How ICT is changing the nature of the farm: a research agenda on the economics of big data

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Abstract: Modern information-based technologies, such as self-driving tractors, GPS, milk robots, automated egg production, satellite data and social media, will change farm practices and agricultural structure and contribute to the prosperity and resilience of farming systems. Based on macro-trends and niche developments we argue that the 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. This has a large potential impact on issues like sustainability, 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 makes the farmer act as a franchisee with limited freedom. But the opposite could be true as well, with more transparency and easier options for direct sales in consumer food webs, using social media and smart solutions for the 'last mile' delivery.

Like with previous technological developments, not all farmers will invest in new skills and where technologies are saving labour, farms will get bigger. Some farms or regions will become less competitive if the basic infrastructure (e.g. in broad band internet or GPS systems) lacks. Competition between advisors could increase, if they are able to serve farmers digitally. That could also mean that a part of such value added activities moves from the most remote rural areas to regions with clusters of knowledge.

As Allen and Lueck (2002) showed in their "Nature of the farm", that family farms are characterised by a low level of specialisation of the farmer's tasks, as the markets does not provide enough incentives to specialise. Due to a low profitability with a high level of risk and especially high transaction costs in factor markets as a result of moral hazard, family farms are competitive over more industrial holdings in most types of farming. ICT, higher food prices and demography could change that.

Keywords: ICT, family farms

Introduction[302]

In the farm sector the use of ICT technology has increased strongly over the last decade. Precision agriculture techniques have been introduced successfully (Henten et al, 2009) and produces much data . Based on satellite data field operations can be very precisely located. This makes it possible to increase labour productivity by making machines bigger (for example, a 24 meter 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 fertilizers (also reducing pollution). Combining remote sensing data on crop growth and farm data on crop interventions (and ex-post yields) lead to more informed decision making. But data are still hardly shared with advisors or the processing industry, analysed by

[302] Part of the text in the introduction has been taken from Poppe et al. (2013).

intelligent software or combined in regional analysis and advice. That will probably change in the next years (see section 2.1).

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 sport 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, BSE) have stimulated that development, partly via 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. Retailers are using apps on smart phones to support consumers and to increase brand loyalty. Such apps help to create shopping lists and optimize 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.

This list of examples shows that several actors in the food chain make already advanced use of ICT and experiment with new developments. However this is just the start of what could become a revolution in agriculture, not unlike the introduction of the tractor and pesticides in the 1950s. It will change the way farms are operated and managed and it will change farm structure as well as the food chain in unexplored ways – just as in the 1950s the changes in the next three decades could not be foreseen.

This bold statement will be substantiated in the next section of the paper. We will argue that the current crisis is not an economic one, but a systemic one, where institutional innovation is needed. And we show how different actors in the food chain will use ICT to solve some of their major concerns, and why governments are supporting that.

One of the things that governments support is the building of an infrastructure to exchange data. With the Internet of Things we have entered the era of big data. But especially in sectors with many small players, like agriculture, there is a need to invest in software that makes data seamless available to business partners and government agencies – like large firms already do internally in their Enterprise Resource Planning (ERP) systems. These firms now have a need to connect to the digital data of farmers and logistic service providers. Section 3 describes an example of such software, which is in the making in the EU's Future Internet Public-Private Partnership.

That brings us to the research question of this paper: how will big data, exchanged between farmers and their business partners change the nature of farming? In order to answer this question, first the impact of ICT on agriculture is introduced at the macro level and at the level of the food chain (section 2). It will be argued that ICT is resulting in a new breakthrough technological-economic cycle (long wave) that will revolutionize agriculture. The application of ICT has resulted in big amounts of data in food chains that are often poorly integrated. For a real breakthrough at a macro level data exchange platforms are needed to enable that these data will be used for better decision making throughout the food chain. Section 3 introduces the project FIspace as an example of how the European Union in a public-private partnership construction (The Future Internet PPP) is developing such infrastructure. Next, the paper will discuss three areas of changes in the farming systems induced by a seamless exchange of (big) data in food chains.

First of all, section 4 describes how the market for farm management software is changing into a market for apps and data. This is a direct (and intended) consequence of the example in Section 3.

Second are the changes in the food chain (section 5). The most obvious change is that tracing and tracking, not only of products, but of their full history of treatments will become a reality. This will lead to more influence from business partners on the farm decision making. Either by pricing environmental aspects, by advice or by contract. Service level agreements by advisors and e.g. companies that sell machines are possible. We will refer to value chain analysis and contract economics. Food chains themselves will also be revolutionised by ICT, including developments in logistics and the (food) factory of the future. Here we will deal with only one scenario: the direct sales of farmers to consumers, that becomes more easy with the internet.

The last important change, linked to the issue of more control by the stakeholders of the farm, is the organisation of the farm itself. As Allen and Lueck (2002) showed in their "Nature of the farm", family farms are characterised by a low level of specialisation of the farmer's tasks, as the markets does not provide enough incentives to specialise. Due to a low profitability with a high level of risk and especially high transaction costs in factor markets as a result of moral hazard, family farms are competitive over more industrial holdings in most types of farming. ICT in addition to higher food prices and demography could change that. We discuss this, based on the theory of Allen and Lueck (2002) in section 6.

As these developments are partly speculative and not very much researched, the paper concludes with some suggestions for the future research agenda.

The ICT revolution

Long-wave theory[303]

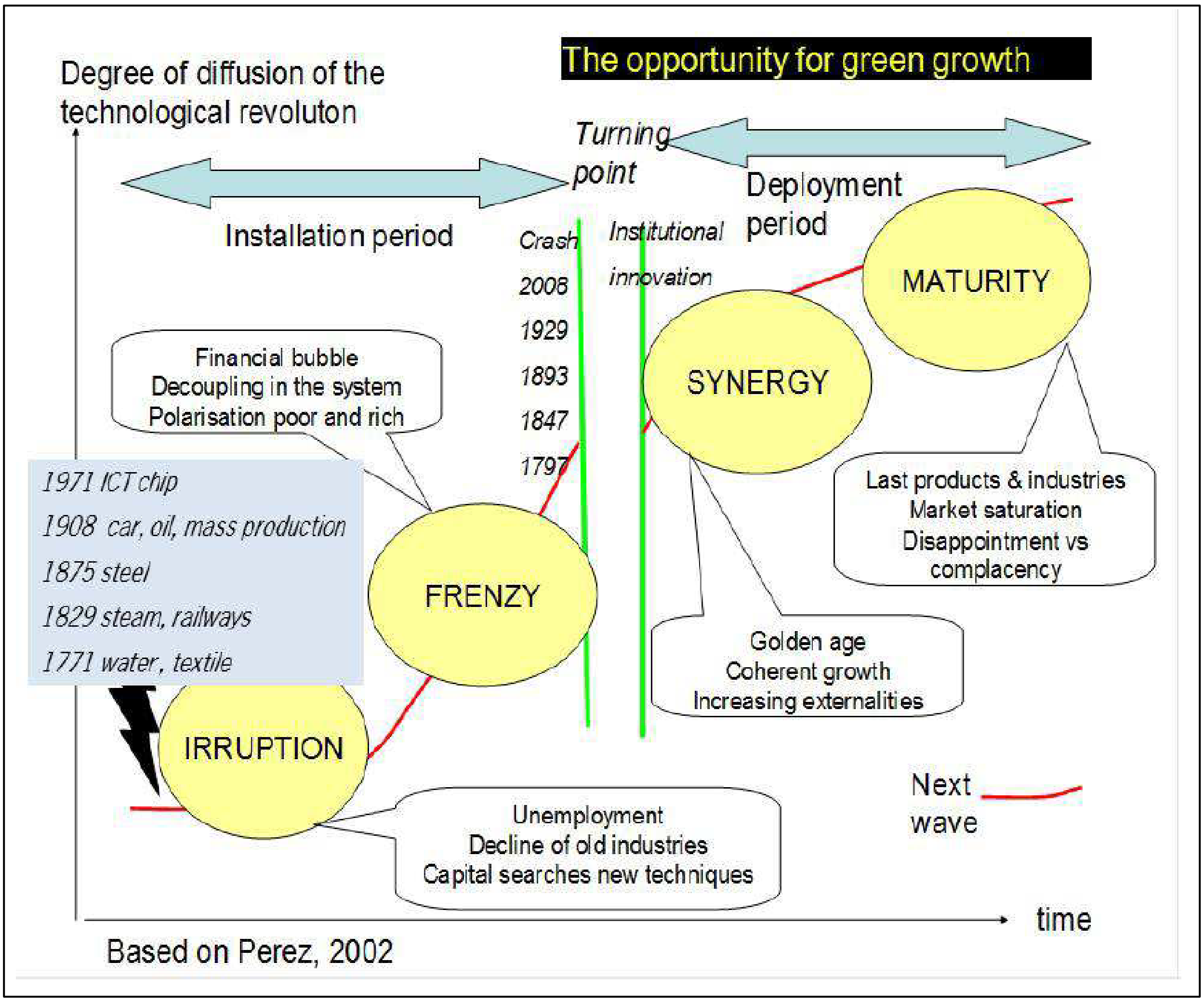
Over recent years the economic outlook in many countries has deteriorated strongly. The financial and sovereign debt crisis has led to leading European politicians arguing that this is 'the biggest crisis in the life of the Euro' and even 'since the depression'. Historical economic analysis of long-term business cycles supports this view (Perez, 2002; Perez 2010). Economic development since the first industrial revolution has been driven by technological-economic cycles (waves) that take about 50-60 years to complete (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.

Such a 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.

[303] Section based on Poppe, 2009, Poppe et al, 2013

It is based on the ICT experiences reported in the introduction above 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.

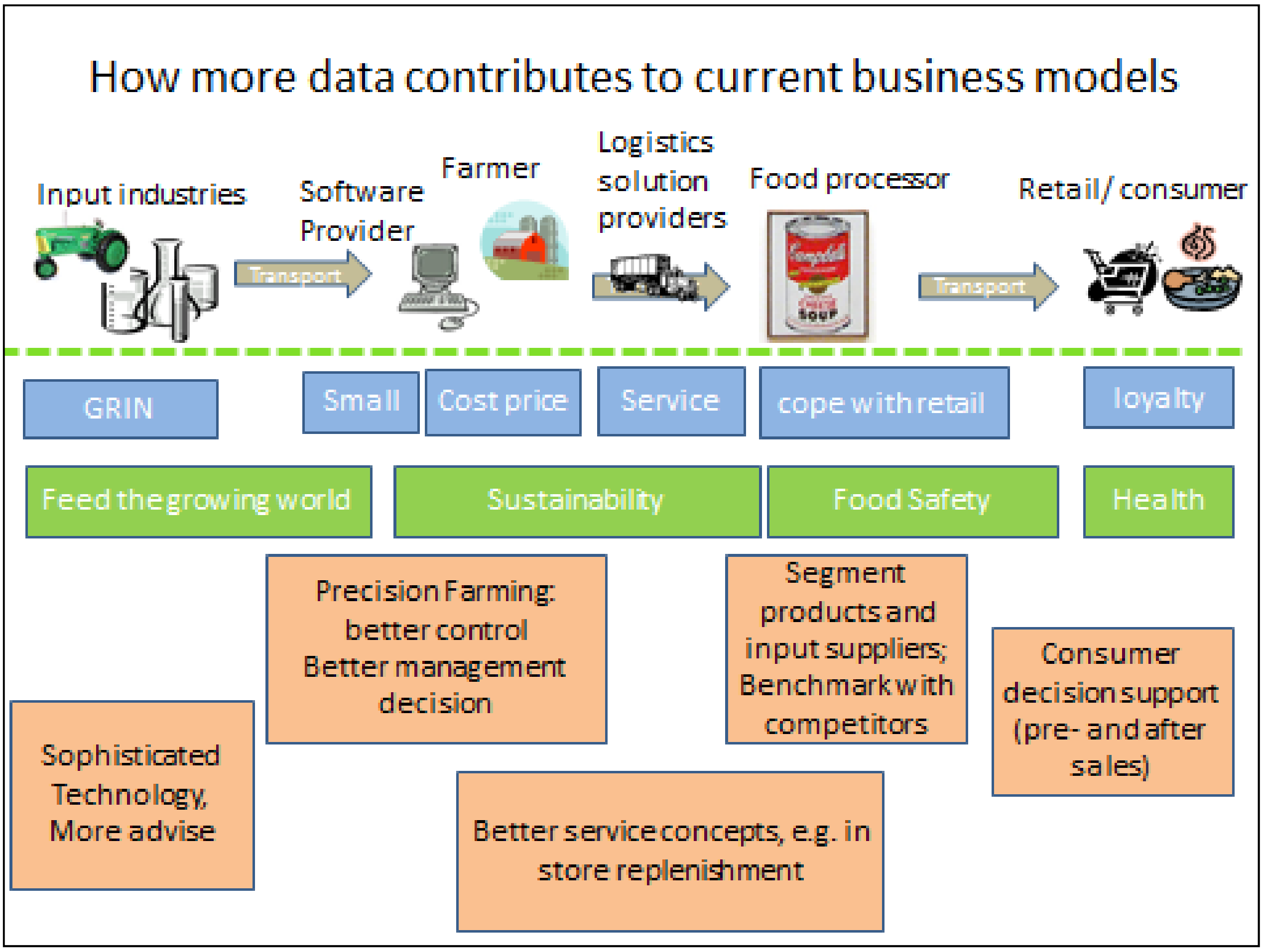
Figure 1: Long wave theory



ICT in the food chain

The current food chains are confronted with several business issues and societal challenges. Figure 2 summarizes 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.

Figure 2: Business and societal challenges and their ict solution in the food chain



What is needed for many ICT-based solutions to address the problems in the food chain is a better exchange of data between the business partners (and with the government). 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. Such a platform is described in the next section, as an example of how the European Union in a public-private partnership construction (The Future Internet PPP) develops the infrastructure for data exchange.

Data exchange with FIspace

Cloud technology (that gives persons access to their data from different devices and places) is an important recent development that makes also the sharing of data easier. Open data (in which governments or others share their data free of charge) is an example of sharing data. Together with the Internet of Things (using data from sensors, machines and other devices) this contributes to the era of big data.

Within an organization these developments can be implemented relatively easy. Enterprise Resource Planning systems (ERPs) and Customer Relation Management (CRM) software can be extended. However between organisations it is more problematic, as the so called 'interoperability' of data and information systems is very low. This holds for sme-to-sme or sme-to-government communication as well sme-to-big company communication. Imagine for instance the challenge for a large dairy cooperative, that would like to exchange digital data with 10.000 farmers. Or a milking robot manufacturer that would like to monitor operational data of milking robots that are sold to farmers.

The issue is even more complex, if one realizes that the data exchange between e.g. farmers and their cooperative or robot supplier leads to digital data that has to be used by third parties: the accountant needs access to the electronic invoices of the cooperative, the farm management system, the veterinary and the herd book needs access to the data of the cows milked by the robot.

Data needs to be exchanged with common standards and we need an Agri-Business Collaboration and Data Exchange Facility (an ABCDEF) as an infrastructure for this data exchange. This is a common pool investment, and the European Union has understood that it should help to build such infrastructure in the FIspace project of the Future Internet Public-Private Partnership.

FIspace (www.fispace.eu) can best be imagined as a business-to-business software tool comparable to LinkedIn or Facebook – a social media service that connects companies (instead of persons) and companies' operations. Businesses can contact each other (or a government agency) and start a collaboration. They could, for instance, detail a contract and specify which data they would like to exchange, the standards the data will conform to (e.g., EDIFAC or XBRL), and under which circumstances the exchange will occur. This could be data like invoices or delivery notes, but also Internet of Things data that allow for real time tracing and tracking.

Sharing such data should be as easy as uploading a photo on the social media, but here the analogy with the social media in private life ends. Companies may be more willing to maintain control of their data, specifying access and use rights, and whether their data can be centrally stored with a third party. Companies typically have their own databases (those CRM and ERP systems or e.g. simpler farm management systems) and use web services to connect them to each other. SMEs can use specialized software applications to store their own data 'in the cloud'. Because companies wish to maintain control of their data, FIspace does not store the data exchanged between companies. It only stores the links between companies and the rules that have been specified to share their data.

Another difference between companies and consumers is that companies need much higher standards of security for their data management. The Future Internet technology on which FIspace is built makes this possible, e.g., by encryption and selective access rights. Once the data is available in a digital form it becomes attractive to employ the data in business processes using special software, similar to how apps on mobile telephones or tablets enrich external data. For this reason, FIspace has an app store in which app developers can market and sell their software (see Poppe and De Smet, 2013 for more information on FI-PPP and FIspace).

Essentially such ABCDEF-software makes it possible to give business partners (and governments) access to data of farms and farmers to combine data from different sources. That has important economic consequences and will help to make the food chain much more sustainable. In the next sections, we explore three main areas of the effects, i.e. i) the impact on the market for farm management software, ii) the changes in the food chain and iii) the organisation of the farm itself.

The market for software, apps and data in agriculture

There is a wide diversity among European agricultural holdings in terms of farm type, size, geography, language etc. Network and communication infrastructures, software, service and media technologies systems thorough the agrifood chain are predominantly produced and distributed on a national or regional basis, or by manufacturers in relation to specific subsectors. The companies selling farm management software have often been established in the 1980s with the introduction of the PC and are SMEs active in a national market. Their revenue stream is often relatively small, based on maintenance contracts from a declining number of farmers. Due to the software trends (like cloud technology) they are confronted with rising costs, especially if they have to build in new functionality based on Internet of Things data that becomes available.

This situation increases the costs of producing devices, software, service and media technologies systems, it slows down the introduction of new products to the market, and it causes frustration among the stakeholders throughout the agri-food chain. Not only is data sharing between systems nearly absent, but there is also little tradition for incorporation of standardized components into the systems.

ABCDEF's like FIspace and Future Internet technologies (as introduced in the FI-PPP) will change that. FIspace puts an infrastructure to exchange (or better: to give access to) data central for software-providers. In this cloud-based business-oriented social media the users (like sme and farms) can make the data they control available to apps. Apps can be bought (or downloaded free) in an app store, like the current app stores on mobile phones.

Apps will replace some - and add new - functionality of the farm management information systems. Such apps can be build cheaper with Future Internet standardized software-components (so called enablers, like a standard component for a web-shop or to run an auction). This implies that app builders don't have to worry about organizing the access to data, as long as they use the data standards in which farmers have access to their data.

As FIspace is a European or global service, this also means that app builders have access to a large European or global market with much more potential clients than software makers in their current national markets have. Besides specialized apps for sale, governments, researchers, ngo's or businesses in the food chain might want to provide services and advise to farmers in an app free of charge.

For current FMIS this means breaking up their software to one or more apps that helps farmers in entering farm data manually, if needed in sync with data exchanged by the farmer (e.g. taking the data from delivery notes or invoices on pesticides bought and adding the information on the use on a particular crop in a particular field by entering additional data on a mobile telephone using its location service) and to apps that help farmers to interprete the data. For a first example of such a Future Internet based farm management system we refer to Kaloxylos et al. (2014).

The technological developments in this way replace a market for farm management software with a market for ABCDEFs (with FIspace as a first product in this category) that have an embedded market for apps. An intriguing question is if this would also lead to an embedded market for data. Currently nearly all data are exchanged free of charge. Exceptions are ticker data from stock markets and marketing data (e.g. viewer statistics of TV programs). In agriculture data is used to prove that products are of a different quality (e.g. organic) and lead to a higher price for the product, but data itself is not priced.

Changes in current food chains
A seamless exchange of (big) data in food chains will have a big impact on food chains. Important changes include: i) the end-to-end tracking and tracing and virtualisation of food chains, and ii) the emergence of direct farmer-consumer markets supported by ICT.

End-to-end tracking and tracing and virtualisation

The most obvious change is that tracing and tracking, not only of products, but of their full history of treatments will become a reality. This will lead to more influence from business partners on the farm decision making. Either by pricing environmental aspects, by advice or by contract. Service level agreements by advisors and e.g. companies that sell machines are possible. We will refer to value chain analysis and contract economics. Food chains themselves will also be revolutionised by ICT, including developments in logistics and the (food) factory of the future. Here we will deal with only one scenario: the direct sales of farmers to consumers, that becomes more easy with the internet.

With cloud-services like FIspace the tracing and tracking of products becomes much easier. Selling business partners can share the data on the history of the product towards the buyers in the next stage of the chain. This implies that apps for consumers can provide information on the product, all the way back to the grower of the product and its seeds. This even holds for complex products like pizza's that are made of many ingredients.

Such data can also be used for real-time virtualization: through sensing of physical objects on different levels of aggregation (e.g. product, box, pallet, container, truck) rich and globally accessible virtual representations of these geographically dispersed physical objects can be created (Verdouw et al., 2013). Virtual objects must provide multiple views for different users, having distinct purposes of usage. Visualisation plays an important role to create views that are experienced by human users as reality. 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 is not only fun for children to see where their milk came from, or to see where the online ordered bottles of olive oil are on route to the consumer. Real time virtualization has first of all practical use in business processes. Examples are applications for advanced visioning (including high-speed/low-cost solutions, 3D, and internal features such as ripeness) for quality inspection of food en flowers based on (mobile) augmented reality.

The exchange of data will also make it possible to add more (computer) intelligence to the chain, including monitoring, problem notification, deviation management, planning and optimisation. Examples of food-specific intelligence functionalities are apps for early warning in case of food incidents or unexpected quality deviations (e.g. temperature or humidity changes), advanced forecasting about consequences of detected changes by the time the product reaches destination, e.g. dynamic simulation of best-before dates. This could also lead to dynamic pricing and less waste.

This development will contribute to more sustainability: food processors, retailers and consumers can trace products to their source and investigate the different aspects of sustainability of individual products or batches of products. They can give feedback to farmers or penalize the least sustainable producers.

It is unclear to which extent the tracing and tracking as well as the real-time virtualization services will be provided by current service providers, including ICT suppliers and auditing firms, or if also new types of service companies will be established. As transaction costs change with such ICT solutions, it is likely that the way the food chain is organized too. In some cases this will even lead to totally new chains that replace current ones. For instance auctions could go online, which makes it possible to sell the fish if the fisherman's boat is still at sea. Another example is the direct marketing between farmers and consumers, the topic of the next session.

Direct farmer-consumer markets supported by ICT

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 (Poppe et al, 2013).

By reducing transaction costs ICT enables collaboration in regional clusters such as local-for-local food webs that deliver local, often organic, food products to local consumers, restaurants or health care institutions. The Internet plays an important role in these clusters to match local demand with supply and subsequently to manage last-mile logistics. The liberalization of postal markets and restraining of labour costs, especially for low-paid jobs, have supported the trend towards increased market share of web shops.

Changes in the scope of the farm and farm organisations

An interesting question is to what extent these developments in ICT are scale-neutral or will benefit larger farms more than smaller ones – which in the past often has been the case with innovations, especially if they improved labour productivity.

The devices (like smart phones and tablets) involved in data sharing with ABCDEFs like FIspace, as described above, are not very costly. The breaking up of complicated farm management systems into apps, based on standard components and marketed in a European instead of national market, makes software cheaper. This all suggests that the trend to big data is not negative for the position of small family farms.

They might even benefit more than large farms from options for direct sales in consumer food webs, using smart solutions for the 'last mile' delivery, as described in the previous section.

However this picture could be far too rosy for the small farm. In the current food chains farmers have to invest in data gathering and farm management information systems to satisfy demands for the food business and retail for tracing and tracking and quality assurance schemes like GlobalGap. As agricultural processes become more programmable (and are less dependent on unpredictable natural events), as investments are less 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). Such developments away from bulk markets towards more complex organizational forms favour larger farms, as it is as easy to contract 1000 tons of potatoes as 10 tons. In the end this could lead to more closely integrated supply chains that make the farmer act as a franchise taker with limited freedom. ABCDEFs like FIspace counterbalance that a bit, as they make a farmer less tied to the software of a supplier or food business, and reduce switch costs between chains.

A second unfavourable aspect for small family farms is the fact that the monitoring of agricultural processes will greatly improve. To understand why that is negative for family farms we have to address the question why we have family farms at all, and not large companies like in food business, retail or other sectors.

Markets generate income by making it possible to specialize, in roles like farm manager, farm laborer, investor and land-owner. In family farms, farmers combine several of these roles (especially those of management, investor-owner and laborer) when the market provides not enough incentives to specialize. There are two explanations why these incentives are too low. The first is that the risks are too high and the profitability too low. That leads to low interest (or too high profitability demands) of outside investors. Therefor large farms where farmers manage a large number of specialized laborers (like in a plantation) cannot compete with family farms that accept a lower profitability as long as it satisfies their income needs. The low profitability and structure of small farms is explained by the (inefficient) working of the labour market: farmers do not leave the sector easily as this means moving to the city, high switch costs and giving up tax advantages; they have a low opportunity cost, also as the total income derived from the farm counts, not the marginal revenue on each of the production factors.

The second explanation, put forward by Allen and Lueck (2002), deals with the fact that the agricultural production processes are difficult to monitor. That leads to moral hazard and an agency problem: the investor cannot monitor the farm manager and is faced with the question if the manager is not shirking and is correctly blaming the weather or diseases for the disappointing results. In the same way the manager wonders if the farm worker is not shirking on the field far away from his office. This Coasean way of thinking implies that the transaction costs of monitoring to address the agency problem determine the organizational form: it is a trade-off between specialization via the market or do-it-yourself to address moral hazard problems.

Both theories that explain the strong position of the family farm imply that some future trends favour large non-family farms. The increasing prices and profitability make it more attractive for outside investors to invest in farming. This is a trend clearly seen in e.g. the Ukraine. Access to cheap labor from Eastern Europe in Western Europe also leads to more specialization. If the second explanation holds, then ICT is a clear thread for the family farm. With ICT monitoring options strongly increase and agency problems can be solved.

Last but not least there is the thread of another change to the organization of the farm, and the rural area. Some activities could disappear from the farm when they become automated. In the past the dairy farmer looked to the behavior of cows to see if they should be inseminated. Now a sensor that measures activity or a milking robot does the monitoring and sends an sms that a certain cow has to be inseminated. An sms to the farmer or to the veterinary. This also could imply that some value added activities, like advice, move from the most remote rural areas to regions with clusters of knowledge where they are provided by ICT. It is more likely that the apps for the farmers are built in Berlin or Wageningen than in a remote area in Bulgaria.

These effects are probably stronger in propriety systems that are linked exclusively to the ERP system of a big food business, retailer or supply company than in a system where switch costs are low. This favours and ABCDEF like FIspace over a propriety system, especially if one wants to support family farms. The analysis suggest that the era of big data is probably less innocent for the structure of farming than the low prices of smart phones and tablets suggest.

Conclusion and research agenda

In this paper we argued, based in the economic theory of long waves (Perez, 2002) that the use of ICT will increase strongly in agriculture in the next decade. “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 positive impact on issues like sustainability, food safety, resource efficiency and waste reduction” (Poppe et al, 2013).

To increase the integration of data and interoperability, investments are needed in common pool infrastructure like Agri-Business Collaboration and Data Exchange Facilities (ABCDEFs) with FIspace as an example.

Our conceptual analysis suggests that they lead to a market for such facilities as well as a market for apps and perhaps even for data. That could be superior to situations where farmers are linked to a propriety ERP system of a big input supplier or food business. This is especially true for family farms. Overall however the trend to big data might have big consequences for how farms and food chains organized.

This conceptual analysis and the claims made by the developers of the Future Internet lead to a large array of research questions that need our attention. Preferably these questions should be tackled with empirical data. We group these questions in the following issues:

- Estimate the costs and benefits of ABCDEFs in a number of concrete business cases
- Analyse the European market for farm software, see if some small national markets for specialized farm types are indeed collapsing and can be replaced by apps in European markets
- Analyse the pros and cons of ABCDEFs over propriety software especially with an eye to the effect on family farms.
- Analyse how ABCDEFs support regional food webs in a number of concrete cases
- Analyse how ABCDEFs support new services (business cases) in food chains
- Analyse the regional effects of the trend to big data, especially the fact that some value added processes might end up with the industry or near universities and that some rural areas have a lack of ICT infrastructure.
- New issues like the dilemma between privacy and transparency could arise. In some cases the ownership of data is unclear. Research is needed on how such property rights might be strengthened. In other cases the ownership of data seems to be very skewed to e.g. laboratories who analyze samples of farmers.

It seems that until now the development of the Future Internet is dominated by research activities to design software and re-engineer business processes based on business modelling and value chain analysis. The economic effects and the longer term effects on the farm structure of the Future Internet need more attention. Our first and rough analysis suggest that it is not necessary positive for the family farm, but that open systems with low switch costs are better than propriety systems where the farmer becomes a franchise taker of the big firms in the chain, tied with its software system.

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