Information and Communication Technology as a Driver for Change in Agri-food Chains

La technologie de l'information et de la communication comme moteur du changement dans les filières agroalimentaires

Informations- und Kommunikationstechnik als Triebfeder für Veränderung in den Wertschöpfungsketten der Agrar- und Ernährungswirtschaft

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The current economic crisis provides an opportunity for governments and actors in the food chain to innovate. History suggests that older industries like farming and food processing will increase the use of new technologies (Box 1). Information and Communication Technology (ICT) will change the agricultural and food sector. We see this trend already happening among the different actors in the food chain: dairy farmers installing milking robots and adopting sensor technology while arable farmers are using satellite based positioning systems for precision agriculture. At the other end of the food chain, retailers are providing product data to consumers on smart phones. Exchanging data in the food supply networks will contribute to alleviating major societal problems like food waste, sustainability and poor health.

The different actors in the food supply networks have their own specific problems that force them to innovate. Retailers focus on market share and brand loyalty: their main worry is to keep customers returning to their stores. Loyalty cards providing more data help in this respect. Competition between retailers is strong, and increasingly with food service and online retailers too. Time-stressed consumers are not necessarily interested in buying large volume products from shelves on a Friday evening, which also explains the interest in ICT-related shopping experiences, from smart phones to web shops.

Food processors have to cope with the increased power of the large retailers. Internationalisation to increase size and consumer-oriented product innovation are key challenges, in addition to finding cheap inputs. Data from input suppliers and data on sustainability can play a role in product differentiation of top A-brands targeted at market niches. Logistic solution providers that organise transport in the food chain try to cope with the pressure on margins by developing service concepts like just-in-time deliveries, so that business partners can concentrate on their core functions. This all leads to increased data exchange in the food chain.

Farms strive to decrease their costs, either by use of more technology, by increasing their size, or a combination of both. They are increasingly data intensive and make these data available to food processors for tracing and tracking (Global-GAP) as well as to governments (for instance, the use of geographical information systems has been partly driven by the Common Agricultural Policy). Other farmers try to escape this trend by focussing on a value-added strategy for special products, often for local markets. Such farmers already benefit from internet technology (websites) and ICT-based home delivery systems. Input industries often work on a worldwide scale; they are R&D intensive and deal with new technologies such as Genetics, Robotics, Informatics and Nanotechnology (GRIN).

> "On pourrait se promener le long de la filière de l'offre et voir ce qui se passe à tout instant."

The need to feed 9 billion people in 2050 with restricted resources while generating less pollution is a major societal challenge with implications for government intervention as well as a business opportunity for the food chain. Besides the challenge to feed the world, the nature and characteristics of farming and transportation raise important issues of sustainability, food safety and the relationship between food and health (e.g. obesity).

The role of ICT

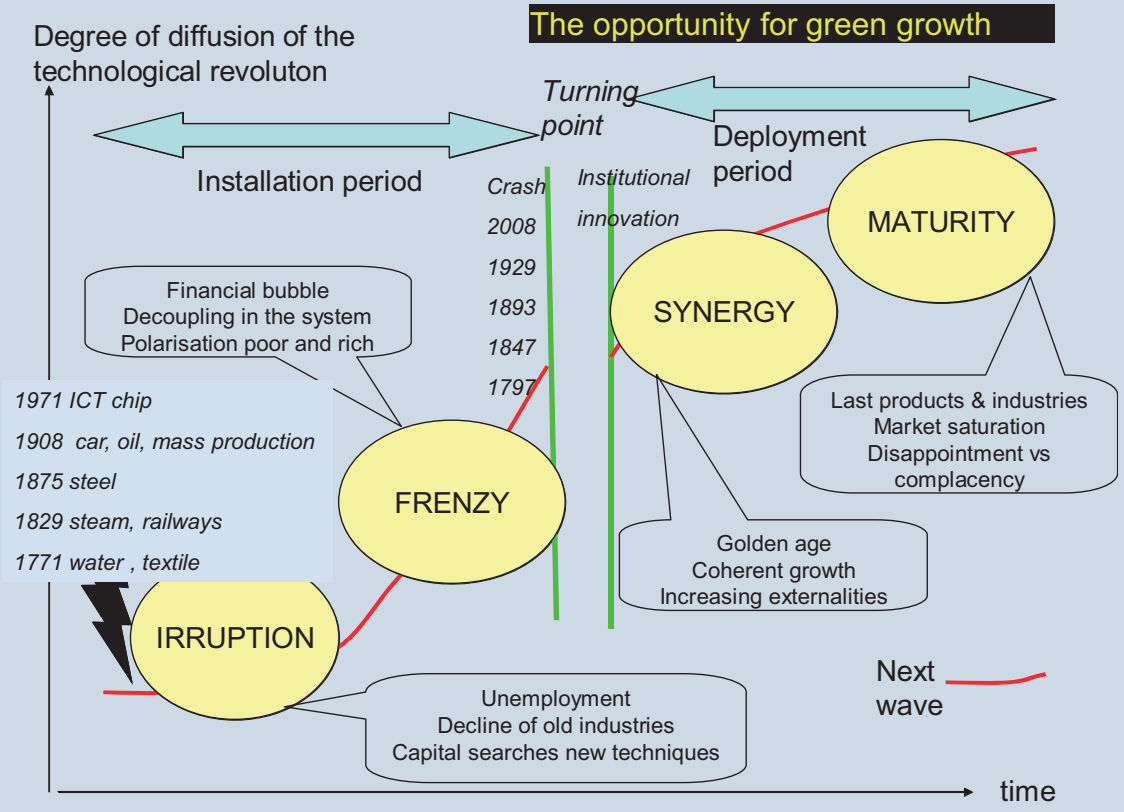
The need for innovation to address all these challenges will be supported by ICT. After the successful installation of computers in the last 25 years of the 20th century, the Internet started to connect those computers in the 1990s, leading recently to new forms of collaboration in social media. Working processes inside

Box 1: Long wave theory

Over recent years the economic outlook in many countries has deteriorated strongly. The financial and sovereign debt crisis has led to leading European politicians arguing that this is 'the biggest crisis in the life of the Euro' and even 'since the depression'. Historical economic analysis of long-term business cycles supports this view. Economic development since the first industrial revolution has been driven by technological-economic cycles (waves) that take about 50–60 years to complete (Box Figure 1). These waves start with a new technology that is not necessarily a new invention but becomes cheaper at such a startling speed that it has big effects on how societies are organised. This is what is now happening with ICT: the microchip that Gordon Moore invented in 1971 still doubles in capacity and halves in price roughly every 18 months.

This breakthrough typically happens in a period of standstill with capital searching for new business opportunities. After this phase investors become too enthusiastic, resulting in a financial bubble. That leads to a crash: the current financial crisis can be interpreted as the mid-life crisis of the ICT wave. Historically, such a period is a turning point that calls for institutional innovation, in which new ways of working are accepted. Rules are put in place to make new technologies work in situations (of older industries like agriculture) that until then had not innovated with the new technology. At the same time higher incomes and labour costs support the adoption of new technologies. This happened in the 1950s with tractors and chemicals and could now happen again with ICT.

Box Figure 1: Long wave theory



Source: Perez (2002); see also Perez (2010) and Poppe (2009).

organisations have been transformed and (long distance) specialisation between firms has increased in global agri-food supply chains. It is likely that in the coming years new forms of collaboration between organisations (businesses, consumers, government) will take off with more intensive data exchange replacing paperwork.

Hardware, like sensor technology and Radio Frequency Identification (RFID) chips but also computer power and transmission capacity, is still getting cheaper and leads to new options, like the Internet of Things (the idea that not only computers could be networked, but a lot of other things that have a chip attached, from cows to containers and refrigerators). Unmanned tractors are on their way: for example, the Austrian company Fendt won a gold medal with a prototype at the 2011 Agritechnica in Hannover.

Drivers

Innovation happens not only because there is a supply of a new technology, but also because there is a demand. In addition to the immediate business and social challenges described above, there are a number of macro-trends that make the huge adoption of ICT in the food supply chains likely. Demographic developments suggest that labour markets will be tight in the coming years. Current unemployment levels might mitigate this, but there are big mismatches between demand and supply in the labour market regarding skills and location, which can be alleviated by the use of ICT. Robotics first come to mind, but the

effect is bigger. Where a lot of blue collar (manual) labour is already mechanised, the remaining labour is engaged in white collar activities, from sales and advice to management. This gives a big incentive to increase size, as costs can be allocated to more products: a farmer and a processor can make contracts for 1,000 tonnes of potatoes at the same cost as for 100 tonnes. And bigger farms and firms depend on professional management systems, less on informal methods of working. This not only leads to the adoption of ICT, but also ICT-adoption will affect the size and structure of farming.

An economic crisis is also a crisis of values. There is an increased interest in 'local' as opposed to the dominance of 'global'. Food has always been a means for consumers to profile themselves in a social environment, but in the last decade food culture has clearly grown in importance. Sustainability aspects are much discussed, by chefs as well as large segments of consumers and NGOs. The consumer market has become more heterogeneous. So has the farm sector. Reducing market interventions in the CAP gives farmers more freedom to produce as well as a pressure to choose their own strategy. With heterogeneous consumers and farm systems it becomes attractive to search for methods to match the demands of those segments.

> "Man könnte die Wertschöpfungskette 'durchlaufen' und jederzeit sehen, was vor sich geht."

Related to the matching of consumer and farming segments, integration of farming in the food chain via contracts and quality assurance schemes like GlobalGap continues to increase. As agricultural processes become more programmable (and are less dependent on unpredictable natural events), as investments are less

Olive oil factory in Andalucia

general in nature but become more tied to specific products (such as know-how on how to grow organic broccoli) and marketing is a joint effort of a producer group and a retail chain (such as with some new apple cultivars), more complex organisational forms appear, as relying on the spot market would be a big business risk for the parties in the food chain (Boehlje, 1999). This all leads to more sharing of data.

These trends have the potential to further increase the uptake of ICT in the agri-food chain and lead to system-innovations, which is already happening in many places.

At the frontier

In the farm sector the use of ICT technology has increased strongly over the last decade. In a number of European regions the use of precision agriculture techniques has been introduced successfully, especially in arable farming. Based on satellite data, tractors can be very precisely located. This makes it possible to increase labour productivity by making machines bigger (for example, a 24 m broad spraying machine must be driven by such technology to keep a tractor on exactly the right track, otherwise the arms of the spraying machine would move too much), and by precise application of pesticides and fertilisers (also reducing pollution). Combining remote sensing data on crop growth and farm data on crop interventions (and *ex post* yields) lead to better decision making. But data are still hardly shared with advisors or the processing industry, analysed by intelligent software or combined in regional analysis and advice. That will change.

Glasshouse horticulture has more control over its production conditions than open air activities. Glasshouses have become wired with sensors and computers to steer the production process in an optimal way. In dairy farming, milking robots have been introduced successfully on family farms in North Western Europe where labour is expensive and farmers are highly educated. The use of sensor technology is increasing: cows increasingly will be measured with

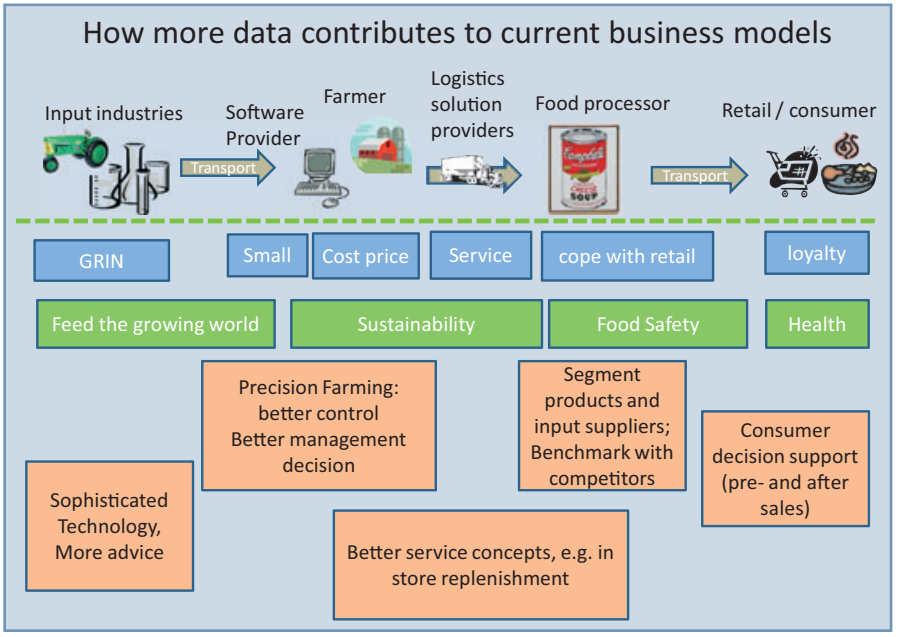
sensors as intensely as sports athletes; sensor data being much better than the human eye at predicting diseases or the optimal time for insemination.

In agri-logistics, tracing and tracking has become standard. The food scares (dioxine crisis, bovine spongiform encephalopathy) have stimulated that development, as has European law. In some cases this has led to advanced systems that include the consumer stage. Barcodes are already used to provide consumers with information on the ingredients in food products and the way they have been produced. If consumers are ready to pay for a 'sustainability' premium, the traceability that barcodes allow for facilitates the transmission of consumer premia back to producers. What starts as a service or segmentation policy could easily turn into new business models and new policy options; a food processing company could offer a premium to farmers to increase the supply of commodities with 'sustainability' characteristics; governments could also use article 68 of the Common Agricultural Policy to reward farmers that produce such commodities.

> "One could 'walk through' the supply chain and see what is going on at any moment."

Retailers are using apps on smart phones to support consumers and to increase brand loyalty. Such apps help to create shopping lists and optimise shopping routes in the store. Tesco has taken the idea one step further in an experiment in South Korea where the supermarket comes to the consumer in a virtual form, projected on the wall of the metro station, as an alternative to an online shopping service. Home delivery systems are becoming more widespread. Sharp falls in prices of delivery services, also due to the liberalisation of the post and parcel market as well as the labour market, have helped farmers to set up web shops. ICT will further help to solve the so-called 'last mile' issue in several ways, from dynamic routing trucks to opening and closing the door of a garage or box by Internet via a phone call.

Figure 1: The need for more data in food chain



Note: GRIN: Genetics, Robotics, Informatics and Nanotechnology.
Source: EU FP7 project SmartAgriFood.

This list of examples shows that several actors in the food chain have already advanced use of ICT and are experimenting with new developments. It is based on these experiences and the trends at the macro level that we think that ICT will strongly change the food chain in the coming years, based on the exchange of data between partners. Figure 1 summarises how more data and ICT contribute to the development of new business models and the relevant policy challenges: more advice bundled with technology; precision farming; better service concepts in logistics; segmentation in the food industry to cope with heterogeneity in farming and among consumers; and consumer decision support. In the near future, Facebook-like data exchange platforms will make it possible to move data seamlessly from one partner in the food chain to another. This will also make it possible to create new services, as outlined in current research projects (Box 2).

Taking all such innovations together, they could potentially lead to a virtual supply chain. The history of a product could be followed from the consumer table back to the input industry. And it goes one step further: as in a kind of Second Life environment one could 'walk through' the supply chain and see what is going on at which stage at any moment, and what its history is. This makes totally new business models possible.

A more data-driven chain

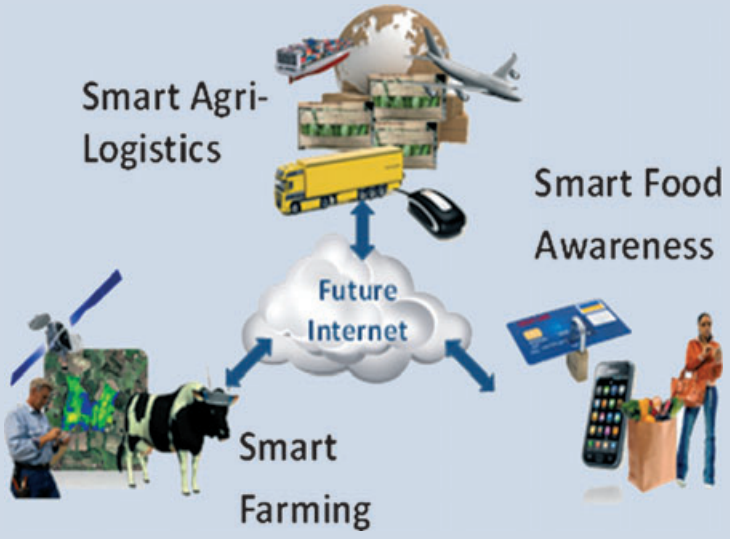
In conclusion we argue that based on macro-trends and current developments, the agri-food chain will become much more data-driven, based on up-to-date ICT. It will move away from a situation characterised by a low level of integration of data, even though internally in companies a lot of data are already available. This will help solve the mismatch between current applications of ICT and the increasing need for intelligent solutions. Such a development has a large potential impact on issues like sustainability,

Box 2: The SmartAgriFood Project

The SmartAgriFood project (www.smartagrifood.eu) is funded in the Future Internet Public Private Partnership Programme (FI-PPP), as part of the 7th Framework Programme of the European Commission. The key objective is to elaborate requirements needed by a 'Future Internet' to dramatically improve the production and delivery of safe and healthy food.

In *Agri-logistics* the project shows how data exchange between growers of pot plants, service providers and retail stores would lead to intelligent dynamic planning that decreases costs and waste and improves product quality. It also shows how RFID technology in vegetable logistics improves operations and tracing and tracking. In *Food Awareness* the project demonstrates how the data from the food chain could be delivered to consumers and matched with their own shopping profile based on health and sustainability considerations. For the *Smart Farming* system, a service-oriented architecture is designed to allow the integration and support of a plethora of services that can be developed by any stakeholder. This is expected to create a new market place like Apple's App Store market. The system is designed to retain all collected raw data (e.g. sensors' values, selling prices, used chemicals) when moving from one system provider to another.

The core idea *SmartAgriFood* is to bring ICT developments one step further by organising data exchange in the chain and to show how this leads to innovative concepts. A number of common pool resources (like an ABCDEF – an Agri-Business Collaboration and Data Exchange Facility) are needed for this data exchange.



food safety, resource efficiency and waste reduction.

The economic effects of such developments are still to be explored. At first sight it could lead to more closely integrated supply chains that make the farmer act as a franchise taker with limited freedom. But the opposite could be true, with more transparency and easier options for direct sales in consumer food webs, using smart solutions for the 'last mile' delivery. It is unclear if all this would widen the gap between large (viable) and small (vulnerable) farms. It could imply that some value-added activities, like advice, move from the most remote rural areas to regions with clusters of knowledge when they are provided by ICT. New issues like the dilemma between privacy and transparency could arise. In some cases the ownership of data is unclear and some valuable data might need to be priced. There are clear common pool issues for companies in a supply network in setting up data exchanges. As the sustainability issue shows, the increased use of ICT can have positive societal effects. For this reason, and the sake of innovation as such, policymakers should support these innovations. In particular, special attention may be needed to ensure the availability of ICT infrastructure in rural areas.

Further Reading

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summary

Information and Communication Technology as a Driver for Change in Agri-food Chains

Agri-food chains will be changed in the coming years by Information and Communication Technology (ICT). Technological trends and economic analysis suggest that ICT will be a major driver for innovation. Satellites and sensors make precision agriculture possible. More and more data are being generated in agriculture and the rest of the food chain, which helps to steer production processes with greater precision. However, there is a low level of integration of these data between actors in the food chain. By improving this 'interoperability' of data, processes in the food chain can be optimised and new business models developed. Data-intensive food chains have the potential to alleviate many of the current sustainability and food safety issues and contribute to human health. The economic and policy effects of such developments still need to be explored. At first sight it could lead to more closely integrated supply chains that make the farmer act as a franchise taker with limited freedom. But the opposite could also be true, with more transparency and easier options for direct sales via consumer food webs, using smart solutions for the 'last mile' delivery. New issues like a trade-off between transparency and privacy or pricing data might well arise.

La technologie de l'information et de la communication comme moteur du changement dans les filières agroalimentaires

Les technologies de l'information et de la communication (TIC) vont dans les prochaines années changer les filières agroalimentaires. Les tendances en matière de technologie et l'analyse économique suggèrent que les TIC seront un facteur majeur d'innovation. Les satellites et les capteurs rendent possible l'agriculture de précision. L'agriculture et les autres éléments de la filière alimentaire génèrent de plus en plus de données qui aident à orienter avec davantage de précision les procédés de production. Ces données sont cependant faiblement intégrées entre les acteurs de la filière alimentaire. En améliorant la compatibilité des données, on peut optimiser les procédés dans la filière alimentaire et développer de nouveaux modèles. Les filières alimentaires à forte intensité en données peuvent contribuer à améliorer les questions actuelles de durabilité et de sécurité des aliments, et donc la santé humaine. Les effets de telles évolutions sur l'économie et l'action des pouvoirs publics restent encore à explorer. A première vue, on pourrait aboutir à des filières alimentaires plus intégrées qui amèneraient l'agriculteur à agir comme un franchisé à la liberté réduite. Mais l'opposé pourrait également se produire avec davantage de transparence et des choix plus faciles pour les ventes directes à travers des sites web de consommateurs faisant appel à des solutions intelligentes pour la livraison de proximité. De nouveaux enjeux comme l'arbitrage entre la transparence et le respect de la vie privée ou la formation des prix pourraient bien émerger.

Informations- und Kommunikationstechnik als Triebfeder für Veränderung in den Wertschöpfungsketten der Agrar- und Ernährungswirtschaft

Die Informations- und Kommunikationstechnik wird die Wertschöpfungsketten der Agar- und Ernährungswirtschaft in den nächsten Jahren verändern. Technische Trends und wirtschaftliche Analysen deuten darauf hin, dass die Informations- und Kommunikationstechnik die bedeutendste Triebfeder für Innovation sein wird. Satelliten und Sensoren ermöglichen Präzisionslandwirtschaft. Immer mehr Daten werden derzeit in der Landwirtschaft und in den anderen Teilen der Nahrungsmittelkette erzeugt, anhand derer die Produktionsprozesse immer präziser gesteuert werden können. Es besteht jedoch ein geringes Maß an Integration dieser Daten zwischen den Akteuren in der Nahrungsmittelkette. Durch eine Verbesserung der Interoperabilität dieser Daten können die Prozesse in der Nahrungsmittelkette optimiert und neue Geschäftsmodelle entwickelt werden. Datenintensive Nahrungsmittelketten besitzen das Potenzial, zahlreiche der aktuellen, mit Nachhaltigkeit und Nahrungsmittelsicherheit verbundenen Probleme zu lösen und zur Gesundheit des Menschen beizutragen. Die wirtschaftlichen und politischen Auswirkungen solcher Entwicklungen müssen noch ergründet werden. Auf den ersten Blick könnte es zu stärker integrierten Wertschöpfungsketten führen, die aus dem Landwirt einen Konzessionsnehmer mit begrenzter Freiheit machen. Das Gegenteil könnte jedoch auch der Fall sein: Mehr Transparenz und einfachere Wege für den Direktverkauf über Nahrungsnetze, die sich intelligenter Lösungen für letzte-Meile-Lieferungen bedienen. Das Auftreten neuer Probleme wie z.B. ein Zielkonflikt zwischen Transparenz und Datenschutz oder Angaben zur Preisbildung wäre gut möglich.