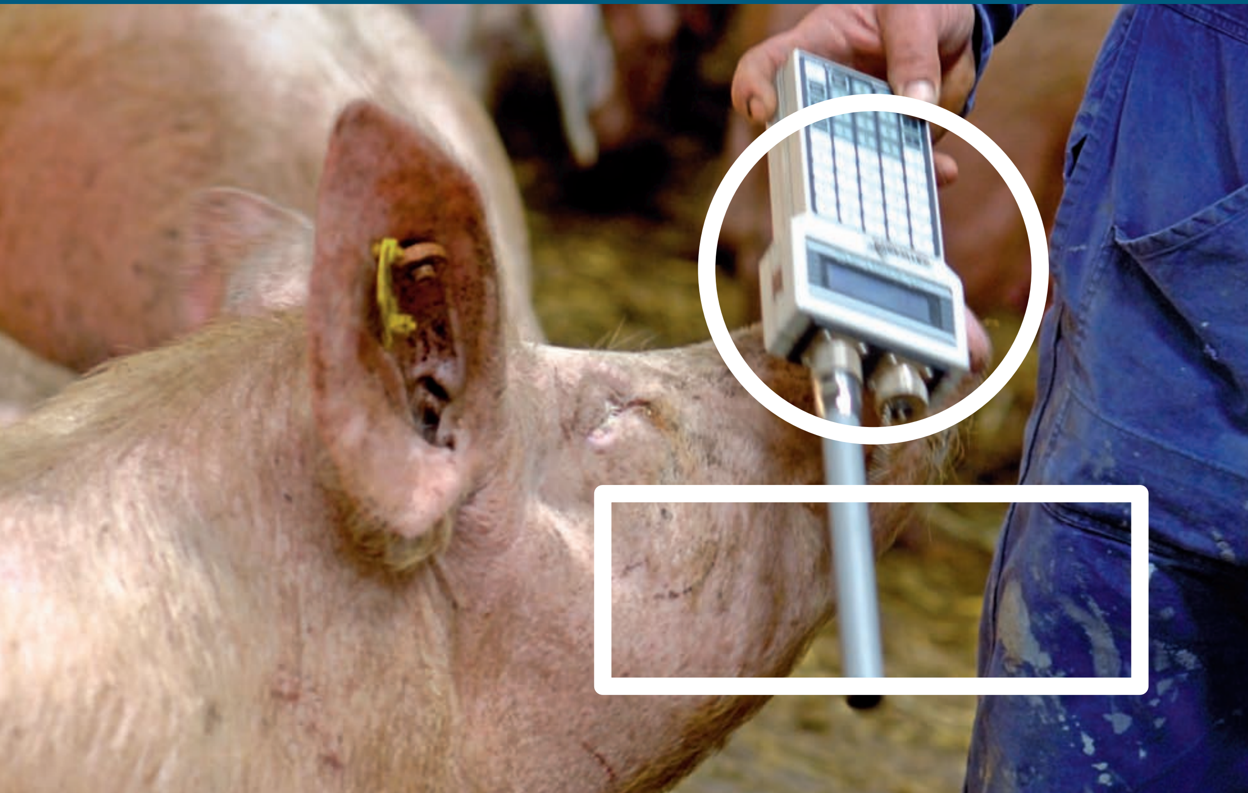
Thought for Food

The impact of ICT on agribusiness



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This report over the research area Consumers and supply chains.

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Thought for Food; The impact of ICT on agribusiness

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This report outlines the impact of ICT on the food economy. On the basis of a literature review from four disciplines - knowledge management, management information systems, operations research and logistics, and economics - the demand for new ICT applications, the supply of new applications and the match between demand and supply are identified. Subsequently the impact of new ICT applications on the food economy is discussed. The report relates the development of new technologies to innovation and adoption processes and economic growth, and to concepts of open innovations and living labs.

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Preface

In 2000, European governments expressed the ambition to make Europe the most dynamic and competitive economy in the world by 2010. To this end, the growth of Europe's labour productivity would need to rise above that of rival economies. In the period up to and including 2008, the European Union was not able to meet this ambition. The ambition was put to the test even further in 2008 as a consequence of the global credit crisis and the recession that then began. The current economic crisis was an extra inducement for Europe to make the European economy more competitive, to allow Europe to fulfil its social and environmental agenda too. In order to make the European economy competitive and sustainable, European governments are investing in reinforcing the knowledge economy. Within this framework, the development and introduction of ICT technologies is stimulated.

In light of this, the Ministry of Agriculture, Nature and Food Quality has asked LEI to investigate the significance of ICT for the agricultural and food cluster. In the literature, ICT is named as one of the major driving forces behind the continual renewal of the economy. Since the relationship between ICT and the economy is a relatively new field of study, LEI joined forces with other institutes within Wageningen UR to carry out a literature study looking at the significance of ICT for the agricultural and food cluster. The expertise of other institutes is used to be able to look at the significance of ICT from various scientific angles and disciplines. This report is the resulting response.

This project was commissioned by the Ministry of Agriculture, Nature and Food Quality. The supervisory committee consisted of Lucie Wassink, Gerrit Meester and Ancel van Royen. The research was carried out by a multidisciplinary team consisting of Frank Bunte, Youri Dijkxhoorn and Sjaak Wolfert (all LEI), Roos Groeneveld and Jan Top (both AFSG) and Gert Jan Hofstede and Jack van der Vorst (both Department of Social Sciences).

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Summary

ICT is one of the major technologies driving changes in both consumer demand and supply chain organisation. ICT allows the transformation of the food economy from an economy based on the production of physical goods to an economy based on the production and application of knowledge. Value added is created by making smarter use of natural and other resources.

This report explores the impact of ICT on the food economy by presenting the main drivers of the ICT revolution on both the demand and the supply side. New ICT applications are implemented in order to meet changes in consumer demand, sustainability requirements, international competition, logistics and product sourcing (chapter 2). New ICT applications include service-oriented architecture, software as a service, the semantic web and some other revolutionary ICT applications identified by Gartner (chapter 3). Companies align the demand for and supply of ICT applications by applying business process management and business process modelling. ICT applications promote supply chain transparency and traceability and make open innovations a viable business strategy. Living labs and open innovations allow companies to involve consumers, customers, suppliers and other potential partners in R&D and innovation processes (chapter 4).

The introduction of ICT influences market and economic performance. Chapter 5 analyses what factors influence the diffusion of ICT applications and the impact of ICT on performance, market structure, market transparency and transaction costs. The introduction of ICT has a higher payoff when it is combined with other investments and activities such as changes in labour organisation. ICT is not a goal in itself. The development, adoption and diffusion of ICT applications depend upon co-ordination and standardisation efforts by companies and government. Market transparency is likely to be higher and transaction costs are likely to lower due to the introduction of ICT. Chapter 6 shows that, among other things, differences in ICT use in wholesale and retail trade and in financial services explain why European productivity lags behind American productivity. ICT and the knowledge economy put increasing demands on employees and labour organisation. Employees typically need different, but also more and higher skills to perform in the knowledge economy.

The main conclusion of this report is that food supply chain networks (FSCNs) develop into open networks sharing information. Open networks offer many opportunities for generating value added. Food supply chain networks slowly become a part of the knowledge economy.

However, there are two bottlenecks in the knowledge economy:

(1) companies collect many data most of which are not used at all;

(2) companies are not ready to process all data available.

Managers, employees and the models they work with are not fully prepared for the knowledge economy as yet. ICT and the knowledge economy are about two issues: technologies and people. The most important challenge the food economy faces is getting the people ready for the new era.

1 Introduction

In 2000, the European Commission as well as the Member States' representatives committed themselves to let the European Union become 'the most dynamic and competitive knowledge-based economy in the world' (High Level Group 2004). Competitiveness is considered to be a necessary condition for guaranteeing sustainable growth, more and better jobs as well as respect for the environment. So far, the Lisbon strategy has failed. In the period from 2000 to 2008, economic growth in the US and Asia outpaced growth in the EU. More in particular, US labour productivity growth outpaced European labour productivity growth from 1995 to 2008. Low productivity growth is due to low investments and a slow rate of technological progress. According to the High Level Group (2004) evaluating the Lisbon strategy, European performance is low in this respect due to insufficient investment in R&D, poor marketing performance and low productivity in both ICT production and application.

The Lisbon targets may not be realised by 2010 and may be harder to attain due to the current worldwide recession, however, they are no less necessary. European living standards depend on economic performance of the EU. In order to achieve the world's highest productivity levels, the European Union focuses on five areas: the knowledge economy, the internal market, the business climate, the labour market and the environment. The focus on the knowledge economy, the business climate and the labour market is to make European enterprise and employees more innovative and productive. The focus on the internal market is meant to eliminate entry barriers between national markets in the EU, to foster competition in the markets concerned and to make the EU more competitive. Entry barriers are still important in services, including telecommunication. State aid is also still an issue.

In order to realise a European knowledge society, the EU has set a range of strategic objectives, among which a rise of R&D expenditure to 3% of GDP, the attraction of top scientists to Europe, adaptation of education and training programmes to the requirements of the knowledge society, the promotion of lifelong learning *and* labour mobility, the definition of a regulatory framework for electronic communication, the spread of ICT and the promotion of e-commerce. The EU promotes accession to broadband communication and has developed a Europe action programme.

Given this background the Ministry of Agriculture, Nature Management and Food Quality commissioned LEI to investigate the implications of the evolving knowledge and information economy for the food supply chain. Jean Kinsey (2001) identifies ICT - more in particular digital computing and the Internet - as one of the two major technologies driving changes in both consumer demand and supply chain organisation. ICT and biotechnology enable the transformation of the economy from an economy based on the production of physical goods to an economy based on the production and application of knowledge. Company assets are increasingly knowledge based and intangible. Value added is created by making smarter use of natural and other resources. The impact of ICT is so large, because it enables new business practices, new skills and new industrial structures. It brings about fundamental changes in the way business is conducted and it is responsible for a range of new products and services as well as improvements in quality, variety, timeliness, convenience and sustainability (ibid.).

The changes in the food economy as described by Kinsey inspired the Dutch Ministry of Agriculture, Nature Management and Food Quality to set up a policy and research agenda for the food economy. In the 2000s, the Ministry urged LEI and OECD to address some specific, topical policy issues which are out of the realm of traditional economics of agricultural production. The OECD addressed among other things private standards, market access and consumer responsibility and consumer health in the obesity era (OECD, 2006a, 2007). LEI addressed among other things market power issues (Bunte et al., 2003; see also OECD, 2006b). Given this background, the purpose of this report is twofold. First, to define the new food economy concept more broadly by taking ICT as one of the main drivers of the new food economy as a starting point for analysis. Second, to derive a research and policy agenda for the years to come on the basis of this broadly defined concept.

This report is constructed as follows. Chapter 2 elaborates the drivers behind the demand for new ICT applications. The chapter presents the demands of major stakeholders with respect to the food supply chain (sustainability, transparency, value added) as well as the demands following from economic and social processes such as competition and globalisation (productivity, innovation). Chapter 3 presents the role of ICT in food supply chain networks and discusses major ICT applications. Chapter 4 matches demand (chapter 2) and supply (chapter 3). Chapter 5 discusses the diffusion of ICT applications at the market level and the implications for market structure. We address three key determinants of market structure: industry concentration, transaction costs and market transparency. Chapter 6 presents the implications for economy and society by studying productivity developments at the macroeconomic level, the organisation of labour and public policy. Chapter 7 summarises the results.

2 Innovation on demand

2.1 Social and economic demands

International food industry and food supply chains are facing an ever-increasing pressure to deliver safe, healthy and attractive food in a highly competitive environment. This imposes a strong pressure on true innovation in short cycles, which in turn requires a continuous interaction between analytical science (creating new insight), applied research and development (creating new products and processes) and industrial applications. Moreover, claims made with respect to health effects, sustainability and ethical aspects of the production chain need to be transparent to society. Information technology plays an important role in increasing transparency, but also in virtualising production.

Without being exhaustive, the following drivers behind the pressure to apply ICT and other technologies can be distinguished:

- *Changing market demands*
  In recent years, Western European consumers have become more demanding of food attributes such as quality, integrity, safety, sustainability, diversity, and associated information services. At the same time they demand an increased product variety which should be available at all times and places, provided in a sustainable way;
- *Sustainability*
  Food supply chain networks (FSCNs) face increasing demands with respect to the sustainability of production and distribution processes. Consumers, citizens, NGOs and public administrations continuously scrutinise the impact of food production and distribution on the natural resources and the environment (Jacobs, 2007). FSCNs do not only face increasing demands from societal stakeholders, but also rising prices of agricultural commodities and other natural resources such as energy;
- *Economies of scale*
  Businesses are getting bigger and bigger in all stages of the supply chain network. Large retail companies dominate the market and put their own requirements regarding logistics, quality management and sustainability on a decreasing number of larger suppliers. The demand for responsive and lean supply chains increases, putting high demands on logistics and information systems;

- *Increase in international competition*
  Technological developments (ICT, processing and transport) make it possible to reach suppliers and customers all over the world. Companies in the food industry are acting more and more on a global scale. This is reflected by company size, increasing cross-border flows of livestock and food products, and international cooperation and partnerships. Although this provides cheap products to our consumers, it raises questions regarding the quality, integrity, and safety of the food;
- *Increasing logistics flows in dynamic networks*
  Chain actors may be involved in different supply chains in different (FSCNs), participate in a variety of business processes that change over time and in which dynamically changing vertical and horizontal partnerships are required. Companies act at the same time on global and regional markets resulting in a world-wide growth of goods flows and increased complexity and dynamics in logistics networks. This increases the importance of our main ports (Rotterdam and Schiphol) and has resulted in the definition of five greenports in the Netherlands. It also requieres the optimisation of business networks and chain control structures to maximise product availability and minimise the environmental load (Commissie Van Laarhoven, 2006), especially because fossil fuels are becoming more scarce.
- *Increased level of outsourcing*
  One of the innovations in logistics is to involve logistics service providers (LSPs) in food supply chain networks (FSCNs) and outsource more non-core logistics activities. This has resulted in a rise of a new type of LSP, called fourth-party logistics provider (4PL), which offers an advanced and complete supply chain solution (Hsiao et al., 2008). DHL EXEL is one of such 4PL companies.

All these developments put dynamic requirements on the performance of the food system initiating a reorientation of companies in Dutch agriculture and food industry on their roles, activities and strategies. Demand and supply are no longer restricted to nations or regions but have become international processes. We see an increasing concentration in agribusiness sectors, an enormous increase in cross-border flows of livestock and food products and the creation of international forms of cooperation. The food industry is becoming an interconnected system with a large variety of complex relationships, reflected in the market place by the formation of (virtual) FSCNs via alliances, horizontal and vertical cooperation, forward and backward integration in the supply chain and continuous innovation. FSCNs encompass the development and implementation of enhanced quality, logistics and information systems. In order to satisfy the increasing demands of consumers, government, business partners, NGOs and to obtain the 'licence to produce and deliver', companies continuously have to work on innovations in products, processes and forms of cooperation in the FSCNs (Van der Vorst et al., 2005).

2.2 Knowledge for innovation

As a result of all these competing demands, innovation is becoming extremely complex, involving many sources of knowledge. This requires strategic cooperation in pre-competitive areas. In fact, even the food industry is opening up its generic research activities, being aware of the fact that sharing insight pays off in the long run. This has already triggered numerous initiatives in open innovation, public-private cooperation and strategic alliances. Moreover, in the Netherlands several top institutes have been launched in recent years, to mention TI Food and Nutrition, TI Green Genetics, TI Separation Technology, TI Pharma, TI Biopolymers. There is a strong tendency towards international networks for industrial innovation, such as the Oresund Food Network FINE, the Food Innovation Network, EUNIP (the European Network on Industrial Policy).

In particular, we see the following effects and requirements for R&D, due to the above trends:

- *Continuous formulation and reformulation of the research agenda at a global level*
  This requires transparency of research questions and activities;
- *Distributed experimentation*
  Because experimental and pilot-scale facilities are increasingly expensive and complex, collaborative experimentation at-a-distance is becoming more attractive;
- *Scientific networks changing rapidly, triggered by new possibilities of digital media*
  Publications are becoming almost paperless. This is only one step towards 'active publications', in which disparate data can be merged at will (data fusion) and for example mathematical models can be executed and verified immediately.

Many influential analysts have stated that in modern society *knowledge* has become a key production factor (Nonaka and Takeuchi, 1995; Davenport and Prusak, 1998; Drucker, 1993). As Peter Drucker puts it:

> 'The change in the meaning of knowledge that began 250 years ago has transformed society and economy. Formal knowledge is seen as both the key personal resource and the key economic resource. Knowledge is the only meaningful resource today. The traditional 'factors of production' - land (i.e. natural resources), labour and capital - have not disappeared. But they have become secondary. They can be obtained, and obtained easily, provided there is knowledge. And knowledge in this new meaning is knowledge as a utility, knowledge as the means to obtain social and economic results.'

This change towards a knowledge economy has a strong impact on how innovation is pursued. We are witnessing a paradigm shift in how companies commercialise knowledge, from 'Closed Innovation' to 'Open Innovation.' Closed Innovation is a view that says successful innovation requires control, and increasingly this approach is no longer sustainable. Open Innovation assumes that internal ideas can also be taken to the market through external channels, outside a firm's current businesses, to generate additional value (Taylor, 2001). Conversely, it can be stated that the attractiveness of open innovation as a business strategy is also the way it leads to exploiting the benefits from imported ideas from outside the firm and exporting intellectual capital that had hitherto been idle (Dogson, Gann and Salter, 2006).

3 Innovations in ICT

This chapter presents some major ICT applications which are expected to be used in food supply chain networks (FSCNs) in the decades to come. Section 3.1 discusses the role of information sharing and ICT in FSCNs. Section 3.2 presents two emerging ICT technologies which play a key role in information sharing. Section 3.3 presents ten major ICT innovations. Section 3.4 elaborates one of them: the web. Section 3.5 discusses information and knowledge management.

3.1 ICT in the food supply chain

Food supply chain networks (FSCNs) consist of actors performing consecutive and mutually dependent business activities. The output of the business activities performed by the respective network actors are continuously exchanged between them. Flows within FSCNs include products and services, information exchange and messages, and money and property flows. Most of the time, money and property flows are also represented in the form of information. Most business activities and exchanges involve such information activities as making, receiving and handling orders, including picking, labelling, billing, invoicing and dispatching. Many information processing activities have been automated in the last two or three decades using ICT.

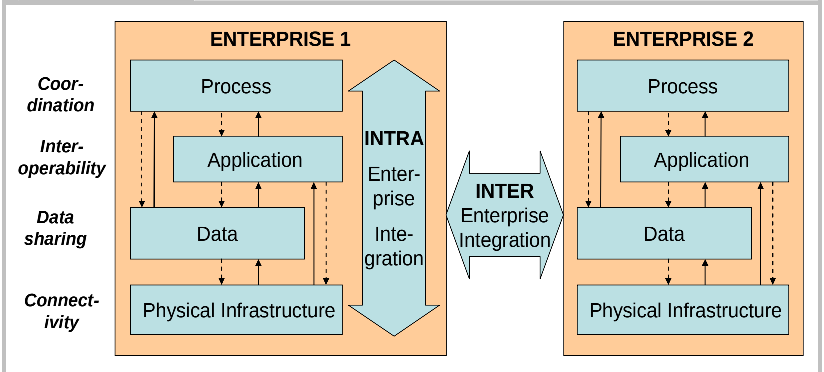
In order to streamline the respective flows in FSCNs, information sharing becomes a key factor in achieving supply chain co-ordination. Information sharing requires the smooth integration of information in all relevant business processes throughout the supply chain leading to standardised communication. Because of the large amount and complexity of information and network of partners, one may clarify the information integration framework by distinguishing different integration levels and types (Verdouw et al., 2007). There is one basic difference in the level of information integration: within and between enterprises (see figure 3.1).The following integration types can be distinguished (ibid.):

- *Process integration - alignment of operational tasks by coordination mechanisms*

  This requires a technical infrastructure, to be complemented by an organisational infrastructure encompassing the organisation and staffing all development, control, help and advisory functions and activities throughout the organisation, aiming at their availability and accessibility at all places in the organisation when necessary;

- *Physical integration - technical infrastructure to enable communication between hardware components (connectivity)*;

Figure 3.1 **Information integration Framework**



Source: Adapted from Giachetti (2004).

- *Application integration - alignment of software systems so that one system online can use data generated by another one (interoperability) (see exhibit 3.1)*
  The use of databases is often no longer restricted to a particular organisation and place but may be accessed anyplace through the Internet or via VPN (virtual private networks);
- *Data integration - alignment of data definitions in order to be able to share data*
  This includes the whole set of formalised coding and message standards (both technically and related to content) with associated procedures for use, connected to shared databases, which are necessary to allow seamless and errorless, automated communication between private and public parties in FSCNs (see exhibit 3.2). International standards organisations such as the European Article Number (EAN) Association play a very important role in that context.

In order to integrate different types of information at various levels in FSCNs, a range of information systems has been developed. Integration of information systems is required in order to guarantee the integrity of basic recordings and a correct and timely communication of information as well as to minimise the administrative burden. Information systems include production automation systems, Supervisory Control and Data Acquisition (SCADA) systems, Manufacturing Execution Systems (MES), Management Information Systems (MIS) and Decision Support Systems (DSS).

Exhibit 3.1	Digital information exchange in Dutch food supply chains

Both private companies and public agencies keep developing Supply Chain Guarantee and Certification Systems. Because private companies and public agencies have similar and complementary information requirements with respect to processes in the supply chain and the accompanying Chain Guarantee Systems, there are possible economies in combining private and public information gathering and processing activities (see LNV, 2008).

For this reason, the Dutch Ministry of Agriculture, Nature Management and Food Quality has developed an E-dossier tool within the EDV programme (Electronic Service Provision). The E-dossier tool supports the exchange of information between private Chain Certification Systems and the databases of the Ministry of Agriculture, Nature Management and Food Quality. For example, the tool may be used to extract information from databases of private companies to support the monitoring and controlling functions of the Ministry of Agriculture, Nature Management and Food Quality. The E-dossier for Chain Certification Systems can also be linked to systems such as I&R (Identification and Registration) and the UBN index (Unsatisfied Basic Needs index). It is also possible to link the tool with databases of Rendac – a company that processes rest materials and carrions - and of GD - an enterprise that offers independent, scientific veterinary knowledge.

Source: Adapted from Giachetti (2004).

Exhibit 3.2	FruglCom: Electronic standards in Dutch fresh produce

FruglCom puts great effort into promoting the use of standardised electronic communication in the fruit and vegetable supply chain. The aim of FruglCom is to get all parties involved in order to make the standards actually work. For this reason, FruglCom informs various parties and tries to convince them of the benefits standardisation will bring. They also organise meetings to establish communication standards. FruglCom applies the GS1 standard.

This standard is broadly used throughout the world. This allows Dutch parties to stay competitive at a global level. The GS1 standard exists of multiple codes and a range of numbers. The main benefits of this standard are improved traceability, and the ability to attach knowledge about content, storage and shelf life, origin, quantity and quality. The success of the implementation of the GS1 standard is mainly dependent on the number of parties involved (network effect, see chapter 5).

Source: www.frugicom.nl.

3.2 Information sharing

In the previous section, we argued that information sharing plays a key role in co-ordinating FSCNs. ICT plays a key role as enabling technology in organising information sharing. The alignment of business processes is the most ideal level of information integration. Integration requires information management (see chapter 4) as well as technological devices. In this section, we elaborate the role of two emerging technologies: the Service-Oriented Architecture (SOA) and Software as a Service (SaaS).

Service-Oriented Architecture

Service-Oriented Architecture (SOA) is a flexible, standardised software architecture supporting the connection of ICT applications and the sharing of data. A practical example is the use of a rental car company's reservation system while one is actually consulting an airline's reservation system. SOA allows different ICT applications to exchange data with one another as they participate in business processes. The aim is a loose coupling of services with operating systems, programming languages and other technologies which underlie applications (Newcomer and Lomow, 2005). SOA separates functions into distinct units, or services (Bell, 2008), which are made accessible over a network so they can be combined and reused in the production of business applications (Erl, 2005). Because of the reuse of existing services, the same personal information does not have to be provided anymore to e.g. both the rental car and the airline company. Services communicate with each other by passing data from one service to another, or by coordinating an activity between two or more services. Applications can be used by different groups of people both inside and outside the company. The SOA concept lowers the costs and improves the quality of developing new ICT applications. SOA is rapidly becoming a standard approach for enterprise information systems.

Software as a service

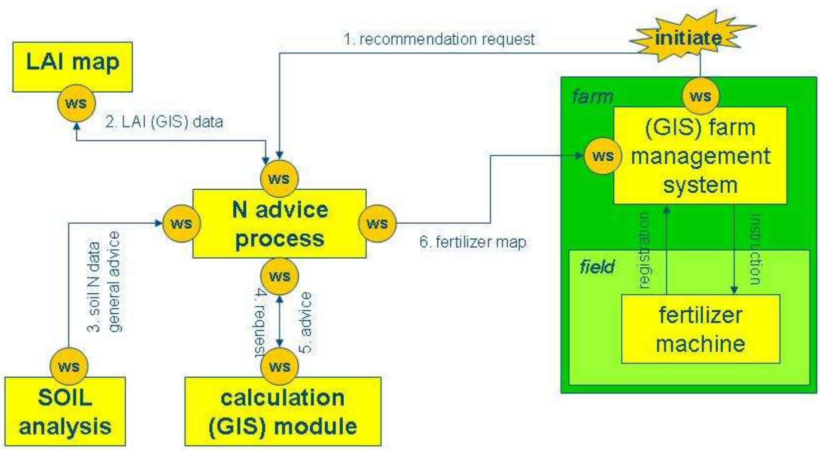
Software as a service (SaaS) is a model of software deployment where an application is hosted as a service provided to customers across the Internet. By eliminating the need to install and run the application on the customer's own computer, SaaS alleviates the customer's burden of software maintenance, ongoing operation, and support. Using SaaS also can reduce the up-front expense of software purchases, through less costly, on-demand pricing. From the software vendor's standpoint, SaaS has the attraction of providing stronger protection of its intellectual property and establishing an ongoing revenue stream. The

SaaS software vendor may host the application on its own web server, or this function may be handled by a third-party application service provider (ASP). This way, end users may reduce their investment on server hardware too (Wikipedia, 2008d). SaaS is successfully applied especially in the field of marketing and sales (e.g. web shops, e-market places, et cetera). This emphasises that the service itself (buying, selling, procurement, et cetera) is leading and software is just a tool.

Exhibit 3.3 SOAs in farm management

Precision fertilising is a practical example of service orientated architecture (SOA). In this business case, a Farm Management System (FMS) is integrated with fertilisation instructions provided by a platform of suppliers.

The fertilisation advice process is the central process that initiates all the actions (see the figure below). The FMS requests a recommendation for a specific field with a specific crop (1) activating the web service containing the fertilisation advice process. It automatically verifies whether the data are valid. The process engine requests a leaf area index (LAI) data (2) according to a standard format. In parallel, the process engine requests the soil data (provided by a laboratory like BLGG) and the general advice for the specific field. All the data are combined into a request (4) to an advice module. This module must be able to calculate an advice (5) for each raster point so that the fertiliser machine can be instructed on the basis of a fertiliser map of the ISOBUS standard (6) (Wolfert, Verdouw and Beulens, 2008).



3.3 Ten disruptive technologies

Gartner has given an overview of the top ten expected most disruptive technologies for the decades to come, technologies that unexpectedly displace already established technologies (www.gartner.com). In general, disruptive technologies lack refinement, or have performance problems because they are new. Disruptive technologies can be put aside against sustaining technologies, which rely on incremental improvements to an already established technology (Christensen, 1997). These technologies still need to find their way to our daily society, and more specific, to the agro-food sector, but may have a major impact in the near future.

- *Multicore and hybrid processors* are processors that are technically offering enhanced performance, reduced power consumption and more efficient simultaneous processing of multiple tasks. This implies that the complexity of tasks performed by computers can still grow.
- *Virtualisation and fabric computing:* computer resources are abstracted from their physical characteristics so that technical details are hidden. Fabric computing combines powerful server capabilities and advanced networking features into a single server structure. When more capacity is needed a group can be networked together easily. Everything is done on hardware at full speed, where one can control the entire fabric instead of reconfiguring machine by machine. The network becomes a single machine, which means transparent access to computing power, storage space but also application software (services), information and knowledge.
- *Social networks and social software* are based on software that supports the building of online social networks and communities, consisting of people who share the same interests and activities. Present examples are Facebook, MySpace and Flickr. With the possibilities that arise with social networks, also small and medium-sized enterprises (SMEs) can share their knowledge and keep up with the latest developments (see exhibit 3.4 for another example).

Exhibit 3.4	**Social Network**

The platform Potplantennet (www.potplantennet.nl) has been established in order to strengthen the sector, as one of the elements of the SierteeltNet organisation. www.potplantennet.nl is an Internet start page, or portal, for producers, manufacturers and subcontractors in the sector. The website visitors can disclose specific information on cultivation. Also, various knowledge items are presented here. The website offers a well-organised interactive trading platform for equipment, greenhouses and plant materials. Through this site people related to the specific niche of 'potplants' can find each other easily.

Furthermore, besides the Horticulture Agenda, vacancies in Glasshouse Horticulture and the latest Growers News, there is also a focus on the following issues:

- *Tuinbouw Vraagbaak* - experts can ask other experts for advice;
- News for professional florists;
- *Hortitube* Horticulture movies, in the style of YouTube;
- *APX Electra Dagmarkt*, with financial results and news.

The interaction between the various parties in the horticulture supply chain and the mutual interaction between growers is seen as a very important function of the website. The medium of the World Wide Web makes it possible for many small and larger parties to find each other in one place, accessible from every office or single computer, sharing the same services, products and knowledge with parties spread over the country or even abroad.

Source: potplantennet.nl.

- *Cloud computing and web platforms* are computing resources that are owned and operated by a third-party provider on a consolidated basis in data centre locations. The target-users are not concerned with the underlying technologies, so it is sold as a service available on demand. Grid computing is a technology for managing a cloud. These technologies can be used to outsource high-performance ICT applications.
- *Web mashups* are applications that combine data from more than one source into a single integrated tool. One of the sources often used is Google Maps, see e.g. www.afstandmeten.nl. There are many implementations conceivable where web mashups can be a great support for actors in the agro-food sector. Think e.g. of web mashups where information about weather conditions and market information are combined into one tool. Web mashups also provide opportunities to integrate technical and economic models, e.g. models at Alterra and LEI.
- *User Interface technology* will encounter various developments and transformations in standards. Both user experience and technical possibilities will

change tremendously, which can already be seen in e.g. the iPhone by Apple or in the new Rich Internet Applications (RIA) web language. Web-based applications will soon enable a user experience that is as advanced as desktop applications.

- *Ubiquitous computing* is about information-processing capabilities integrated into everyday objects (car, kitchen, climate control, et cetera) and activities. The computing services will take over various tasks to serve convenience and cost-efficiency. This will also have considerable impact on agro-food chains, including the consumer. A consumer can be informed that he has run out of milk or, alternatively, the milk may be automatically ordered.
- *Contextual computing* extends current systems with abilities to detect contextual information about users, documents and systems, and to represent it, to manipulate it and to influence the behaviour of applications in order to better support users.
- *Augmented reality* deals with the combination of the real world and computer-generated data. Think e.g. of applications with GPS. The applications might also be seen as extensions of the human body. Think also e.g. of immersive gaming.
- *Semantics* will be discussed below in the context of the Semantic Web.

To conclude, we can state that from the technological point of view new developments in ICT will, in some way or another, increase the computational power and transparency of the collective information system. Moreover, the threshold for accessing this technology will decrease and its perceived intelligence will increase. In other words, the idea of the network as a 'massive collective brain' is coming into reach. It will contribute to the effectiveness of supply chains because all required information is made available instantaneously. Moreover, this information is combined with knowledge, creating new insight and innovation. However, even though technological advance is moving forward almost autonomously, social and political issues may cause barriers or even unintended effects in the applications.

3.4 The Web

Initially, the Web was a new medium (the Internet) with mainly the characteristics of already existing media. In the early days, for example, e-mail was seen as a digital manner of writing letters and a website could have been seen as a digitised brochure with exactly the same text, pictures, information as the printed version. Rapidly the medium got features that were characteristic of the Internet:

- *Hyperlinks*, enabling new ways to navigate through otherwise linear text. It allows the organisation of information different levels, from general entry level descriptions to detailed expert knowledge;
- *Interactivity*. Two-way traffic allows instant communication across the world;
- *Multimedia*. Text is augmented with graphical material, audio, video, et cetera;
- *Availability of low-threshold technology*, creating a high participation rate (for example, everyone can create his own website);
- *Scale*. The world-wide penetration of the web creates an impact of its own, the Internet has become a mass medium.

Exhibit 3.5	**Friend Of A Friend**
FOAF (Friend Of A Friend) has been in development since 2000. The basic idea is that when people publish information about themselves in the FOAF format on the web, machines are able to make use of that information. So with FOAF a web of machine-readable pages is created that describes people, the links between them and the things that they create and do. For example, an expert on food technology can be found automatically once he has published this information in the FOAF format.	
Source: www.foaf-project.org/.	

Having become a network using hyperlinks and multimedia information, the Internet has created the fundaments for the Social Web, or Web 2.0 applications. The term Web 2.0 has been introduced by Tim O'Reilly in 2002 (O'Reilly, 2005) and has become a widely used term today. Central to Web 2.0 applications is the social aspect of participation. In this framework, web-based communities have arisen. Also, web-hosted services originated, such as social-networking websites (like www.facebook.com) and wikis (like www.wikipedia.org). These are websites where many people share their knowledge and correct each other until the information is complete and reliable. Also blogs (web-logs, websites with texts messages, often combined with pictures, audio and video) around a topic or around someone's personal life, with for example an opportunity for the users to interact are a typical example of Web 2.0.

A significant expansion of Web 2.0 is called the 'Semantic Web.' Sometimes this is referred to as Web 3.0, although it is doubtfully a sequel of Web 2.0, for it has been under development for some time already. The term Semantic Web was coined by Tim Berners-Lee (Berners-Lee, Hendler and Lassila, 2001). In the

Semantic Web plain content (words and sentences as sequences of 'characters') becomes connected to the meaning of the content as understood by people. In this way semantic search engines can search and link information in a way previously only people could do, which offers great advantages. When the Semantic Web is developed to its full potential, an environment will be created where software agents are roaming from page to page, carrying out sophisticated tasks by users, offering a rich user experience where many applications are linked to each other. This offers the user great comfort and ease. For example, with the help of the Semantic Web various sources of information in the agriculture domain (about the weather, prices, equipment, crops) can be combined (Haverkort et al., 2006). This way a farmer can easily find out what is the best moment to harvest crops and how to sell them in the most economically and organisationally advantageous way. The Semantic Web could for example also give advice on choosing the right products to plant in the next seasons.

From a technological point of view, the first component of the semantic web is XML. This technique allows users to add arbitrary structure to content of their documents, but says nothing about what the structure means. Here the capacity of RDF (Resource Description Framework) assists the Semantic Web, since it creates associations between concepts that are expressed. Each concept is defined uniquely across the web, thus minimising ambiguity and misinterpretation. In addition to the concepts and the relation between concepts, inference rules can be defined, representing specific domain knowledge (if … then ...). This is a first step towards a situation in which machines understand the meaning of human communication. One step further, the Web Ontology Language OWL adds logical reasoning capabilities to this. With OWL reasoning engines can check for example consistency and completeness of knowledge models. These models are called ontologies, ranging from weakly structured vocabularies, thesauri and taxonomies to full-fledged knowledge bases. Presently, Semantic Web research focuses on connecting and disclosing heterogeneous information sources on the web. However, future Semantic Web services will do much more. They will act as intelligent advisors on any subject in a personalised manner.

Exhibit 3.6	Food Informatics

How did we once make that trial product using starch? What was the outcome of the sensory panel for that product again? How do these data relate to that recent study in the US? In the world of food science this type of question is being asked continuously. R&D - in particular in the context of open innovation - becomes more efficient and effective if relevant and reliable information is available at one's fingertips. Even better, the information is checked and pre-processed automatically. This requires an infrastructure that safely shares research output, controls experiments, performs computations, and reasons about data and models from various origins. It is crucial that all data, text, graphs and images are interpreted and applied correctly. This requires attention for the logical, *semantically enriched* side of research information.

Food Informatics is an application project (part of the research programme Virtual Lab e-Science VL-e), focusing on R&D in food. In this project, Unilever, Friesland Foods, TI Food and Nutrition, TNO en Wageningen UR-AFSG work together on semantics for food data. By for example annotating reports and publications with concepts from the food domain, relevant information can be found much more efficiently than before. Moreover, the boundary between textual information, digital data and models, graphs, audio and video is fading. This project has made the first steps towards the world of e-science. In this world, researchers cooperate across project borders to create scientific lines of reasoning, which are automatically linked, checked and expanded. Data from various sources - with unambiguous quantities and units - are used directly as input to models via digital services. Information is presented at will in any form, suitable for a specific audience. And finally, IPR and confidentiality are properly ensured.

Source: www.foaf-project.org/.

3.5 Information and knowledge management

Knowledge creation, accumulation, combination, dissemination and activation have become essential in our present economy. This is true for optimisation of running processes and existing products, but even more for real innovations, leading to original and unexpected solutions. Knowledge management is becoming a core activity in today's industry, trade and other business areas. Knowledge management focuses on:

- Organisational learning from present employees, but also from running processes. We refer to the *knowledge spiral* of Nonaka (Nonaka and Takeuchi, 1994) for transformation between implicit and explicit knowledge, or *business intelligence* as the general activity to learn from process data;

- Lifelong learning of individual employees;
- The availability of skills, expertise and technological infrastructure to be able to receive and absorb knowledge. The technology adoption rate may be quite different for different areas of business;
- Obtaining knowledge from elsewhere. Properly working knowledge chains are required, which include academic research, applied research, consultants, professional education, et cetera. The above-mentioned initiatives attempt to build new knowledge chains.

In the context of innovation it is crucial that knowledge is shared. However, knowledge sharing is typically a long-term interest at organisational level. Individual professionals and experts still often fail to recognise the advantages of sharing their knowledge with others (Top and Broersma, 2008). Three conditions need to be satisfied before a general attitude towards knowledge sharing arises. First, social, psychological and political borders have to be removed (motivation, incentives, interests, trust, credits, commitment, time). This is a cultural change that is not easy to bring about. Secondly, processes, standards and agreements are needed to get the 'flow of knowledge' going. Agreements on knowledge collaboration between organisations have to be supported by detailed descriptions how knowledge transfer is actually implemented. Third, a technological infrastructure is required to make knowledge sharing easy, cheap and attractive. Wikipedia for example is apparently successful in luring people to ventilate their knowledge. The use of ICT technologies has helped to support the shift towards more open, collaborative and network-centered innovation practices (Dogson, Gann and Salter, 2006).

4 Managing ICT and FSCNs' transparency

This chapter highlights ICT adoption by companies and FSCNs. The chapter investigates whether the supply of new ICT technologies identified in chapter 3 matches the social and economic demands identified in chapter 2. This chapter analyses the match between demand and supply from a company and FSCNs' perspective. The next chapter discusses the implications of ICT adoption at the market level. This chapter is organised as follows. In section 4.1, we present Business Process Management as a way to align a company's supply with customer demand. In section 4.2, we discuss the impact of ICT on transparency in FSCNs. This section discusses transparency, traceability, open innovations and living labs.

4.1 Managing ICT adoption: matching demand and supply

Businesses and supply chains may match demand and supply by applying Business Process Management (BPM). BPM is a method of efficiently aligning an organisation with the wants and needs of clients. It is a holistic management approach that promotes business effectiveness and efficiency while striving for innovation, flexibility and integration with technology. As organisations strive for attainment of their objectives, BPM attempts to continuously improve business processes. A business process is a collection of related, structured activities that produce a service or product that meets the needs of a client. These processes are critical to any organisation as they generate revenue and often represent a significant proportion of costs (Wikipedia, 2008a). Business processes are an important concept for facilitating effective collaboration. Therefore, the businesses processes are the key instruments for organising these activities and for improving understanding of their interrelation (Weske, 2007). BPM can be used to understand organisations through expanded views that would not otherwise be available to organise and present. These views include the relationships of processes to each other which, when included in the process model, provide for advanced reporting and analysis that would not otherwise be available.

BPM as such is not an ICT technology. However, nowadays business processes are so complex that the designing of the information system goes hand in hand with the overall structure of the organisation of business processes

(Van der Aalst and Van Hee, 2002). Besides, because information about the process and the product must be shared with others, the tight connection with an information system is obvious. Moreover, business processes should be leading in designing the information system (Verdouw et al., 2007). In that respect BPM can be considered as bridging the often separated cultures of business and IT managers.

The connection between BPM and ICT is made by Business Process Modeling which can also be abbreviated by BPM but is essentially not the same as Business Process Management. BP Modeling is the activity of representing both current ('as is') and future ('to be') processes of an enterprise, so that current process may be analysed and improved. BPM is typically performed by business analysts and managers who are seeking to improve process efficiency and quality (Wikipedia, 2008b). The process improvements identified by BPM may or may not require IT involvement, although that is a common driver for the need to model a business process, by creating a process master. Change management programmes are typically involved to put the improved business processes into practice. With advances in technology from large platform vendors, the vision of BPM models becoming fully executable (and capable of simulations and round-trip engineering) is coming closer to reality every day. BP Modeling addresses the process aspects of an Enterprise Business Architecture, leading to an all-encompassing Enterprise Architecture. The relationships of a business proces in the context of the rest of the enterprise systems, e.g. data architecture, organisational structure, strategies, et cetera create greater capabilities when analysing and planning enterprise changes.

Exhibit 4.1	BPM in Canadian Poultry Processing

Pinty's Delicious Foods, an Ontario-based producer of fresh and frozen chicken products, drastically cut down delays in sales reporting and improved its data analysis capabilities by automating these procedures using *business process management (BPM)* software tools. The company recently launched the 'Golden Egg' project, which aims to increase productivity by using applications from Business Objects and SAP.

One of the key areas where project Golden Egg will make a big impact is in the migration of reporting processes from a largely manual task using an Excel spreadsheet software tool to a fully automated process. The company expects to cut delays in this area giving accountants and analysts more time scrutinising data and making business decisions rather than building reports.

Currently, it takes around five days for Pinty's employees to generate sales and financial reports. Because the process also involves manual cutting and pasting of data from various sources into Excel spreadsheets, it is not uncommon for errors to occur. Rectifying these errors can add more delays. Many organisations employ spreadsheets such as Excel because employees are familiar with the software, even though spreadsheets are often inadequate for more complex tasks.

Source: www.itcanada.ca.

4.2 Transparency in FSCNs

4.2.1 Transparency

Information governs the relationship between suppliers on the one hand and customers and consumers on the other hand. Within supply chains, information governs the relationship between a chain of participants on a range of issues. With respect to information, one may make a difference between the past, the present and the future (after Hofstede, 2007, Hofstede et al., 2004). Information on the past requires less strategic interaction and trust than information on the present, let alone the future.

- *History transparency*
  This level is about knowing the product and process history of food flowing through the FSCNs. Its promise is to improve recall management and prevent calamities. It is discussed below in section 4.2.2 as 'traceability'. The technology is rapidly being put in place by companies in the food sector, particularly the large ones. It is being enforced by laws and by the threat of accountability for food scares. RFID technology is rapidly making detailed history transparency affordable in many agri-food sectors (see exhibit 4.2).

Exhibit 4.2	Electronic identification of animals and products

An advanced way to stay well informed about animals and their well-being is to use electronic methods, instead of the more traditional identification methods, certificates and information systems. One way to do this is to use transponders transmitters and receivers of information - for example electronic earmarks, BOLI (Barcode Of Life Initiative; a form of DNA-bar coding, which is becoming a standard for identifying species) or tag injections (which can be done with animals as well). These identification methods can store information or codes about the related animal or certificates. There is interest in both the dairy sector and in the calf meat sector for this electronic identification method, in particular registration of additional information on the chip that can be put in earmarks.

What counts for animals, also counts to some degree for products. Instead of adhesive labels with barcodes one could use electronic labels which are based on RFID technology. However, the present costs of electronic identification still hinder the application in products.

Source: LNV (2008), Onderzoek informatie-uitwisseling ketengarantiesystemen.

- *Operational transparency*
  This level is about knowing what is happening across the FSCNs. It involves keeping partners informed on one's logistics and other operational parameters. Its promise is to improve the effectiveness, efficiency and responsiveness of FSCNs, for instance by reducing waiting times and stocks. Examples of operational transparency are SCM (Supply Chain Management), VMI (vendor-managed inventory) and co-operative planning. In practice, ownership and co-ordination issues frequently limit the quality of operational transparency.
- *Strategy transparency*
  This level is about deciding what may happen in the FSCNs. It involves creative investigation of the FSCNs' context to find opportunities and threats and to design adaptive responses. Joint innovation is a case in point. Strategic R&D alliances are vehicles for strategy transparency. Strategy transparency demands high levels of trust and it is vulnerable on that account. The usual growth path in the food sector would be to start from history transparency. This forces FSCNs' partners into contact and can be the opportunity to grow to operational and perhaps to strategy transparency.

4.2.2 Traceability

Traceability is a special case of transparency. In EU food law, *traceability* is considered as one of the main instruments to guarantee food safety and to reduce the size of a product recall. With respect to traceability, the General Food Law (GFL) states that companies must be able to identify the suppliers of its raw materials and the customer of its end-products on a transaction basis. This general traceability requirement is non-prescriptive but encompasses all food and feed business operators including primary producers. Retailers of goods to the final consumer are exempt from the requirements of forward traceability. The basic idea of tracking and tracing is the possibility to determine where a certain item is located and to trace the history of that item. On the basis of that information, it should also be possible to determine the source of any (quality) problem of an item, and it should be possible to find out where the other items with the same problem are located in the supply chain. In literature the concept of traceability is often used as synonym to tracking and tracing.

Exhibit 4.3	**Traceability at Van Drie Group**

The Dutch Van Drie Group is the world's market leader in veal. The group is made up of more than 20 companies constituting the world's largest veal integration. The Van Drie Group provides 20% of all European veal (www.vandriegroep.com). The group processes 1.4 million calves each year, 95% of which are exported all over the world.

The Van Drie Groep has developed Safety Guard, an integral chain management system. The core of the management system is an extensive tracking and tracing (traceability) system. The Safety Guard chain management system makes it possible to trace the history of each individual calf that is being handled throughout the entire chain. The individual earmark of the animal, the ID code, remains in place in the final product and forms the foundation of all stages of the production process. The individual animal can even be tracked through the boning plant, independent of the number of cuts in which it leaves the slaughterhouse.

Traceability has impact on chain level, as well as on company level. On *the company level* a system should provide information on the location of the product and on the history of the product (product and process information). On *the chain level*, besides information on the location of products, also information on the origin of the product is important. In this regard it is also important to identify the current unique characteristics of lots (components) and the historical relationship between lots.

4.2.3 Implications for R&D and innovation

Open innovations

Innovation processes are open if the development of new product and processes involves different categories of partners in FSCNs, in particular customers or consumers (AWT, 2006). Companies are demonstrating a greater openness to external knowledge and to new organisation models and principles in order to accelerate innovation. SOAs (chapter 3) provide the technological infrastructure for realising open innovations. Open innovation is often contrasted with a closed innovation model, based on knowledge protection and the development of innovations within an R&D department. There are several reasons why this closed model is under pressure, including mobility of knowledge workers, the higher level of education among the working population, availability of venture capital, et cetera. These factors make external cooperation and knowledge exchange simpler and, often, necessary (Chesbrough, 2004). Open innovation is in fact a collective term for several trends that have been recognised by researchers for quite some time. These trends include the role of lead users and the organisation of R&D in network relationships.

Exhibit 4.4	**Open innovations at Procter & Gamble**
Procter & Gamble (P&G) is one of the world's largest and most successful consumer business. P&G has a substantial R&D organisation, with over 6,500 scientists. In June 1999 P&G launched a new strategy to increase growth through innovation called Organisation 2005. One of the main aims was to stimulate innovation by making P&G internally focused and fragmented communications more outwardly focused and cohesive. The objective of the new strategy of P&G using open innovation practices is to turn more technologies into products. Some products are from ideas from outside sources, by investing money from P&G. Throughout the study, numerous members of P&G staff referred to the significant cultural changes accompanying the move towards an open innovation strategy. It is estimated that P&G's innovation success rate has more than doubled, and R&D productivity has increased by nearly 60%.	
Source: Dogson, Gann and Salter (2006).	

The literature on innovation contains numerous examples showing that multinationals in the Netherlands no longer innovate solely through their own R&D departments. Philips and DSM are well-known examples. However, the telephone survey and the analyses of secondary data sets show that small and medium-sized enterprises also frequently make use of open forms of innovation. In fact, SMEs have been using the open innovation method for many years. Because of their limited size, they lack the specific infrastructure needed for closed innovation and have to rely on contributions from and cooperation with other parties (see exhibit 4.5). Very few SMEs have their own R&D department.

Exhibit 4.5	**Horizontal alliances enable innovation**
How can small and medium-sized enterprises be a powerful partner to ICT companies, so that they can innovate without having to merge into large companies? This was recently shown by a group of 35 potted-plant growers in the Westland region in the Netherlands. By joining forces in the association 'Plantform' and attracting an ICT consultant they were able to professionalise their ICT while remaining independent enterprises. Crucial elements of their success were: starting with a clear goal, creating independent leadership, being transparent and professional about dividing tasks, being explicit about the aspects on which you collaborate and those on which you compete.	
Source: Hofstede and De Mos (2007).	

Living Labs

Large-scale innovation requires experimentation with a large variety of technologies, and access to a wide range of potential service providers and users, from early on in the development phase. Local, regional, national and European policy makers are rushing to establish or support joint test and experimentation facilities as pivotal tools to drive broadband innovation. Living Labs are one of these broadband innovation methods.

A Living Labs (LL) is an environment where the end-user takes part in the creation of new products and services (Garcia Guzman et al., 2007; Mulder et al., 2007 and Fahy et al., 2007). They represent a user-centric innovation approach for sensing, prototyping, validating and refining complex solutions in multiple and evolving real life contexts. LLs promote an alternative innovation paradigm, the end-user's role shifts from research object to a pro-active position where user communities are co-creators of product and service innovations (see exhibit 4.5). The Living Labs concept should be distinguished from other approaches such as test beds (laboratory environment) and field trials (test of a technology or application in a limited but still real-life environment). The LL approach is applied at every stage of the innovation process: (1) sensing and identifying consumer and business needs, (2) prototyping new solutions, (3) testing new solutions, (4) pre-market validation and (6) test pilots.

There is now an emerging movement to tailor the Living Lab concept to ICT applications. The purpose of this particular Living Lab is promoting the usefulness and usability of ICT applications. The development of an ICT Living Lab is based on the belief that the full potential of ICT today is not achieved by the continuous invention of new technical applications, but rather by understanding the user situation. New ICT applications should be solutions matching the changing demands in society.

Exhibit 4.6	**European Living Lab initiatives**

CoreLabs

As of 20 November 2006, under coordination of the CoreLabs project, a 'first wave' of twenty Living Lab sites across Europe has joined forces to set up a sustainable network to develop and offer gradually growing sets of networked Living Lab services. This European Network of Living Labs (ENoLL) aims to be a strong tool for making the industry innovation process more efficient and dynamic by involving citizens in the development of new services, products and societal infrastructures and is a step towards a New European Innovation Infrastructure.

One of these CoreLabs, Ami@netfood, has introduced a strategic research agenda (SRA) to address key challenges and identify the ICT research needs of rural development and the agri-food sector. This SRA is being developed as a key tool for European policy makers for elaborating long-term strategies in these domains. On the basis of these challenges the Strategic Research Agenda outlines four research and technology programmes and proposes a number of specific objectives for each:
1: ICT applications for the complete traceability of agri-food products and services throughout a networked value chain; 2: Collaborative environments in agrifood and rural areas;
3: ICT as key enabler to support innovation and development in rural areas creating value for citizens and businesses; 4: Innovative ICT applications in rural areas using broadband infrastructure.

Exhibit 4.6	European Living Lab initiatives (continued)

Rural Living Labs

Within the LL movement the Rural Living Labs (RLLs) play quite a pioneering role. They are united within the EU-FP6 Integrated Project named Collaboration at Rural (C@R). C@R is dealing with the problems of introducing innovations based on ICT Collaborative Services in Rural Areas. Rural living is characterised by widely-distributed activities of work and life. Successfully integrating these activities and multiple roles requires that solutions design is driven by human-centric innovation principles, adapted to the rural requirements.

In the Cudillero Living Lab the goal is to offer technical support and services to users involved in the fishing industry in order to facilitate their daily tasks using the collaborative environment supported by the platform proposed in C@R. Cudillero LL will serve to develop applications based on collaborative technologies to improve processes in small vessels devoted to the 'hake fished by hook' fishing art. The applications are intended to include functionalities to manage alerts on board, catches reports and technologies for collaboration on board-on shore. Cudillero is taken in the context of C@R as an example to implement this collaborative environment with the final idea of spreading it out to the rest of rural coastal areas with similar characteristics.

Source: www.c-rural.eu.

5 ICT adoption and market structure

This chapter discusses the economics of ICT adoption and the impact of the ICT revolution on market structure. Competition is shaped by three key determinants of market structure: market concentration as determined by the number of firms and their market share, transaction costs and the transparency of markets. We will discuss these three elements consecutively in section 5.2. Section 5.1 discusses ICT adoption and diffusion.

5.1 Diffusion processes

The impact of ICT depends on a series of inventions and innovations each of which is adopted by a user and subsequently by another user and so on. The impact of ICT on productivity depends on the speed by which ICT applications spread through the economy and society.

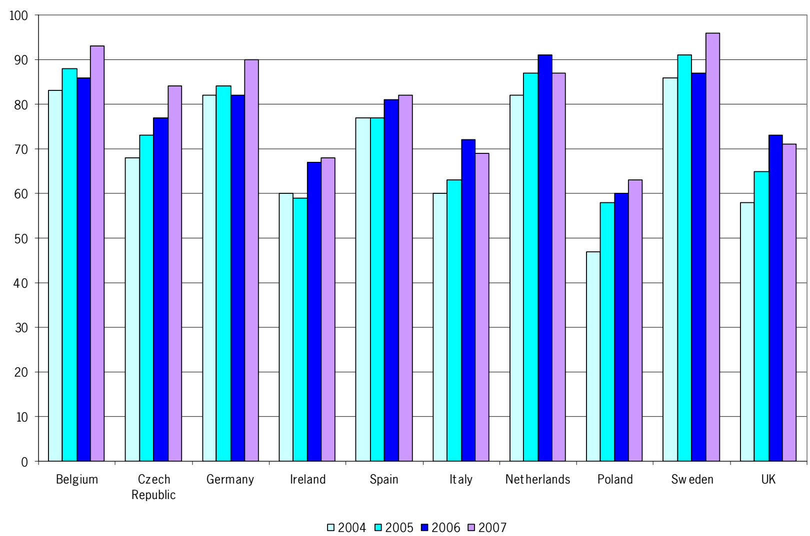
The diffusion of new technologies takes time, sometimes a lot of time. There are various examples of new technologies which require a long period of time before they are adopted, even if the benefits seem self-evident (Geroski, 2000). Typically, new technologies gain ground slowly before they spread with some speed through the economy until demand for the new technology becomes satisfied and the spread of the new technology drops off. The literature on technology diffusion presents this diffusion pattern as a stylised fact in the form of an S-curve.

> 'Diffusion rates first rise and then fall over time leading to a period of rapid adoption sandwiched between an early period of slow take up and late period of slow approach to satiation.' (ibid., p. 604)

Exhibit 5.1	Diffusion of ICT application in the EU

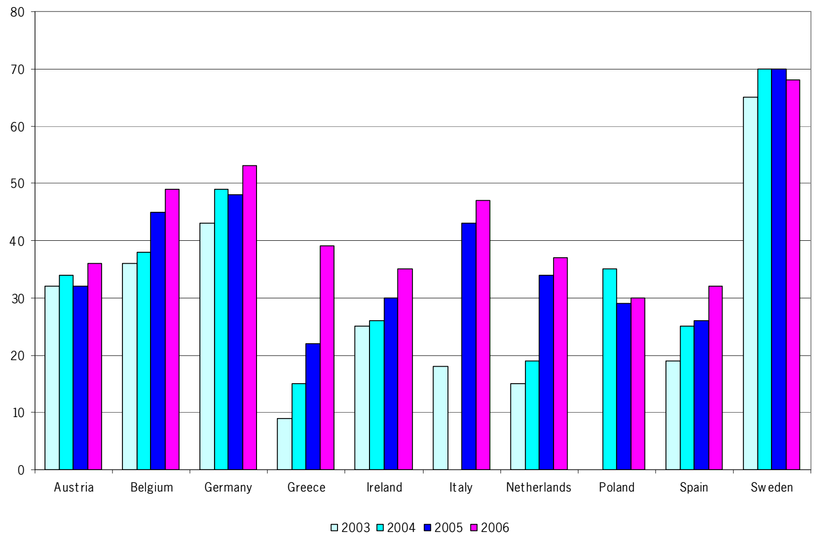
Figures 5.1 and 5.2 provide two examples of the diffusion of ICT applications in the EU. The EU has fairly good data on ICT production and use, be it at a relatively high aggregate level. The data distinguish economic sectors at the one-digit level (manufacturing and trade), and do not allow analysis at the two-digit level (food manufacturing and general merchandising). It may very well be possible that individual EU Member States have more refined data. Figure 5.1 shows that most European traders use either Extranet, Intranet, LAN or wireless LAN and that the number of traders using at least one of these technologies is still growing. Figure 5.2 shows that 30 to 70% of European manufacturers use the Internet to receive digital goods and services. This percentage is still growing in most countries, with the exception of Sweden, where already 70% of the firms use the Internet for this reason. In the next section, we pay attention to diffusion patterns in e-commerce.

Figure 5.1	Percentage of firms using either Extranet, Intranet, LAN or wireless LAN (wholesale and retail trade)



Source: EU.

Figure 5.2	**Percentage of firms receiving digital goods through the Internet (manufacturing)**



Source: EU.

Diffusion of new technologies takes time, because the adoption of a technology is a social phenomenon involving the choices of many people, often in an interdependent manner. Before a new technology is adopted, people need time to find out that a new technology is available and they need to be convinced that the new technology is an improvement over existing technologies. And even then, the diffusion of technologies is typically slower than the diffusion of information. It is relatively easy to buy and install an ICT application. It is less self-evident that the ICT application is used effectively. In order to do so, a thorough knowledge base is required. Part of the knowledge may come with the user manual; other parts come with experience and may very well remain tacit, i.e. embodied in an organisation or even in an individual. The adoption of ICT applications requires well-educated employees with the incentives to act independently as well as interdependently.

Because the benefits of ICT adoption depend on the diffusion process, both entrepreneurs and policy makers are interested in speeding up this process. For this reason, it may be good to elaborate some of the factors influencing the diffusion speed.

(1) ICT is not a stand-alone technology. ICT contributes to firm performance, but only when it is complemented by other investments and activities such as changes in work organisation (OECD, 2003). ICT is a co-invention technology opening up a variety of innovation potentials such as restructuring organisations (delegation of responsibilities and reduction of hierarchy), re-engineering business processes (just-in-time management and e-commerce) and developing new products (Hempell et al., 2004). ICT networks improve firm performance, because they allow firms to outsource activities, to strengthen relations with suppliers and customers and to improve logistics by reducing lead times and inventories. The Zentrum für Europäische Wirtschaftsforschung (ZEW) concludes for Germany that investments in ICT increase the returns of product and process innovations or *vice versa* (OECD, 2003).

(2) The diffusion of new technologies passes more quickly if potential users are located in the same region. Geographical distance is a factor in spreading information on new technologies, their benefits as well as the knowledge required to apply them. Baptista (2000) shows that regional proximity fosters early adoption of computer numerically controlled (CNC) machine tools and microprocessors in the UK. This argument favours the formation of Greenports and other clusters.

(3) Adoption processes may be particularly slow if the benefits of a technology depend on network economies. Network economies refer to the fact that the value of a telephone, a fax or an e-mail account increases with the number of people and enterprises having a telephone, a fax or an e-mail account (Cabral, 2000; Kinsey, 2000). What is the use of a fax if your customers do not have it? What is the use of a mobile telephone if your friends do not have one?

Network economies are important in ICT. Bertschek and Fryges (2002) point out that there are substantial network economies in, for instance, e-commerce. It only pays off for Albert Heijn to start e-commerce with Coca Cola, if the soft drink producer, but also companies like Campina, Unilever and Nestlé, start doing e-commerce with Albert Heijn. Likewise, it probably only pays off for Coca Cola to start e-commerce with Albert Heijn if Coca Cola can also start e-commerce with Tesco, Aldi, et cetera. Technologies involving network economies require a critical mass. As a result, the adoption of ICT applications involving network economies may either be postponed for a long period (excess inertia) or alternatively put through very quickly (excess momentum - bandwagon effect) (Cabral, 2000). Bertschek and Fryges (2002) find for Germany that the network value of e-commerce influences the adoption decision of individual firms. The chance that a firm decides to engage in e-commerce increases with the number of firms already involved in e-commerce. Kinsey (2000) points out that open networks such as UCCNet may encourage both small and large retailers and manufacturers to join the e-commerce community. Open networks lower the costs of setting up e-commerce and reduce compatibility requirements (see below).

Network economies may not be fully realised if the standards allowing communication between telephones, faxes and e-mail accounts do not match. Again this is a major issue in ICT. When Albert Heijn develops e-commerce, it may very well develop software which is not compatible with Tesco's software. Coca Cola may very well be reluctant to engage in a large number of incompatible e-commerce relations. As a result, e-commerce does not pick up or only very slowly. Network systems such as e-commerce only arise if the system meets the expectations of the parties involved, if the technology standards are compatible and if there is some co-ordination (Kinsey, 2000).

(4) Government policies may have a large influence on the speed with which technologies spread through the economy. There are, for instance, two policy decisions which had a significant influence on the diffusion of mobile telecommunication (Gruber and Verboven, 2001). The Scandinavian countries were able to gain a first-mover advantage in mobile telecommunications, because their governments were among the first to grant the necessary licences to use the spectrum. The Scandinavian countries were able to sustain their lead until recently. The welfare costs of a technological delay may be substantial (ibid.). The spread of mobile telecommunication was further enhanced by the government decision to allow for competition.

There is discussion in the literature whether governments have a role in laying down technology standards. Some economists point out that technology standards do not come about due to the market failure called network economies and that governments have a role for this reason. Other economists point out that network economies may be capitalised by the entrepreneurs coming up with ICT applications and the standards incorporated in the applications (Kinsey, 2000). The EU tends to lean toward the first argument, the US to the second. With respect to second-generation mobile telephony, Cabral (2000) points out that the European approach worked out in the short run - due to enhanced compatibility - but that the US approach worked out in the long run - because competition lowers prices and improves technological progress.

5.2 Market structure

5.2.1 Dynamics in market concentration

Recent studies on the relation between ICT and firm performance find that there is a positive correlation between the use of ICT and productivity (OECD, 2003). This holds in particular for firms investing in communication network technologies. US and Canadian evidence points out that enterprises using advanced technologies are more likely to expand their activities and are less likely to be forced to exit an industry (ibid.). The evidence for Canada shows that this leads to major shifts in market share over a decade.

Market structures change, because firms enter and exit industries and because firms gain or lose market share. ICT influences market structure by influencing a firm's performance and thus the likelihood that firms enter or exit, grow or decline. Wal-Mart's rise in US general merchandising is a good example of the implications of ICT-induced firm performance for market structure in food retailing (see exhibit 5.2).

The long-run impact of ICT on market structure depends on the impact ICT has on economies of scale and scope (Baumol, 1982; Baumol et al., 1982; Sutton, 1991, 1998; Van Witteloostuijn, 2007). In the long run, price competition drives market structures to configurations minimising production and transaction costs and reaping all possible economies of scale and scope (Baumol, 1982), unless there are substantial barriers to entry. This basic premise also holds when product differentiation - quality and variety - is allowed for (Sutton, 1986). From this perspective, which follows the logic of the Chicago School, one would posit that Wal-Mart's size and profitability are determined by its efficiency.

There are indications that ICT increases economies of scale in food wholesale and retail trade and leads to further market concentration at the retail and wholesale level. According to Kinsey and Ashman (2000), economies of scale in food retail are due to bargaining power vis-à-vis suppliers, more efficient use of transportation and ordering systems, and the ability to utilise information technology to manage inventory throughout the supply chain. The implementation of EDI - an instrument supporting ECR - was slower than expected because only the largest retailers and manufacturers were able to invest in the necessary hardware, software, and human capital (Kinsey, 2000). Research of the Retail Food Industry Centre of the University of Minnesota shows that stores investing in data management and coordination activities tend to be large. An increase in the scale of a food retailer, e.g. through a merger, reduces purchasing costs by

0.5% and leads to cost saving throughout the supply chain by 2.5% (Kinsey and Ashman, 2000). Operating expenses of traditional wholesalers exceed those of self-distributing chains, in particular because direct labour costs are higher and inventory turnover is lower (ibid.). Almost all large retail chains in the US and Europe make use of self-distribution.

Exhibit 5.2	**The Wal-Mart revolution**

Wal-Mart's growth strategy is based on three concepts: (1) a large product assortment (big box format); (2) every day low pricing; and (3) efficiency in logistics (McKinsey, 2001). Wal-Mart succeeded in its growth strategy by pioneering in IT applications. Wal-Mart was among the first to adopt computers to track inventories in distribution centres (1969), to use computer terminals in stores to facilitate communication (1977), to use UPC codes for scanning (1980), to introduce EDI (1985), to implement a satellite communication network (1987), to use radio frequency guns (late 1980s), to expand EDI to an extranet (1991) and to develop 'Retail link' (1991).

McKinsey (2001) estimates that Wal-Mart had a 44% productivity advantage over its rivals in the US market in 1987. This advantage enabled the retailer to increase its market share from 9% in 1987 to 27% in 1995. By 1995, the productivity gap equalled 48%. Because Wal-Mart's rivals reorganised their own organisations as well as their supply chains, they were able to reduce the productivity gap with Wal-Mart from 48% in 1995 to 41% in 1999. Sears divested non-core activities and reduced the number of employees. Target, Kmart, Meijer, MacFrugals and others reacted by introducing or extending the big-box format and enhancing throughput. As a result, the increase in Wal-Mart's market share decreased to 3%.

5.2.2 Transaction costs

ICT opens up new ways of doing transactions. This holds notably for e-commerce. E-commerce started up slowly, in particular in agri-food sectors (Kinsey, 2000; Bertschek and Fryges, 2002). Business-to-business e-commerce is more developed than business-to-consumer e-commerce. The B2B segment accounts for 80% of the e-commerce market. B2B e-commerce is least developed in the consumer goods industry, retail trade and the chemical industry (Bertschek and Fryges, 2002). B2B increases firm performance in four ways: automation of transactions; creation of new market intermediaries; concentration of demand and supply; and changes in vertical co-ordination (Bertschek and Fryges, 2002).

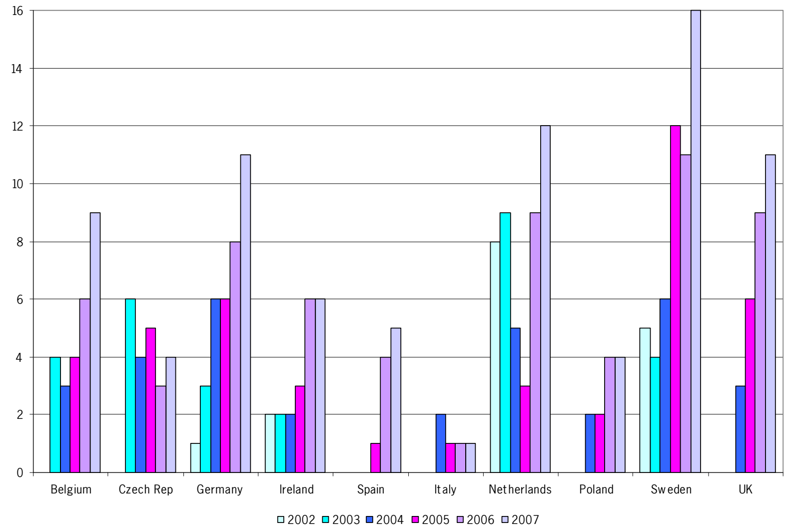
Above, we already showed that the market share of Internet sales is low in European wholesale and retail trade, but also that Internet sales grow rapidly.

Figure 5.3 shows that the number of European wholesale and retail traders selling more than 10% of turnover through the Internet is still limited, but growing rapidly. In 2007, 10% of wholesale and retail traders in Germany, the Netherlands, Sweden and the UK sold more than 10% of their turnover through the Internet. The number of manufacturers selling more than 10% of turnover through the Internet tends to be somewhat lower, but also tends to rise (figure 5.4). Italy lags with respect to Internet sales. Poland may very well take up quickly. In the Netherlands, Internet sales recovered in 2006-2007 from a drop in 2004-2005 after a quick start in 2002-2003. The number of firms selling through EDI and related networks is lower than the number of firms selling through the Internet and does not rise very rapidly (see appendix 1).

As indicated above, business-to-business (B2B) electronic commerce is still in its infancy, in particular in food supply chains, even though electronic trade has the potential to broaden the scope of potential trade partners to the European market, if not to the 'global village'. This is due to network effects (see above), but also to a lack of trust. Indeed, trust is among the main reasons why electronic commerce develops slowly (OECD, 2003). There is a lack of trust with respect to the safety of personal information including financial data (OECD, 2003). There is also a lack of trust due to the absence of personal relationships (Hofstede et al., 2008). The role of personal relationships in commercial relationships depends on cultural beliefs with respect to trust (ibid.).

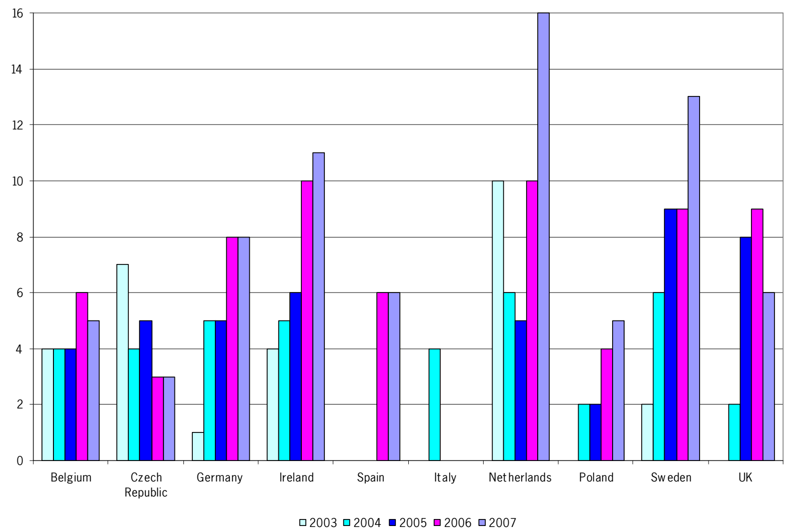
Transaction costs do not only refer to the costs of contracting commercial transactions, but also to the administrative costs of both public agencies and private companies with respect to a wide body of public regulations, such as border controls, food safety and quality regulations, et cetera. Public agencies and private companies undertake independent and joint actions to reduce the administrative costs of public regulations (exhibit 5.3). This is not unimportant given the proliferation of public regulations. The number of (European) border regulations, for instance, has increased from 100 in 1994 to 400 in 1998 (Expertise Centrum, 2004).

Figure 5.3	Percentage of firms selling more than 10% of turnover through the Internet (wholesale and retail trade)



Source: EU.

Figure 5.4	Percentage of firms selling more than 10% of turnover through the Internet (manufacturing)



Source: EU.

Exhibit 5.3	Client: Reducing the transaction costs of border control

The Client project is an example of a successful transition to digital data exchange between several parties. The Netherlands plays a central role in global distribution processes. Therefore, much time and effort is spent on the execution of border inspections, which are subjected to many import and export regulations. Animal transport is one of the main flows. The Client project was executed by the Department for Industry and Trade from the Ministry of Agriculture, Nature Management and Food Quality. It appeared that customs processes were certainly not optimal; they were paper based and not harmonised.

The solution chosen was to introduce electronic declarations and other forms. The resulting information flows were less error prone. The process could be optimised by reducing the number of checks. Moreover, the mutual exchange of electronic data between business partners was also stimulated.

First a general architecture ('map') was outlined. The electronic infrastructure was then designed and implemented in several more or less independent projects, using XML as a common data carrier. During the project, close collaboration with trade parties was considered of utmost importance. After 2.5 years the project concluded with successful pilots on import and export of cut flowers and on veterinary health certificates from New Zealand. As a consequence of this process the administrative load decreased significantly. Moreover, business communities were built that channel information exchange to and from government agencies.

The success of the CLIENT programme is among other things due to the fact that CLIENT has been developed as a policy programme. The programme was meant to solve organisational bottlenecks. Moreover, the ICT architecture and software developed was built on proven technology in order to avoid errors and loss of time. This, of course, contributed to the acceptance of the technology by all the parties involved.

5.2.3 Market transparency

From a consumer perspective, markets are transparent if they have sufficient insight into the number of suppliers as well as the prices and qualities offered to reach a balanced choice (Stefanski et al., 2002).[1] If markets are transparent, search costs - time and money spent in collecting and processing information - are low. Markets are transparent if information is accessible, understandable, reliable and comparable. In transparent markets, consumers buy the products they want in the price-quality relations they want. Electronic commerce creates the possibility for suppliers to target specific groups of customers and consumers (exhibit 5.4). Consider for instance small or tall people who probably had to

[1] For suppliers a similar analysis holds.

resort to catalogs in the period before Internet in order to find clothing, shoes or furniture. Or, alternatively, people with special dietary needs. Facilitated by electronic information, consumers also get access to information they did not have access to up until now, e.g. with respect to production conditions such as environmental and animal welfare.

ICT is likely to enhance transparency in the sense that there is more information available. ICT lowers the cost of information collection and processing, e.g. by linking public and private monitoring activities (LNV, 2008). In this respect it is also noteworthy to point to EU initiatives to re-use public sector information (exhibit 5.5).

Information provision is more likely for search and experience attributes than it is for credence attributes. When producers have an incentive to invest in their reputation, e.g. to promote repeat purchases, information provision is more likely than when reputation is not a competitive factor. Transparency is likely to make markets more competitive, e.g. to lower prices, but it does not have to. A famous example with respect to food prices in Canada in the 1970s shows that consumers react to price information by buying cheaper products and that retailers react by offering cheaper products. Another famous Danish example shows that concrete producers may abuse transparency to co-ordinate their price policies tacitly (Stefanski et al., 2002; Cabral, 2000).

Exhibit 5.4	Loyalty programmes at supermarkets

Companies are collecting all kinds of different information about the purchase behaviour of customers. In order to do this, they have incorporated all kinds of client loyalty programmes based on enhanced ICT, e.g. Albert Heijn: Bonuskaart programme, KLM Air France: Flying Blue programme). Albert Heijn is the largest retailer in the Netherlands. It owns an extensive network of supermarkets. Albert Heijn introduced the bonus card in 1997 and it has been developed ever since. For example, this card gives individual clients of Albert Heijn a discount on general promotional products.

Furthermore, loyalty programme gives the retailer the possibility to collect data of client shopping behaviour. The retailer is able to analyse consumer behaviour and it will give an enhanced understanding of why, when and what people buy. This makes it possible to translate the collected information to promotional activities. However, used until today the potential of the Albert Heijn bonus card has not been used to the fullest. The extensive amount of available customer data makes it possible to launch promotional activities that are specific for each individual client. Because promotional products are being offered that are in line with the specific demands of the client, this might eventually increase the clients spending during a single supermarket visit. In addition this may lead to a higher customer loyalty because the client is not being offered promotional products in which he is not interested.

Exhibit 5.5	EU Directive on the re-use of public sector information

A key piece of legislation affecting the use of public sector information is the European Directive on the Re-use of Public Sector Information (PSI). This is perhaps not the most widely known piece of law but is critical in that it places a duty on EU governments to create national policy on public data re-use. The European Commission (EC) describes the Directive's objectives as follows:

> 'It sets minimum rules for the re-use of PSI throughout the European Union. In its recitals it encourages Member States to go beyond these minimum rules and to adopt open data policies, allowing a broad use of documents held by public sector bodies.'

The UK Government set up an Advisory Panel on Public Sector Information (APPSI) as part of its process of implementing this Directive. There is also a new data-unlocking service, where one can make a request for certain data. In the EU there are many regulations concerning the agricultural sector. Because of this EU member states have a lot of information in databases that can be of interest. For example, information on regulations, product safety, inspections as well as permits and geological data can all be of economic value to citizens or to the (agricultural) sector. In the context of Web 2.0 (see section 3.4), the Internet will function as the platform for effectively re-using government data.

6 The knowledge economy

This chapter discusses the consequences of the ICT revolution for the economy and society. Section 6.1 discusses the impact on macroeconomic productivity. Section 6.2 discusses the impact on job content and labour conditions. Finally, section 6.3 discusses the implications for public policy.

6.1 Macro-economic productivity

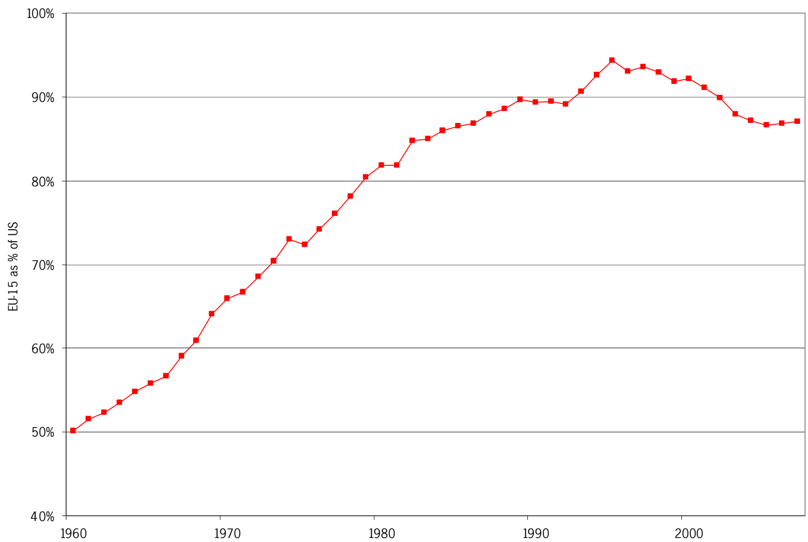
Productivity and income are key targets of the EU's Lisbon Agenda. The EU has the ambition to become the most competitive economy in the world. For this reason, the EU invests heavily in the knowledge economy. However, despite this ambition, European productivity as measured by GDP per hour has fallen relative to the US ever since 1995 (figure 6.1). As we will show below, differences in ICT-related productivity are a key explanatory variable in explaining this development. This holds in particular for the retail and wholesale trade. There is a substantial difference in the impact ICT has on factor productivity in the US and Australia on the one hand and the European Union, in particular Mediterranean countries, on the other hand (Pilat, 2004; Van Ark et al., 2008).

ICT has a major impact on productivity and income growth throughout the economy, including the food supply chain. The impact of ICT is substantial because ICT is a general-purpose technology. There are two channels through which ICT influences economy-wide productivity developments (Pilat, 2004).

- Investments in ICT increase the amount and quality of the equipment (capital) of workers. Capital deepening refers to the fact that labour productivity rises if employees have more and better equipment at their disposal (Jorgenson et al., 2008).
- Increases in the use of ICT raise overall efficiency (multifactor productivity). Multifactor productivity relates output to all production factors one may identify - capital, labour and land - and primarily reflects process and product innovations (ibid.).

Apart from both developments, ICT influences nationwide and worldwide productivity and income developments through the ICT-producing sector (Pilat, 2004).

Figure 6.1	GDP per hour worked in EU15: 1960-2007



6.1.1 Empirical evidence

There is a substantial body of empirical literature measuring the impact of ICT on labour productivity, both economy-wide and for parts of the food economy (McKinsey, 2001; Bosworth and Triplett, 2003; OECD, 2003; Pilat, 2004; Timmer and Van Ark, 2005; Jorgenson et al., 2008; Van Ark et al., 2008). On the basis of growth accounting, the literature measures changes in the growth of real output as well as the contribution of ICT and other factors.

The growth of real output depends on changes in the number of hours worked and changes in labour productivity.

Real output growth	=	Changes in number of hours	+	Labour productivity growth

The change in labour productivity may be contributed to three factors: changes in human capital of the labour force, changes in the amount and quality of capital available to the labour force, and changes in overall productivity or multifactor productivity. Human capital contributes to labour productivity growth, because the number of people following higher levels of education is still growing - in universities and colleges (polytechnics). Changes in multifactor productivity are primarily due to process and product innovations.

Labour productivity growth	=	Human capital	+	Amount and quality of capital	+	Overall productivity (MFP)

Changes in the amount and quality of capital available and changes in overall productivity may be contributed to the availability of ICT and non-ICT capital. Following Van Ark et al. (2008), we measure the contribution of the knowledge economy on real output growth as the sum of the contributions of human capital, ICT capital and multifactor productivity.

Above, we saw that European output per hour worked has fallen relative to US output per hour of worked since 1995. Despite the Lisbon Agenda, European productivity falls behind. In the US, labour productivity growth doubled in the 1990s, while European labour productivity growth declined (table 6.1).[1] The fall in European labour productivity growth is primarily due to a fall in multifactor productivity and the availability of non-ICT capital. The fall in multifactor productivity points to a lack of process and product innovations. The rise in the US growth rate is due to an increase in the availability of the amount and quality of capital and multifactor productivity growth.

[1] Due to data restrictions, EU data apply to 10 Member States only (see table 6.3).

Table 6.1	US and European productivity growth explained					
			European Union		US	
			1980-1995	1995-2004	1980-1995	1995-2004
(1)	Real output growth	(2)+(3)	1.8	2.2	3.0	3.7
(2)	- Number of hours worked		-0.6	0.7	1.4	0.6
(3)	- Labour productivity	(4)+(5)+(8)	2.4	1.5	1.5	3.0
(4)	- Human capital		0.3	0.2	0.2	0.3
(5)	- Capital	(6)+(7)	1.2	1.0	0.8	1.3
(6)	- ICT capital		0.4	0.5	0.5	0.8
(7)	- Non-ICT capital		0.8	0.5	0.2	0.4
(8)	- Multifactor productivity	(9)+(10)	0.9	0.5	0.5	1.4
(9)	- ICT capital		-	-	0.3*	0.7*
(10)	- Non-ICT capital		-	-	0.2*	0.7*
(11)	Total knowledge economy	(4)+(6)+(8)	1.6	1.1	1.3	2.6

- Not available; * Based on Jorgenson et al. (2008).
Source: Van Ark et al. (2008).

Van Ark et al. (2008) show that the difference in total productivity growth can be attributed to two sectors: distributive (wholesale and retail) trade and finance and business services. Table 6.2 shows that the contribution of agriculture, mining, manufacturing, construction, utilities, ICT production and personal services to national labour productivity growth is comparable between the EU and the US. There is wide gap for wholesale and retail trade and for finance and business services. For both sectors, the divergence is primarily due to multifactor productivity and not so much to differences in the availability of human and physical capital. Apparently, the US is able to carry through more process and product innovations in both sectors than the EU does.

Table 6.2	Contribution of major sectors to labour productivity growth: 1995-2004		
	Netherlands	EU	US
Agriculture and Manufacturing a)	0.6	0.8	0.7
ICT Production b)	0.4	0.5	0.9
Market services	1.1	0.6	3.0
Wholesale and retail trade	-	0.6	1.6
- Multifactor productivity	-	0.2	1.0
- Human capital and capital	-	0.5	0.6
Financial Services	-	0.1	1.2
- Multifactor productivity	-	-0.5	0.4
- Human capital and capital	-	0.6	0.8
Personal services	-	-0.1	0.2

a) Including mining, construction and utilities and excluding electrical machinery; b) Electrical machinery and post and communication services; - Not available.
Source: Van Ark et al. (2008) and Jorgenson et al. (2008).

Van Ark et al. (2008) posit several explanations for these differences. US retail makes more use of ICT capital (barcode scanners, communication devices, inventory tracking devices and transaction processing software). US retail may be more innovative in terms of new retail formats, service protocols, labour scheduling schemes and marketing campaigns. Finally, European regulation with respect to opening hours, land zoning and labour markets may have inhibited the rise of big-box formats such as Wal-Mart. The latter is considered to be the driving force of productivity growth in the US.

These explanations are confirmed by McKinsey (2001). McKinsey posits that two thirds of the productivity increase in US general merchandising is due to an increase in real sales per hour. The other third is due to a rise in values added per unit of sales. The increase in real sales per hour is primarily due to improvements in the organisation of functions and tasks which are made possible by information technology. The improvements refer too: cross-docking and the in-store flow of goods in-store; forecasting tools; store responsibilities and cross-training; and productivity measurements and utilisation rates. McKinsey estimates 50% of these improvements in the organisation to be IT-enabled. Wal-Mart has been directly and indirectly responsible for the jump in productivity growth in US general merchandise retail (see exhibit 5.2). IT intensity tripled during the 1990s in general merchandising. According to McKinsey, retail trade is the second largest contributor to US productivity growth from 1995-2000. Wholesale trade is the largest contributor.

There are also estimates of the impact of ICT on productivity growth for individual European countries. Table 6.3 divides the European Union into the 10 countries investigated by Van Ark et al. (2008). There are major differences between the ten European economies investigated. Finland actually outperforms the US. Austria, the UK and to some extent the Netherlands are able to follow the US in terms of labour productivity and the contribution of the knowledge economy. Spain and Italy perform particularly poor.

Table 6.3	**European productivity growth compared, 1995-2004**					
		Productivity contributions from				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	labour productivity	**labour compo-sition**	**ICT capital**	**non-ICT capital**	**multi-factor productivity**	**knowledge economy**
	(2)+(3)+(4)+(5)					**(2)+(3)+(5)**
Austria	2.2	0.2	0.6	0.1	1.2	2.1
Belgium	1.8	0.2	0.7	0.4	0.4	1.4
Denmark	1.4	0.3	1.2	0.3	-0.4	1.1
Finland	3.3	0.1	0.5	-0.1	2.8	3.4
France	2.0	0.4	0.5	0.4	0.8	1.6
Germany	1.6	0.1	0.5	0.6	0.3	1.0
Italy	0.5	0.1	0.2	0.6	-0.4	-0.1
Netherlands	2.0	0.2	0.6	0.1	1.0	1.9
Spain	0.2	0.4	0.3	0.4	-0.9	-0.2
United Kingdom	2.7	0.5	1.0	0.4	0.7	2.2
EU	1.5	0.2	0.5	0.5	0.3	1.1
US	3.0	0.3	0.8	0.4	1.4	2.6

Source: Van Ark et al. (2008).

6.2 The knowledge society

6.2.1 The knowledge economy on the work floor

In section 6.1, we argued that the European knowledge economy does not fully perform as yet. In this section, we explore the implications of the ICT economy in industrial relations - the organisation of work - at the micro-level. In section

5.1, we saw that investments in ICT generate high rates of return if they are accompanied by other investments, notably in skills and organisational change. ICT enhances firm performance if skills have been improved and organisational changes are introduced (OECD, 2003). This result is emphasised in the literature on co-invention, which argues that workers make investments in technologies more valuable by experimentation and invention. Without co-invention, the economic impact of ICT may actually be quite limited.

OECD (2003) discusses several longitudinal studies pointing out that investments in ICT are skill biased. For France, for instance, there is evidence that indicators of computerisation and research on the one hand are positively correlated to productivity, wages and the share of administrative managers on the other hand. Moreover, there is a negative correlation with the share of blue-collar workers. There is also empirical evidence for France that organisational change leads to a fall in the share of unskilled workers. For the UK, there is also evidence that the demand for manual workers declines with computerisation and that human capital, technology and organisational change are complementary. Similar results are presented for Germany, Australia and Canada. The studies for Canada point out that the demand for educated and skilled employees may remain unsatisfied due to shortages in supply. The studies also point out that the technologically most advanced companies typically are not plagued by these shortages.

The demand for skilled workers is not only related to computers as such, but also to organisational change. Investments in ICT complement organisational changes such as new strategies, new business processes and practices and new organisational structures. In the past, employees performed standardised tasks within the framework of standardised production processes. Today, workers have responsibilities in different domains. For this reason, they require multiple skills and the ability to co-ordinate their activities with other employees in a flexible way. Current work practices include team work, flatter management structures and employee involvement. Workers have a larger responsibility and autonomy. Because the organisation of work tends to be firm-specific, there are large differences in firm performance. OECD (2003) presents empirical evidence supporting this analysis.

6.2.2 The digital divide

There are important differences with respect to the use of ICT between countries, but also within countries. In section 6.1, we saw that the ICT is more widespread in the US than it is in the EU. In the EU, northern countries are more advanced tin the use of ICT applications than southern countries. Differences in culture are a key explanatory factor in this respect.

There is also an important difference in ICT use between urban and rural areas. ICT use is more advanced in urban areas than it is in rural areas. On the basis of regional data, Schleife (2006) argues that urbanisation may be an argument in explaining differences in Internet use. Urbanisation is an explanatory variable together with education, the number of one-person households, unemployment and the number of foreigners. However, on the basis of personal data, Schleife argues that urbanisation as such is not an explanatory factor. Geography merely captures such personal characteristics as type of household (one-person household), age, gender, education, nationality, income and occupational status. Network effects - the local share of experienced internet users - are also a key explanatory factor. Schleife (2006) argues that Internet literacy programmes should not target rural areas as such, but rather target groups who are predominantly present in rural areas (older and less educated people).

6.3 Public policy

In order to give some policy perspective to the literature review in this report, we briefly address the ICT agenda of the Dutch government for 2008-2011. In the Introduction, we indicated that there is a rising productivity gap between the EU and the US. In section 6.1, we concluded that this gap is due to, among other things, differences in the use of ICT capital, in particular in retail and finance. In line with the Kok Report, the Dutch Social Economic Council recently concluded that the European internal market should be strengthened in order to address the productivity gap and to put forward the Lisbon Agenda (SER, 2004). There are still major bottlenecks hindering the functioning of the European internal market. There are still barriers with respect to the trade of services including network sectors, the mobility of employees and government tenders. The functioning of the internal market is further hindered by differences in policies with respect to intellectual property rights, competition policy and taxation.[1] If the internal market is strengthened, European markets for goods, services, labour and capital may become more competitive.

[1] Other bottlenecks refer to the conversion of European law into national law. Some European laws are not converted, some European laws are not monitored nationally and laws are made needlessly complicated at the national level.

The creation of a Common Market for knowledge and education may strengthen the knowledge infrastructure for the common market for goods, services, labour and capital (SER, 2004). In order to foster the European knowledge economy, R&D expenses should be promoted (3% target), the market for higher education (polytechs and universities) should become a Common Market and the EU should be able to differentiate between European research institutes and universities and to allocate more money to the centres of excellence.

In the ICT Agenda 2008-2011, the Dutch Ministry of Economic affairs expresses the expectation that ICT applications will deliver a major contribution to labour productivity growth and other societal objectives (EZ, 2008). For this reason, it is important that on the one hand ICT applications are widely available and that on the other hand the (working) population is able to use them. In order to promote the use of information, ICT applications should be based on the needs of final users as well as on open standards (see section 4.2.3 on living labs). In the future, people will not only be passive consumers of information, but will actively consume and produce information. Collaboration in networks will play a larger role. Future generations should have adequate e-skills in order to do well in the future knowledge economy and society, skills to apply ICT applications, a comparative advantage of younger generations, but also skills to process information, a comparative advantage of older generations. The growth of ICT applications and the growth of open networks also puts increasing demands on the security and the integrity of ICT applications and architectures in order to secure the privacy of individuals and groups (RAND, 2006).

In order to let ICT contribute to economic and social growth, European governments defined three goals: the creation of an internal market for information services and goods; the promotion of innovation in ICT; and an increase in the participation in the use of ICT. The Dutch government takes the demands of the final consumer as leading when defining its priorities (EZ, 2008). For this reason, the governments invests in e-skills; e-government (public e-services); interoperability and e-standards; e-education; and the competitiveness of the e-service sector (internal market and trade liberalisation). The government also continues to invest in the basic ICT infrastructure: physical infrastructure, research, security and integrity, and competition issues such as transparency, access, et cetera.

7 Conclusion

This report elaborates the importance of the ICT revolution for the food economy. The purpose of the report is to come to a more thorough underpinning of the new food-economy concept by exploring the contribution of ICT as one of the main drivers to the evolving food economy. The report brings together a review of the literature from four disciplines: knowledge management, management information systems, operations research and logistics, and economics. The conclusions drawn are based on the literature reviewed and are not based on own research. The literature does not always refer to the food economy, but rather to the economy in general. Specific research is necessary to investigate to what extent the conclusions also hold for the food economy.

The report may be summarised as follows:

- The knowledge economy is evolving in which value added and competitive advantage depend on knowledge rather than natural resources;
- ICT is one of the main drivers of the emergence of the knowledge economy, because it enables new business practices, new skills and new industrial structures and leads to new products and services as well as improvements in quality, variety and convenience;
- There is a strong pressure to innovate in ICT. This pressure is caused by changes in market demand, increases in economies of scale, the intensification of worldwide competition and changes in logistics and sourcing;
- ICT enables a paradigm shift from closed to open innovation;
- Information sharing becomes a key factor in achieving supply chain coordination;
- Revolutionary ICT technologies include Service-Oriented Architecture, Software as a Service and the semantic web. Current and future developments in ICT are expected to increase the computational power and transparency of collective information systems. Moreover, the threshold of accessing these technologies will decrease and its perceived intelligence will increase. This will enable the new business practices, new skills, et cetera referred to above;
- Innovation requires among other things collaboration between actors and the sharing of information and organisational learning from employees;
- However, there may be barriers to information sharing. These barriers include social, psychological and political borders; poor processes and standards for knowledge transfer; and a poor technological infrastructure;

- Companies may align ICT applications to their customers' wants by Business Process Management and Business Process Modelling. Note, however, that ICT is not a stand-alone technology. ICT contributes to value added when it aligns business activities to customers' wants. ICT contributes to profits when it is combined with complementary investments. Note also that ICT applications do not guarantee sustainability. They enable sustainability. Sustainability remains the outcome of demand and supply;
- ICT applications may promote transparency and traceability in FSCNs. Open innovations and living labs are revolutionary applications of ICT technologies;
- The diffusion of ICT applications, especially revolutionary, takes years, if not decades;
- Notwithstanding the fact that ICT reduces time and space, the proximity of enterprises promotes early adoption of new applications and thus the diffusion speed;
- The adoption of ICT technologies may be slow due to network economies;
- Government policies may influence the diffusion rate of ICT technologies. This holds in particular for liberalisation policies and for standardisation policies;
- In the long run, differences in ICT and economic performance lead to profound shifts in market structure;
- E-commerce takes up after a slow start in food supply chains;
- ICT applications are likely to raise the transparency of markets and to lower the search costs of suppliers, customers and consumers. As a result, new products, transactions and markets come about;
- The EU has made a bad start in the knowledge economy. In terms of labour productivity and innovation, the EU has lagged behind the US ever since 1995;
- The US shows more productivity growth in wholesale and retail trade as well as in financial services;
- The knowledge requires a well-educated workforce with more skills and responsibility and which is better paid;
- There is digital divide between urban and rural areas. German research indicates that this divide may very well be due to personal characteristics rather than the rural environment.

The main conclusion of this report is that FSCNs develop into open networks sharing information. Open networks offer many opportunities for generating value added. FSCNs slowly become a part of the knowledge economy.

However, there are two bottlenecks in the knowledge economy:

1: companies collect many data most of which are not used at all;
2: companies are not ready to process all data available.

Managers, employees and the models they work with are not fully prepared for the knowledge economy as yet. ICT and the knowledge economy are about two issues: technologies and people. The most important challenge the food economy faces refers to getting the people ready for the new era.

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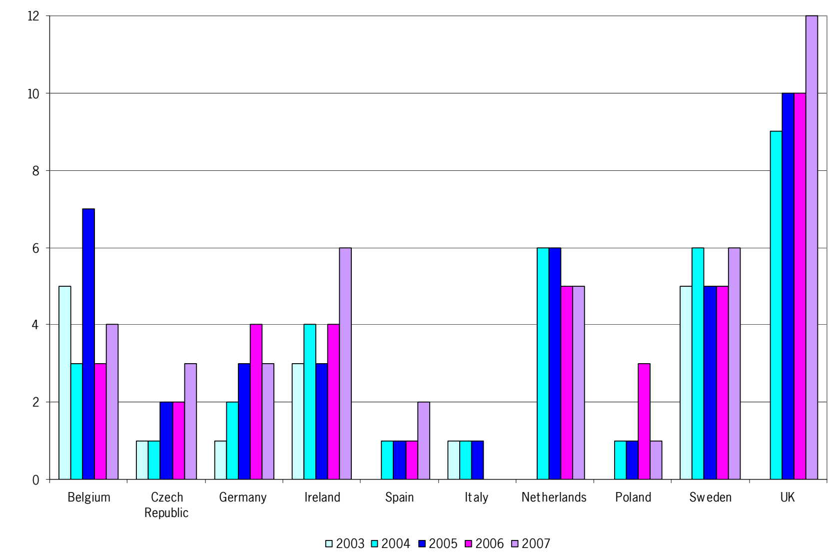
Appendix 1

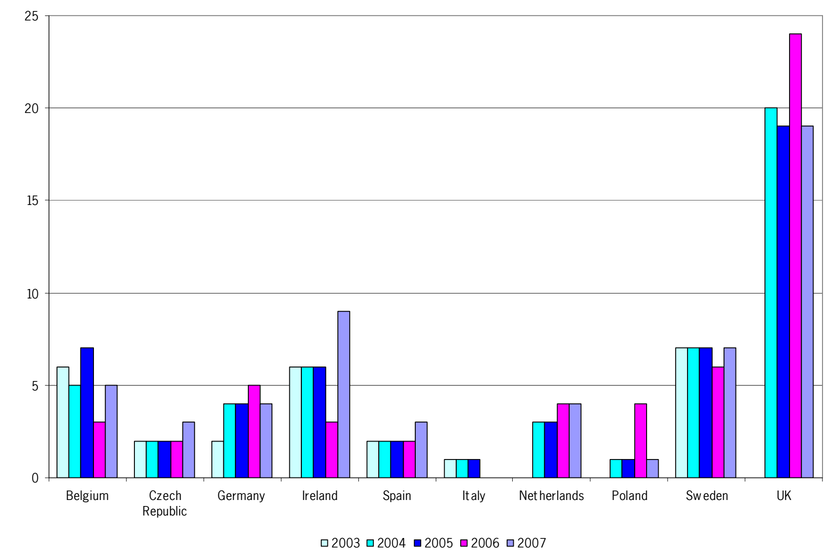
Sales through non-internet networks

Figure B1.1	Percentage of firms selling more than 10% of turnover through non-Internet networks (EDI), wholesale and retail trade



Source: EU.

Figure B1.2	Percentage of firms selling more than 10% of turnover through non-Internet networks (EDI), manufacturing



Source: EU.

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