market.

For enabling development of appropriate ICT technology, continuous effort in research and technological development is required. As a response to the next millennium, the European Commission has recently proposed the Fifth Framework Programme, which, as a major component, introduces a single Information Society Technology (IST) programme that integrates R&D and take-up measures in the area of ICT [5].

1.2. The IST Programme under the 5th Community Framework Programme

The IST Programme (1999–2002) has four inter-related specific objectives: For the European citizen the objective is to meet the needs and expectations of high-quality affordable general interest services. For European enterprises, workers and consumers, the objective is to enable individuals and organisations to innovate and be more effective and efficient in their work, thereby providing the basis for sustainable growth and high added-value employment while also improving

the quality of working life. In the sector of multimedia content, the key objective is to confirm Europe as a leading force, realising its full potential. For the enabling technologies, which are the foundations of the information society, the IST programme objective is to drive their development, enhance their applicability and accelerate their take-up in Europe.

The bulk of the R&D is centred in four key actions as follows:

- *systems and services for the citizen* to provide flexible access for everybody, from anywhere, at any time and covers the domains of health, special needs and elderly, administrations, environment and transport and tourism;
- *new methods of work and electronic commerce* to enable industry to increase its competitiveness in the global market place and, for example, to boost trust and confidence in the information infrastructure;
- *multimedia content and tools* to enable Europe to realise the potential of its creativity and culture covering, for example, systems for IPR and content infrastructures in cross-disciplinary areas; and,
- *essential technologies and infrastructure* which focuses on the convergence of information processing, communications and networking technologies, and infrastructure.

In addition to the key actions, the IST thematic programme includes, “future and emerging technologies” and “research networking” covering research of a long-term nature and providing broadband interconnection between national research and education institutions.

1.3. The CEECs economies and their participation under the IST Programme Research Actions

Preparing for enlargement is the major challenge for Central and Eastern European Countries (CEECs) for the next coming years. Of particular importance will be the building of a strong industrial base in Central and Eastern Europe and the maintenance and improvement of the level of employment. Industrial modernisation – in terms of improving levels of productivity or, for example, improving the quality of products – will be of critical importance. This relies very much on improving the framework conditions in which industry performs, the essential role played by the liberalisation of the telecommunications sector and the development of

a modern information and telecommunications infrastructure.

In this respect, the speed of change in Central and Eastern Europe is encouraging both in the telecommunications sector and in industry. In a recent report in the Panorama of EU Industry on “*Industrial Restructuring in Central and Eastern Europe and Emerging Patterns of Industrial Specialisation*” (see [1]), it is noted that the most advanced of CEECs’ economies have embarked upon a process of convergence in broad industrial structural terms with the more advanced Western economies.

When focusing at the detailed industrial level however, developments are much more varied. Some of the economies have made in-roads in some sophisticated industrial branches (particularly engineering) and have reduced their deficit in R&D and skill-intensive areas. They have also strengthened their presence in international trade in certain resource and labour-intensive sectors. Other CEEC economies have mainly moved in the latter direction. The picture over the period 1990 to 1994 is still strongly affected by the short- to medium-run impact of the dramatic process of trade liberalisation, absorption of the “transition shock” and only the gradual – but constant and positive – evolution of new industrial organisational structures in the different CEECs.

The ultimate goal is the integration of the Central and Eastern European countries into the Internal EU Market with CEEC acting as fully-fledged players. This will ensure the free movement of high quality goods and high standards of consumer protection, security, health and environment protection. In this integration, the role of industrial co-operation and the importance of foreign investment cannot be underestimated. A win-win situation can be created provided that EU industry fully takes up the opportunity offered by the enlargement process recognising the CEEC countries as an important growth market and increasing their co-operation in RTD by means of alliances and focused collaborative actions.

This above is indeed happening:

- The EU share of CEEC imports typically varies between 50 and 65% of the total imports and European exports to the CEECs have grown more rapidly than any other region over the last five years.
- In the RTD arena, CEEC entities will have the possibility to participate – with financial support – in the IST programme and, in fact, in the whole 5th Community Framework Programme. In this

way, the European Commission will continue to support their research organisations and industry to gain experience in working with their Western European counterparts.

2. The 2nd ESPRIT-COPERNICUS Symposium in the area of ICT and production industries

Within the international framework described above and with the objectives to disseminate emerging results of EU funded COPERNICUS and ESPRIT projects in the "ICT and production industries" area and to provide information on co-operation possibilities in Research and Technological Development, the European Commission and the Wroclaw Centre for Technology Transfer (Poland), organised a Symposium in Wroclaw entitled "The ESPRIT/COPERNICUS Symposium on Distributed Enterprise, Intelligent Automation and Industrial Benchmarking – Putting ICT-technology into practice". The Symposium was held on 23 and 24 April 1998 in Wroclaw and was also supported by KBN, the Polish State Committee for Scientific Research.

2.1. The Symposium's topics

The Symposium comprised three main themes, i.e., Distributed Enterprise, Intelligent Automation and Industrial Benchmarking. All three themes concentrated in putting ICT technology into practice.

2.2. Distributed enterprise and relating ICT tools

In the context of the global networked economy described in the previous sections, European companies need to reinforce their co-operation and establish multiple partnerships that make optimal use of available expertise and create a competitive edge. In the confluence of new markets, networked co-operations of all actors, including industry, universities, research centres, users and governments are essential for spurring innovation and creating success at global level.

Networked (or distributed enterprises) and virtual companies need an ICT network environment that permits and enables *seamless* and *secure* interconnection of business operations of decentralised and geographically dispersed business units and that facilitates the sharing of enterprise knowledge at all corporate levels.

Comparative advantages can be obtained by distributed and virtual enterprises in the networked economy. Success will be with individuals and organisa-

tions that are able to leverage the capabilities of today technologies to transform business and invent for tomorrow new innovative business practices.

A new breed of R&D in ICT tools for distributed enterprises is essential for:

- Enabling inter-working and global inter-operability in heterogeneous user environments for the inter-connectivity of local and remote locations and for the deployment and optimisation of advanced intra- and inter-organisational business applications;
- Increasing flexibility and efficiency of manufacturing, design, component production, assembly, distribution and marketing processes. These processes must deliver *better products, in less time, on a global basis, customised to individual customer requirements, complying with all regulations* and, at the same time, record and maintain the information that will support any related service business and any required future analysis.

A key element for the deployment of novel ICT tools and emerging RTD results in industry will be the continuation and strengthening of education efforts for engineers and professionals.

The above constitute a representative sample of issues presented and discussed at the sessions of the Symposium dealing with the Distributed Enterprise.

2.3. Intelligent automation

Automation is an important issue for companies in both Eastern and Western Europe, as it refers to a sector of the economy, which covers a large number of industrial products and services as well as of consumer goods. For example, smart automation products can be found in everybody's household appliances and automobiles and components and systems for industrial automation represent a most important export sector of European industry.

2.3.1. Intelligent automation and the production industries

Automation is an integral part of industrial manufacturing and production. To improve and optimise production processes, provide high-quality products and services and minimise material and energy waste, industries have a systematic recourse to advanced automation technology. This includes *shop-floor control, quality control* and distributed *production control and agent-based manufacturing systems* integrating *smart*

sensors, actuators and other smart industrial equipment (including advanced *robotic and mechatronic* systems) equipped with user-friendly (and increasingly multimedia-based) *man/machine interfaces*. To increase flexibility, companies look for *advanced distributed control architectures* and for *re-configurable and self-learning systems and machines*; and in order to master the increasing complexity of new products (composed of an ever expanding number of components, being increasingly miniaturised, and integrating more and more service elements), they seek for automation solutions coping with the increasing number of processing steps in manufacturing and assembly and for new specialised and flexible machinery.

In general, the introduction of modern automation devices and systems in production industries is seen as an essential means for: improving productivity; achieving high process quality and constantly high product quality; increasing efficiency and flexibility of production; improving the ergonomics at the workplace and ensuring higher health and safety standards for employees; enabling production at the highest technical, hygienic and clean-room levels.

The development of automation technology is very closely related to a number of component technologies. In a very simplified view, automation is the combination of these supporting technologies coupled with 'intelligent' ICT. Today indeed, ICT is becoming the most important basic technology for automation. For example, the development and use of modern *field bus communication systems* and recent advances in computer technology are at the basis of PC-based open controls. Complex software for sensor data processing, or communication networks and Internet-based technologies enable *remote configuration* and *optimisation* as well as *remote diagnostics, maintenance and service* of industrial processes and industrial equipment.

2.3.2. Intelligent automation and the service sector

Automation plays also a fundamental role in the service sector. There, intelligent automation systems exhibit as primary goals to relieve the physical and mental strain of human beings, to provide the prerequisites for a good state of health of European citizens and to improve the quality, availability and cost-effectiveness of service tasks. Typical examples of intelligent automation devices and products include:

- Smart products, such as automatic water faucets and hand dryers, smart air-conditioning systems, smart power drills, "intelligent" kitchen appliances, cruise navigation systems, etc.

- Modular multi-purpose service and personal robots interacting with humans (informing, safeguarding, supporting, entertaining), with the environment (maintaining, repairing, cleaning), or simply performing an autonomous function (surveillance, transport, etc.)

The value of automation in the service sector is measured both in terms of technical and economic aspects but also as an important societal requirement since providing solutions to undertake work, e.g., in environments which are contaminated or dangerous for human life, offering invaluable services to aged and disabled, etc.

As for industrial automation, advances in ICT technology enable the implementation of more flexible, reliable, user-friendly, secure and in term, more intelligent automation devices and systems capable of communicating with humans through sophisticated man machine interfaces and accomplishing ever increasing complexity tasks in a fast, secure and reliable manner.

A representative sample of automation systems used in the manufacturing/production industries and in the service sector has been presented at the sessions of the Symposium dealing with Intelligent Automation. Papers in this issue present and discuss modern theories and practical implementation issues and results achieved relating to the introduction of automation technology:

1. in production industries (papers on holonic manufacturing systems from P. Valckenaers et al., on shop-floor control systems from J. Chrobot et al. and on industrial automation communication systems from J. Koch et al.); and,
2. in the service sector (advances in postal automation systems from G. Garibotto and in the use of mobile robots in industrial and underwater environments from J. Batlle and P. Ridao).

2.4. Industrial benchmarking

In the ever-more competitive business environment, the issue of *benchmarking*, i.e., a means for monitoring progress on an on-going basis and assessing the situation against best practice world-wide, is becoming of prime importance. Improved competitiveness of the European economy constitutes an important means to ensure a sufficient rate of net job creation and to ensure that all those willing and able to contribute to well being in the Union through productive employment have the opportunity to do so.

The primary responsibility for ensuring that enterprises remain competitive lies with firms themselves. While competitive analysis identifies gaps in performance in key dimensions such as productivity, growth, costs, investment and innovation, competitive analysis does little however to explain why these differences in performance have occurred and, in some cases, remain for many years despite widespread access to new technologies, capital and skilled human resources amongst developed countries.

Benchmarking goes beyond competitive analysis by providing an understanding of the processes that create superior performance. In fact, benchmarking is a tool to promote better implementation of measures in key areas for competitiveness by focusing on factors and conditions that determine superior performance and exchange of information on best practice. Benchmarking can be considered at three levels: enterprise benchmarking; benchmarking of sectors; and, benchmarking of framework conditions (costs, skills, innovation, and environmental efficiency).

The main emphasis of benchmarking sessions at the Symposium was on industrial benchmarking and the consequent business re-engineering of industrial processes (BPR) and on tools to support the BPR implementation. State of the art was reviewed and representative case studies described.

3. Conclusions

The Symposium was targeted at industrialists, researchers, representatives of industrial associations, and regional and national authorities from Eastern and Western Europe. It provided an open forum to discuss and learn about latest developments and trends in Dis-

tributed Enterprise, Intelligent Automation and Industrial Benchmarking. Emphasis was given on exchanging practical experience in the deployment of ICT solutions.

Several of the Symposium participants highlighted the importance of such events for CEECs and especially for the hosting country as a platform for strengthening European collaboration in the industrial sector. In general, the Symposium has served as a good platform for establishing new partnerships and networks for forming new Consortia to tackle the new challenges and to transfer the knowledge from EU industry to the CEECs.

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