Guidelines for governance of data sharing in agri-food networks

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Abstract

Big Data is becoming a new asset in the agri-food sector including enterprise data from operational systems, sensor data, farm equipment data, etc. Recently, Big Data applications are being implemented to improve farm and chain performance in agri-food networks. Still, many companies are refraining from sharing data because of fear of governance issues such as data insecurity, or lack of privacy or liability, among others. To overcome such barriers for developments with Big Data, this paper aims at: 1) analysing governance issues in agri-food networks, and 2) introducing a set of guidelines for data-sharing. Based on a literature review, a framework for analysing agri-food networks was developed, with internal governance factors (efficiency, effectiveness, inclusiveness, legitimacy & accountability, credibility and transparency) and external governance factors (political, economic, social, technological, legal and environmental factors). The framework contributes to development of a set of draft guidelines. Accordingly, for each factor, the guidelines address issues, best practices and lessons learned from other projects and initiatives. The approach developed in this paper creates a baseline for possible future developments of Big data in terms of 1) upscaling of the guidelines at a global level, 2) refining and fine-tuning of the guidelines for context specific agri-food networks, and 3) contributing to solving governance challenges in data sharing. In the future, the relevance of Big Data in the agri-food domain is expected to increase, and so are the contributions of this approach.

Introduction

Big Data is becoming a new resource, a new asset, also in the agricultural sector (Assunção et al., 2014; Hashem et al., 2014; Shin et al., 2014). Big Data in the agricultural sector includes enterprise data from operational systems, farm field sensor data (e.g. temperature, rainfall, sunlight), farm equipment sensor data (from tractors, harvesters, milking robots, feeding robots), data from wearable animal sensors (neck tag, leg tag), harvested goods and livestock delivery vehicles sensor data (from farms to processing facilities) etc. Increasingly, Big Data applications, Big Data initiatives and Big Data projects are implemented and carried out, aiming for improving the farm and chain performance (e.g., profitability and sustainability) and support associated farm management decision making (Wolfert et al., 2017).

In the agri-food sector in the Netherlands different kinds of data-driven initiatives are taking place responding to the trends of more transparency in food production, demands of customers and an increasing amount of food labels. These data-driven initiatives involve farm companies that share their (big) farm data with enterprises and organisations who strive to add value to that data. This implies that the data from one party is combined with data from other parties in the chain, and then analysed and translated into advices, knowledge, or information for farmers. In this way Big Data becomes an asset in supporting farmers to further improve their business performance (e.g., higher yield, better quality, higher efficiency). These data-driven initiatives often involve collaborations between agri-IT companies, farmers' cooperatives and other companies in the food supply chain. These business-to-business initiatives and interactions are increasingly conducted through inter-organisational coordination hubs, in which standardised IT-based platforms provide data and business process interoperability for interactions among the organisations (Klievink et al., 2016).

Although possibilities to proceed towards enhanced production effectiveness and sustainability with Big Data are massive, many companies are refraining from sharing data because of the fear of data insecurity, lack of privacy or liability. Also, sometimes companies meet a deadlock or are afraid to take the first step even though they expect to develop new business with data. Understanding governance issues in terms of how people best interact is seen critically important to future development if Big data, as these technologies will be part of the human system.

To overcome these governance related bottlenecks and to facilitate development of Big Data applications in agri-food business the aims of this paper are to:

- provide a framework for analysing governance of data sharing
- introduce a set of guidelines for governance of data-sharing in Big Data projects or initiatives.

Methods

A systematic stepwise methodology was applied in this study, in which a set of guidelines for governance of data-sharing in Big Data projects in the agri-food sector eventually was developed. An initial framework for analysing governance of data sharing was based on a literature review conducted in Scopus. A first search provided only 7 articles based on search terms of Big Data and agriculture but no search terms for governance or stakeholders or networks or alike. A second, wider search resulted in a total of 43 articles. The framework was further modified in two parallel steps: a set of draft guidelines was derived from literature (1) and scanning past and current project on Big Data in agri-food (2). At the same time these steps iteratively resulted in refining and adjusting the framework. Based on the literature review and a workshop discussion, this paper first introduces the current framework and draft guidelines, and thereafter discusses some core arguments raised during the workshop.

Results

Outcomes of literature review

As the Scopus search shows, the literature is scarce on agri-food governance and Big Data. Still, they address some relevant issues. For instance, one article addresses the inherent problems with mixed data quality across data sites specifically for watersheds, ranges and forests, and recommend that combinations of scientific databases with social media and crowdsourcing can be helpful to bring research one step forward to effective use of Big Data in agriculture research (Susan Moran et al., 2016). Another article uses Big Data of the soil, which is basic to agriculture production, and recommend that efficient methods can be created to utilize data mining to enhance exactness of classification (Rajeswari and Arunesh, 2016). Also, one article presents a web service approach for forecasting of agricultural drought based on a Big Data and geoprocessing modelling (Deng et al., 2013). These articles have in common that they refer to multiple opportunities at different levels and on different themes related with agriculture that make use of Big Data, and to efforts which are made to improve existing data systems. Hence, technology factor is central. Other external factors include the environmental issues such as climate change, which in the future will harm agricultural yield (Gustafson et al., 2015). It is recommended that improvements of leveraging Big Data network (agronomic, economic, environmental and genomic) will support possibilities for adaptation and mitigation measures.

One article though addresses governance qualities related with Big Data, including (i) anticipatory, (ii) moralising and (iii) a movement that multiplies absent presence (Carolan, 2016). While these governance qualities explain farmer perceptions about future use of new technologies such as Big Data in agriculture, perception is just one of the many aspects in what we you could call ‘institutional change’. The governance aspects that we are looking for should apply to a stakeholder network level as illustrated in Figure 1. One article addresses institutional change more explicitly, such as changes in policy institutions, organizational structures, governance processes, lifestyles, workforce, etc. due to Big Data (Ramasamy, 2016).

Governance Framework

While governance in general can be interpreted as interactions between actors and/or organization entities aiming at the realization of collective goals, it is frequently distinguished into two inter-related processes (K Soma et al., 2016; Katrine Soma et al., 2016; Termeer et al., 2010). On the one hand, governance refers to governing based on steering principles, on how to influence a group of actors towards reaching collective goals. In the agri-food network situation, the steering aspect of governance refers to strategies aiming at influencing behaviours of other stakeholders in the network, and could include the management of data when this intends to influence other stakeholders' behaviours. One the other hand, governance refers to the changing formal and informal institutional settings. A shift can be observed when new ways of behaviour creates new formal and informal rules about what is a good thing to do and what is not. Hence, possible changes in data management will also influence the institutional setting, including informal and formal rules about how to manage data. Given that, these two inter-related processes are basic to analysing governance, they are also seen as a basis for analysing Big Data governance. Consequently, the two interrelated factors are put as a central, cyclic process in the framework for analysis (see Figure 1). Next, the framework addresses the internal governance factors playing a role within the stakeholder network, as well as the external factors influencing the stakeholder network. These factors are described in the following subsections.

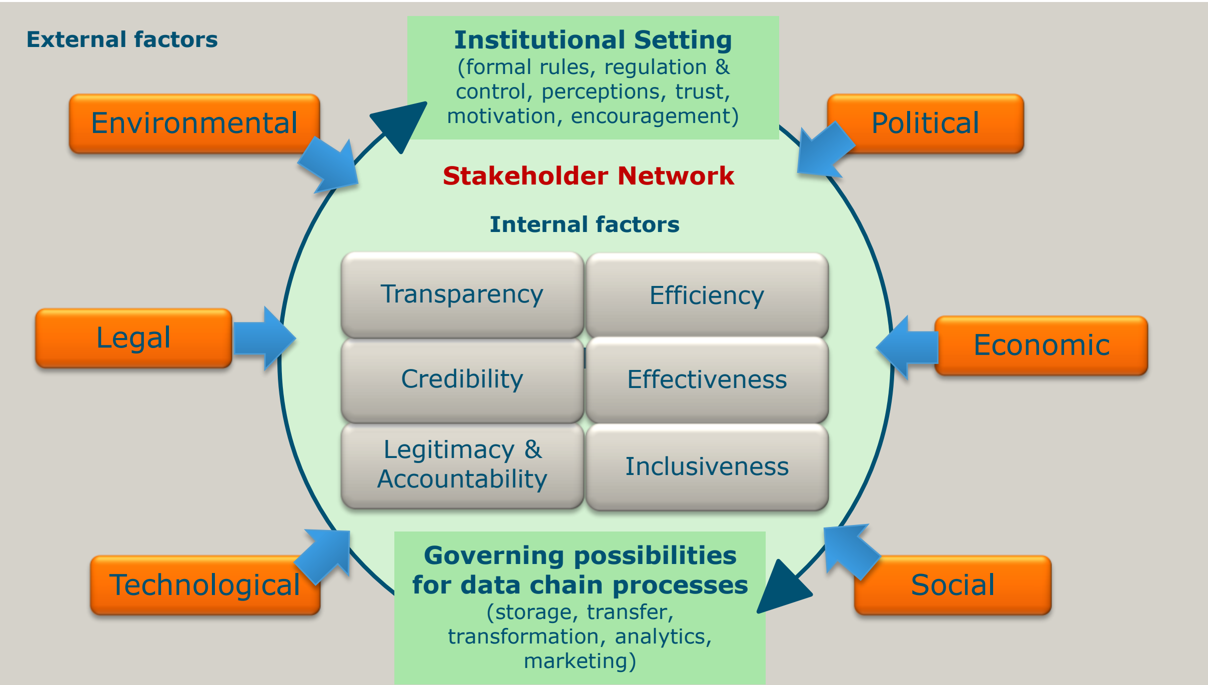

Figure 1. The Big Data governance framework. Further explanation in text.

Internal factors for the governing-institutional change interaction

The networks described in the selected literature are not exclusively referring to agri-food networks, but also refer to smart city networks, social media (Facebook and Twitter), smart meter networks, transport logistic networks, as well as different forms of market chain management networks. Still, these networks contribute with a series of governance experiences beneficial to this research. Overall, a large share of articles praise the new opportunities that Big Data can give due to the new scope to enhance effectiveness of data network capacities (Joo et al., 2015; Park et al., 2015), data processing (Zhou et al. 2015), transmission control mechanisms (Bao et al., 2016). It also refers to increased efficiency of food chain management (Li and Wang, 2015), or the multiple opportunities that Big Data provides in general (McAfee and Brynjolfsson, 2012). While these opportunities for increased effectiveness in general, some of the literature explicitly refers to cost-effectiveness (Tao et al., 2014). Whereas *efficiency* in the following refers to reducing costs and increasing generated income, *effectiveness* goes beyond, and refers to real acting and performances in terms of for instance, decision-making and information treatment, as well.

Networks consist of people who take part actively having more power, while others are not involved or informed. *Inclusiveness* is a term used to reflect on why some have influence and others not within a network. In the literature, one article analysed how inclusive networks can contribute to learning (Ferguson, 2016). Two other articles address relations between changing structures of power and institutional change (Campbell-Verduyn et al., 2016; Prasad et al. 2016).

Accountability refers to the decision-making group within a network, i.e. the network administrative organization in Figure 1 and their support to perform decisions by other partners of the network. One article, for instance, does research on accountability (which is linked with inclusiveness and power relations) related with the increasing presence of Big Data in contemporary financial practices (Campbell-Verduyn et al. 2016). Related with this is the concept of *legitimacy*. Legitimacy is in the literature referred to as a process that can be judged as fair with a high level of trust among different parties who eventually support a policy decision on this basis (Varjopuro et al., 2008). It was found that, even in a Facebook network used to promote marketing, a top-down approach is applied, making little possibilities for spontaneous user-generated content that can encourage legitimacy (Mariani et al., 2016). Moreover, social drivers for legitimacy in the digital water age, included customer satisfaction of a smart meter, community acceptance, customer engagement and trust (Beal and Flynn, 2015). The governance factors accountability and legitimacy are both addressing trust relations in a stakeholder network.

A series of the selected articles refer to Big Data attributes such as volume, velocity, veracity, value and variety (Prasad et al., 2016), or accuracy, reliability and utility (Pachepsky et al., 2015) or achievements of reliability and validity of research (Fu et al., 2013). These attributes contribute to *credibility*, which is a perception about competence, and can encourage perceived trustworthiness and goodwill (Westerman et al. 2012).

Transparency is another term observed in the selected literature. *Transparency* refers to how different types of information, assumptions, uncertainties and complexities are dealt with and illustrated in a decision making process (Lockwood et al., 2010; Soma et al., 2013). For instance, in the literature the production of knowledge creation, recycling and modification throughout technology processing is analysed and transparently illustrated (Hansen and Flyverbom, 2015). Moreover, transparency is enhanced in analyses of intellectual differentiation between scientific and human expertise (Savage, 2013). This research focuses on needs for transparency about how Big Data is translated into human expertise, how it is used and processed by people and how it eventually influences acting (e.g. consumption, production).

While the concepts of efficiency, effectiveness, inclusiveness, accountability and transparency have been identified as critical governance aspects of processes of governing within Big Data stakeholder networks, they also contribute to processes of generating new institutional settings by changing existing informal and formal rules for stakeholder networks. For instance, one article addresses smart cities which can bring about quality, sustainability and resilience of cities, by means of developing new institutional settings based on new physical and informatics technologies, policies and behavioural interventions (Kontokosta, 2016).

Based on this literature analysis six internal factors, referring to the stakeholder network, were identified and are described as follows (see also Figure 1):

1. **Efficiency** - refers to business plans for network directly on Big Data as a product. Refers also to agribusinesses who directly or indirectly take part, as Big Data advice can be important to future developments of agriproducts.
2. **Effectiveness** - refers to time spent on data capture, storage, transfer, transformation, analytics of Big Data, and data/ IT management. It also refers to time spent on decision making, and on communication within the network. How fast are the objectives reached eventually?
3. **Inclusiveness** - refers to a series of aspects: (i) is inclusion in network voluntary or forced, (ii) who takes part in decision-making and why, (iii) is it easy to enter and leave the network at any time?

4. **Legitimacy & Accountability** - refers to the feeling of members towards the decision making structure. For instance, do members support, trust and comply with management decisions made? Do they agree that the people in charge are the best ones to represent? In other words, do people feel ownership to the processes?
5. **Credibility** - refers to (i) quality of Big Data, and (ii) quality of agri-food business making use of Big Data. This is relevant when beginning a network as well when it develops, and after some years of functioning.
6. **Transparency** - refers to qualities that must be openly communicated. The stakeholder network needs to know that Big Data contributes a good product. Refers to processes of data capture, storage, transfer, transformation, analytics of Big Data, and data/IT management costs. For instance, how much must a farm (member) know about the actual data process?

External factors based on PESTLE
The external factors for the analysis of Big Data governance in the agri-food sector were based on the PESTLE approach. PESTLE is a well-known concept in marketing principles and is originally used as an analytical tool by companies to identify external key factors causing change in the strategic business environments (Basu et al., 2015; Heise et al., 2015; Ignacio et al., 2011; Issa et al., 2010; Mayaka and Prasad, 2012; Shilei and Yong, 2009; Stuiver et al., 2016; Weisheng et al., 2013). PESTLE stands for Political, Economic, Social, Technological, Legal and Environmental factors. The PESTLE approach was therefore used for identifying and classifying issues that could hinder Big Data-driven initiatives in agri-food sector to be successful. The description of the PESTLE factors in relation to Big Data Governance based on literature are as follows:

1. **Political** – the partnering companies have to operate in a policy context, and may be influenced by agricultural policies at national or EU levels, or EU policies for information flow across countries, privacy or restrictions in use of some information. The selected literature provides an example of smart grid network which has to operate in the context of politics of urbanism (Bulkeley et al., 2016). However, the influence is also the other way around, since Big Data increasingly is used to guide choices in external policy settings (Gano, 2015).
2. **Economic** - refers to demand, supply and competition outside the Big Data driven initiative, which will impact the development and governance of the initiative. This may be influenced by technological development (Ha and Bae, 2014), but may as well be linked with levels of globalization (West and Heath, 2011).
3. **Social** - is linked with the discussion about digital divide (Gullino, 2009; Myeong et al., 2014; van Deursen and van Dijk, 2013; van Dijk and Hacker, 2003), referring to a new scale of societal inequality that is based on having access online or not. New groups in the society having no access, loose opportunities for influence, work, networks, assets, etc., and as a consequence they are dammed to marginalization.
4. **Technical** - refers to external technological developments that have influences within the data driven initiative and can result in new business models (Ha and Bae, 2014). The technologies are developing fast, and developments are addressed in the selected literature (Joo et al., 2015; Jun et al., 2015; Park et al., 2015). Also, the technologies for attacks of datasets are advancing and are challenging data security (Loy et al., 2014). The decision making within a firm when it comes to, for instance, investments in new technologies, will be impacted by the new possibilities technological development will provide.
5. **Legal** - refers to legislation that can have impact on the development and implementation of the data driven initiative of the partnering companies: data ownership, privacy regulation, standardisation of data exchange and the interoperability of data, database rights, open data regulation (governmental role in network), consumer rights (transparency), etc.
6. **Environmental** - refers to the Big Data associated activities, such as agriculture, but also city planning, smart grids, etc., that influence natural resource use, pollution and climate change, among others. In the literature a series of articles link directly or indirectly with the environment. For instance, one article addresses the opportunities for addressing shifts in plant phenology by means of integration of multiple disciplines including ecology, evolutionary biology, climate science and remote sensing (Tang et al., 2016). Moreover, it is also referred to new possibilities for ecological sustainability innovations to reduce such impacts (Gano, 2015).

The core idea with the literature review in the following section is thus to identify guidelines for each of these internal and external factors and to judge whether a stakeholder network works well or not.

Draft Guidelines

In this section, for each internal and external factor, a set of draft guidelines is provided that can help to address the different factors that are relevant to governance of data sharing in Agri-Food networks. They are based on a preliminary analysis of past and current projects in the agri-food domain.

Guidelines can consist of:

Issues that have to be addressed, steps to be taken, etc.

Best practices with pro's and con's including checklists and, if relevant, references to examples, templates, etc.

Lessons learned from other projects and initiatives

The following tables provide the draft guidelines by a bulleted list; these have to be elaborated in future work.

Table 1. Guidelines for internal factors

Efficiency Think about arrangements for costs for taking part/entering the network, and needs for investors. Calculate Total Cost of Ownership (TCO) of Big Data including costs that are related with capture, storage, transfer, transformation, analytics of Big Data, and data/ IT management costs.	*Legitimacy & Accountability* Make sure that people representing others actually do so. Make a good plan for interaction and communication, and conduct it properly. Note that too many people involved in decision making will decrease effectiveness. Confront conflicts immediately. Communicate mistakes openly. Responsibilities must be taken in all roles in the network. Listen to all advices and wishes in network, and act accordingly
Effectiveness Decide on the structure of a network that can benefit effectiveness. Think of the different roles – who makes decision on behalf of others? A smaller management team can increase effectiveness of decision making. Avoid decreasing communication if number of decision makers is increasing and if goal is to enhance inclusiveness, legitimacy and accountability. Clear communication can decrease lost time on misunderstandings, and potential conflicts. Set clear long term ambitions, and communicate them clearly.	*Credibility* Ensure quality in the processes of capture, storage, transfer, transformation, and analytics. Be plain in the facts that the benefits of Big Data can only be realised through a proper data infrastructure and a lot of tough work to ensure data quality. Do not pretend that Big Data can contribute to more than it can. Do not hide mistakes, inform of what is gone wrong, what has been successful, what strategy needs to be implemented, etc.
Inclusiveness Encourage voluntary membership. Involve the members appropriately in the decision-making. Make it easy for potential members to join the network (low costs), and for members to leave (personal contract).	*Transparency* Think of a system (e.g. tables, figures) that are easily accessible and interpretable to network members. Mistakes must be communicated, together with intended solutions. Communicate actively throughout any period in time. Avoid one-way information sharing, but encourage two ways dialogue (maybe an associated online platform for discussions).

External Factors

Table 2. Guidelines for external factors

Political Communicate strategies for dealing with the risks for members of a network of governmental open data policies, which can result in their sharing in a network being distributed openly. Take account of possible environmental policy restrictions, and take advantages of public investments in telecommunication in rural areas.	Technological Be updated of latest developments in new technology develops continuously that facilitate Big Data capture, storage, transfer, transformation, and analytics. Consider market advantages by early investments in new technologies. Prepare for hacking problems. Do not invest in outdated technologies.
Economic Think of your business plan in the larger economic context. For instance, are there relevant barriers to international trade? Are there other competition of similar Big Data contributions? What is the relation between smaller enterprises and multinationals? Do not invest in Big Data which already is available elsewhere. Do not ignore market failures.	Legal Formal contracts are needed at data level, personal level and product level. Use a data code of practice between stakeholders Be aware of impacts of intellectual property rights. Do not make the legal contracts too complicated, the needs can be obligations, but also culture/ country dependent. Codes can also mystify issues on data value, transparency, etc. Codes can obstruct new market entrants Prepare for data hacking.
Social Big Data applications can create increased gaps between poor and rich, developed and under development. Search for programmes, supported by public sector, which can assist in avoiding such development, as inequality will eventually create instabilities across world regions.	Environmental Communicate all environmental effects of Big Data externally. Enhance adaptations to existing equipment rather than replacements, due to the problems of technological waste, which often are dropped in developing countries, with severe health problems (poisoning soils, waters etc).

Workshop outcomes

The workshop resulted in a number of do's and don'ts as listed in Table 3:

Table 3. Do's and don'ts for data sharing in agri-food networks

Do's	Don'ts
Start with sharing data in a closed experimentation environment to showcase the (unexpected) value of big data Make clear arrangements for the distribution of costs and benefits Make the data-driven initiative appealing to suppliers of capital as well as to agricultural and technology stakeholders	Don't promise improvements that are not proven yet Don't start an initiative without a clear business case for all participants Don't limit access to data: without open data no successful big data project Don't share data with a third party without secured consent and guaranteed data quality

Discussion

The framework and draft guidelines as described in the previous section were discussed in an interactive workshop with experts from business and research. It was suggested to first carefully define the scope of the stakeholder network that wants to share data. A next initial step should be to define a shared vision or objective that the network wants to attain. This could be considered as a pre-step before applying the governance framework guidelines. But it could also be included in the internal factors e.g. on 'Efficiency' by including a step 'describe a business plan'. In general it was concluded that the scope of the framework is complete and appropriate, but this should be further validated by extending the guidelines and applying them to concrete cases.

Concerning the draft guidelines it was generally agreed that they are a good first attempt but that they should be extended. A further categorization like in the example of the external factor 'Legal' was well received. Instead of best practices it was suggested to change this into 'common practices', because what is 'best' can vary with different contexts. It was also recommended to publish the guidelines in a wiki-type of website so that they are openly accessible and can be adapted and enriched by a community that is interested in this subject.

Another idea mentioned was to differentiate the guidelines for different maturity levels of stakeholder networks (both in technological and in organisational sense) e.g.:

1. *basic/essential* – a starting initiative or project in which stakeholders are exploring if and how they are going to share data;
2. *extended* - an existing data-sharing network that has already reached a certain level of organization;
3. *optimized* - a data-sharing network that shares many datasets among each other and is already well organized.

Such a classification seems to be logical, but provided the current development in agri-food business the largest need will come from level 1 networks so it was advised to focus on that level first.

Finally, although the guidelines should be further extended and refined, they should also remain practical to apply. This work should not be an 'academic exercise' or become an exhaustive recipe book, but more a practical guide or navigator for stakeholder networks that want to share data. If it goes into the direction of a recipe book the target group should shift towards consultants that have to advise businesses. In that case they should learn how a large set of guidelines can be quickly applied to different contexts. Then the guidelines should be developed more for educational purposes.

Conclusion

The draft guidelines that are presented in this paper can be considered to be a first valuable step into the direction of solving governance issues in data sharing within agri-food business networks. If they can be applied to starting networks it could accelerate the development of Big Data applications in the agri-food sector. A next version of the guidelines should be developed and further tested and validated for concrete projects or initiatives.

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