

Informational institutions in the agrifood sector: meta-information and meta-governance of environmental sustainability

Lan Ge¹ and Christopher A Brewster²



In the agrifood sector, the explosive increase in information about environmental sustainability, often in uncoordinated information systems, has created a new form of ignorance ('meta-ignorance') that diminishes the effectiveness of information on decision-makers. Flows of information are governed by informal and formal social arrangements that we can collectively call Informational Institutions. In this paper, we have reviewed the recent literature on such institutions. From the perspectives of information theory and new institutional economics, current informational institutions are increasing the information entropy of communications concerning environmental sustainability and stakeholders' transaction costs of using relevant information. In our view this reduces the effectiveness of informational governance. Future research on informational governance should explicitly address these aspects.

Addresses

¹ LEI, Wageningen UR, Hollandseweg 1, 6706KN Wageningen, The Netherlands

² Aston Business School, Aston University, Birmingham B4 7ET, United Kingdom

Corresponding author: Ge, Lan (Lan.Ge@wur.nl)

Current Opinion in Environmental Sustainability 2016, **18**:73–81

This review comes from a themed issue on **Sustainability governance and transformation 2016**

Edited by **Bertrum MacDonald, Katrien Termeer, Paul Opdam and Katrine Soma**

Received 22 January 2015; Accepted 12 October 2015

<http://dx.doi.org/10.1016/j.cosust.2015.10.002>

1877-3435/© 2015 Elsevier B.V. All rights reserved.

Introduction

More than half a century ago, the Nobel prize-winning economist George Stigler opened his seminal paper on 'The economics of information' [1] with the following statement: '*One should hardly have to tell academicians that information is a valuable resource: knowledge is power. And yet it occupies a slum dwelling in the town of economics.*' In the last few decades, information economics has become a booming town itself but one still needs to remind economists, and other academics that information, knowledge and

power, although all intimately related, are not automatically the same thing. Moreover, the use of the term 'information' in academic literature as well as in the grey literature is vague and ambiguous.

The often interchangeable use of the terms 'data', 'information', and 'knowledge' conflates three types of informational problems: technical problems concerning the quantity of information, semantic problems related to meaning and truth, and the 'problem of influence' concerning the impact of information on human behaviour [2]. Although solving the third type of 'problem of influence' or 'governance problem' lies at the heart of informational governance [3], understanding the intricacies of the first two problems is of equal, if not more importance. From a governance perspective, distinguishing different types of informational problems enables better understanding of how informational governance arrangements can fail or be effective.

For informational governance in the agrifood sector, the 'governance problem' of information can take many forms. For example, the increase in environmental information should, in theory, contribute to 'informed decision making' but the volume of information is at the same time too overwhelming for decision-makers to process and act upon. A good example would be the amount of sustainability-related information on food labels [4]. This can result in information overload that paralyzes both the updating of new information and the decision processes. Furthermore, as in wider society, technologies like Twitter and the move towards open data have added to information systems in the agrifood sector a wide range of uncontrolled flows of information [5]. These developments have triggered the demand for meta-information, that is, information about information, which can be easily or readily incorporated into decision-making. The proliferation of meta-information like labelling and certification has, however, frequently created more confusion than clarity for the users and is threatening their perceived legitimacy and credibility [6,7].

In view of the above-mentioned phenomena and the inherent link between governance and institutions, we consider what characterises the institutions engaged in informational governance and how they are functioning in the agrifood sector. To address these research questions, we survey the relevant academic and grey literature mostly of the last 2–3 years through the online database

Scopus (www.scopus.com) and the search engine Google. The objective of our survey is to obtain insights into the current features and functioning of the informational institutions concerning environmental sustainability in the agrifood sector. In order to do so, we integrated theoretical frameworks from new institutional economics and information theory. In the section that follows, we explain what we mean by ‘informational institutions’ and introduce the key concepts we have used in reviewing these institutions in the agrifood sector. The main features of informational institutions, as identified in the literature, are then summarised and analysed in relation to their way of functioning.

Informational institutions

In the literature, the notion of an institution embodies several elements: formal and informal rules of behaviour, ways and means of enforcing these rules, procedures for mediation of conflicts, sanctions in the case of breach of the rules, and organisations supporting market transactions or other human interactions [8,9]. Following North [10], we define informational institutions as the informal and formal social arrangements governing the flows of information to influence behaviour. North makes a distinction between institutions and organisations, referring to the first as the rules and the second as the players. This distinction is important as the same set of rules may be set or followed by different players. However, it would be of little practical relevance to discuss the rules without looking at the players. We consider informational institutions therefore as consisting of both the rules and the players.

One of the main means by which institutions influence human interaction is decreasing information asymmetries (relevant information is known to some but not to all parties involved) as the institutions help channel information about market conditions, goods and participants and consequently reduce transaction costs related to the search and processing of information. Inspired by Williamson’s [11] different levels of social analysis, Figure 1 illustrates the interactions between what we called informational institutions and the more generally known social institutions amid massive and messy flows of information in society. When looking at the informational institutions as the social arrangements governing the flows of information, we may, similarly to the four levels of social analysis described in [11], distinguish three levels of rules of information based on their degree of formality and sphere of influence:

- The ‘zero-order’ informal rules such as customs and conventions that provide the context and setting within which the formal rules function. Such rules may collectively be called the ‘culture of information’. The primacy of scientific knowledge in society is, for example, part of the culture of information.
- The first-order rules that formalise the rights and principles of information, usually legally or authoritatively enforced, that is, the information laws and regulations.
- The meta-rules that address the legitimation of the first-order rules. The meta-rules then take the feature of ‘rule of rules’. Examples of meta-rules are legitimacy assessments, conformity evaluation, and meta-reviews. Since rules can again be made of meta-rules, we may encounter higher order meta-rules such as meta-meta-reviews.

As part of a broader set of social institutions, informational institutions may, similarly to other institutions, engage different players and use different governance mechanisms to fulfil the objective of informational governance. Examples of governance mechanisms include regulations, market-governance (through price mechanisms), contracts, agreements, etc. [12]. Obtaining insights into the rules, players, and governance mechanisms is a key step to understanding the functioning of informational institutions.

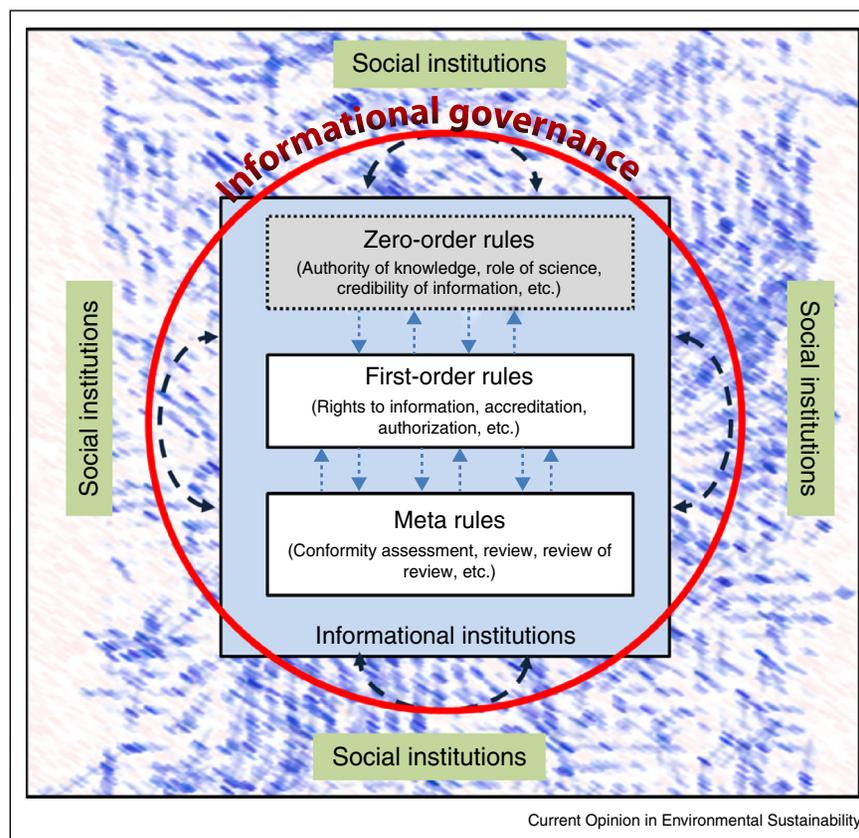
Transaction costs and information entropy

In our review we examine developments related to informational institutions using two interrelated concepts from the new institutional economics (NIE) and information theory that we consider crucial to understanding the efficacy (or not) of informational governance: *transaction costs* and *information entropy*.

Transaction costs are broadly defined as the cost of resources used to define, establish, and maintain social exchanges and interaction [13]. An important insight from NIE is that, in a given institutional setting, the choice of alternative governance mechanisms would be determined by transaction cost-economising considerations [11]. The functioning of institutions is therefore often studied through the lens of transaction costs. In relation to informational institutions, we may distinguish two kinds of transaction costs: the transaction costs of establishing and maintaining the informational institutions and the transaction costs for actors operating therein to carry out transactions or interactions.

While transaction costs have become a well-known concept in literature on governance and institutions (therefore often used without being defined), information entropy is still an underexplored concept in this area. Entropy is originally a concept from thermodynamics describing the disorder of a system and as such has long been related to environmental sustainability by physicists [14]. More recently, social scientists have begun to discover the theoretical and empirical importance of entropy [15,16]. However, with regard to informational institutions, the approach to entropy we are taking is based on the use of the concept in information theory. Inspired by

Figure 1



Informational governance, informational institutions and social institutions.

the entropy concept in thermodynamics, Shannon developed the concept of information entropy (also called Shannon entropy) in information theory as a measure of the uncertainty associated with a random variable that may have different possible results (information states) [17]. By taking into account the probability distributions of the information states, information entropy is commonly used to quantify the information content of a message. Although the thermodynamic perspective of entropy is certainly relevant to environmental sustainability, information entropy is more closely related to informational governance due to the common focus on information and communication.

Considering the essential role of information in coordinating social activities, developments in informational institutions are inextricably intertwined with developments in social institutions [18]. If we view society as consisting of many interacting open systems, informational institutions are essentially anti-entropy arrangements (i.e. opposing chaos or disorder) that intend to reduce transaction costs for actors operating within the social institutions by providing low-entropy information [13^{••}]. Establishing such arrangements, however, incur transaction costs as well for

actors responsible for such arrangements. There is a trade-off between the first kind of transaction costs and the second kind of transaction costs as sophisticated institutions often reduce the transaction costs for actors operating therein but incur high transaction costs to be established and maintained. In evaluating the efficacy of informational governance, both kinds of transaction costs should be considered.

Informational institutions in the agrifood sector

The agrifood sector is known to be fraught with information problems due to long supply chains, heterogeneity of actors, and the inherent unpredictability of biological systems [19]. To solve the problem of uncertainty and information asymmetry, there has been a long tradition of establishing and maintaining information and transparency systems. Well-known examples to be found in the literature include price information institutions, food quality standards, traceability systems, food safety certification systems [20,21]. Challenges identified with regard to information and transparency in the food system include first, food products have the character of credence goods (i.e. goods with attributes that are not directly

observable); second, the lack of standardisation which hampers smooth exchange of information throughout the supply chain; third, the heterogeneity of the actors involved in the food supply chain; fourth, current regulatory requirements on tracking or provision of information; and fifth, the limited penetration of information and communication technologies (ICT) in many areas of the food supply chain and logistics [12[•],22].

Information systems in the agrifood sector are in the process of rapid change in all three aspects of information (i.e. technical, semantic, and governance) mentioned in the introduction. Concerning the technical aspects, facilitated and accelerated by ICT developments, information concerning environmental impacts and sustainability in the agri-food sector has grown immensely in recent years [12[•],22,23]. In particular, mobile applications (or apps) have gained popularity as smartphone and mobile device ownership has increased. Concerning the semantic aspects, discourses and values are increasingly diversified with regard to what constitutes environmental sustainability [7,24]. The polysemy of the term sustainability is considered to undermine the credibility of the concept and consequently reduce its practical virtue [24]. Thirdly, in the institutionalisation of information concerning environmental sustainability, new modes of governance are emerging and the concept of ‘meta-governance’ has gained ground and significance [25[•]]. Meta-governance is understood as the management of plurality in governance modes with the aim to induce more coherence in

the governance of an issue area [26]. When information is used as a governance mode, it inevitably requires rules and meta-rules for interpretation and use. These rules must deal with the plurality in meanings as information is subject to multiple interpretations and uses by different actors. From this perspective, meta-governance is an inherent feature of informational governance.

In Table 1 we summarise the current status and developments in the information institutions based on the literature related to the informational governance of environmental sustainability in the agrifood sector. Technical, semantic and governance problems of information are dealt with at each layer of the informational institutions, although to a varying extent. The key features of these developments are briefly discussed below.

The culture of information in the agrifood sector

Transparency and information sharing have become a widely accepted norm in the agrifood sector, both among public and private actors. Informational governance has become a salient feature in the democratisation of state decision-making where e-government, transparency, and open data are gaining increasing popularity [27–29]. Citizens and consumers are getting used to more real-time information through the internet and craving ‘instant gratification’ of information needs. Consumers increasingly wish to be informed about many credence attributes of their food like the safety, its origin, ethical aspects, and

Table 1

Informational institutions and characteristics of the players in the agrifood sector

Level of rules	Key characteristics, roles and responsibilities of the players			
	Citizens/consumers Information users and disclosers	Academics ‘Scientist 2.0’: knowledge broker	NGOs & business Private transparency systems	Government Legislated transparency systems: legal mandate to compel disclosure, high legitimacy and accountability
Zero-order rules: the culture of information	<ul style="list-style-type: none"> • The custom to search for information on ethical aspects of food products • The social convention that information be made instantly available and shared 	<ul style="list-style-type: none"> • The convention of having interactions between scientists and wider society [33] • The primacy of knowledge derived from the scientific method 	<ul style="list-style-type: none"> • The social norm of having active web and social media presence • The convention of providing corporate social responsibility (CSR) reporting 	<ul style="list-style-type: none"> • Democratisation of state decision-making: Informational governance [27] • Convention to develop e-government and open data [28,29]
First-order rules: the formal rules defining the rights and obligations of information	<ul style="list-style-type: none"> • Entitled to the right to know about food safety, origin and production methods • Legal protection of privacy information 	<ul style="list-style-type: none"> • Peer-review system • Open Access 	<ul style="list-style-type: none"> • Industry and retail standards [21] • Certification and labelling schemes [36,38[*]] 	<ul style="list-style-type: none"> • Food labelling laws • Food certification and standards • Environmental reporting regulations
Meta-rules: legitimation and enforcement of lower-order rules	<ul style="list-style-type: none"> • Providing feedback and Reviews • Review the reviewer (online peer review) 	<ul style="list-style-type: none"> • Meta-reviews • Impact evaluation • Meta-meta-review 	<ul style="list-style-type: none"> • Third-party auditing and evaluation • Meta-labelling, meta-standards, meta code of conduct [41^{**}] 	<ul style="list-style-type: none"> • Participatory policy making and evaluation • Third-party evaluation

the sustainability of the processes that have produced and delivered it. Consumers have, however, neither the technology nor the time to determine whether everything they purchase is safe, so they rely on measures such as standards, inspection, and labels [7,30,31]. Non-governmental organisations (NGOs) and businesses, using their web presence and social media, are actively promoting supply chain transparency and encouraging ethical consumption through sustainability marketing and information campaigns [32]. Corporate social responsibility (CSR) reporting has become a business norm.

A noteworthy aspect of the culture of information is the changing role and position of academics in society [33]. As the scientific community increasingly opens its gates and interacts with wider society, scientific uncertainty has caught the attention of the general public and policy makers, and the primacy of expert knowledge has been subject to more scrutiny [34]. Furthermore, philosophical debates on the nature and role of science as providing objective knowledge are intensifying.

The formal rules of information in the agrifood sector

The formal rules of the information concerning environmental sustainability consist of legalised transparency systems, market-based transparency systems and the academic knowledge systems. Government mandates are a key feature of legalised transparency systems that require corporations or other organisations to provide the public with factual information about their products and practices. With regard to the market-based transparency system, the economics of voluntary and mandatory labels has been widely studied [35]. The informational rules take the form of industry standards and various certification and labelling schemes. Green claims of food products (including various forms of standards, codes, labels, indices, and certifications) are proliferating fast in the market place [6]. The social institution of the formal rules of information (i.e. the rules concerning rule-making) is characterised by the co-creation of standard-setting and certification by global partnerships between leading firms and international NGOs who design standards that aim to enhance environmental sustainability [36].

Although the formal rules of scientific knowledge are embodied in the scientific method and the peer-review system, the scientific community, formerly dwelling in an ivory tower, has been taking on a hybrid role of knowledge provider, knowledge user, consultant, and knowledge broker [37]. The 'openness' of the academy is enforced and enhanced by open access journals, bibliographic services (reference finding, bibliometrics, article prompts, etc.) offered by publishers and information organisations like Google, Scopus, ResearchGate, and the AGRIS bibliographic service (<http://aims.fao.org/agris>) of the Food

and Agriculture Organization of the United Nations (FAO).

The meta-rules of information in the agrifood sector

A significant feature of the information flows in the agrifood sector is the rapid growth of meta-information like food labels, reviews, and rankings. Ecolabel Index (www.ecolabelindex.com), the largest global directory of ecolabels, is currently tracking 458 ecolabels in 197 countries and 25 industry sectors, of which 148 are in the category of food. In contrast to first-order information concerning ingredients, quantities, calories, origin, etc., meta-information provides information about first-order information, usually in the form of classifications such as certification (typically as front-of-pack labels) or evaluations (usually available on third-party websites or food apps).

The increase in meta-information coevolves with the increase in meta-rules, that is, rules that are set for legitimating and enforcing the use of meta-information. Such meta-rules are usually set by different public and private organisations. This is evidenced by the plethora of evaluation studies commissioned by public and private organisations for the evaluation of various sustainability labels and standards [38*,39,40]. Among certification and labelling schemes, a distinction can be made between first order certification and labelling schemes (as most food labels) and meta-certification and labelling schemes (as 'label about labels'). Meta-rules concerning the evaluation of first order labels or the implementation of overarching labelling schemes (meta-labelling) are in fact creating meta-meta-information about food [41**].

While meta-information on environmental sustainability continues to grow, questions have been raised concerning the legitimacy and credibility of certification and labelling schemes. From a governance perspective, there are serious doubts about the efficacy of 'green claims' in driving sustainability outcomes and their success in creating real consumer preferences [42]. A great deal of resources has been devoted to assessing the credibility and consequential legitimacy of certifications [43–47]. At the same time, the results of such assessments are subject to meta-reviews and meta-meta-reviews commissioned by private partnerships and governments in their efforts to regulate or scrutinise voluntary sustainability standards and certification [38*,40,48].

Meta-information and information entropy

Information theory states that information entropy of a message increases with more possible information states, that is, higher uncertainty of the outcome [2]. This can occur when a message has multiple interpretations or implications or similar messages have distinct meanings. For example, the label 'organic' is considered one of the

most confusing for consumers as it is interpreted as being ‘tasty’, ‘nutritious’, ‘natural’, ‘healthy’, ‘from sustainable farms’, etc. It follows that informational institutions may increase the information entropy of a sustainability message when they increase the number of possible information states about the message. This implies that the increase in meta-information does not automatically result in lower information entropy of the sustainability message the product seeks to convey.

In Table 2 we summarise our interpretations of the literature on how informational institutions are increasing information entropy from the technical, semantic and governing perspectives of information. Factors increasing information entropy include ‘noise’ in the information flows, misinformation, conflicting cognitive frames, and the complexity of information rules.

Developments in ICT can, on the one hand, decrease information entropy by increasing the compression and transmission rates of data flows and, on the other hand, increase information entropy by facilitating the generation of large volume of uncontrolled information flows into the information systems that lead to information overload.

The informational problem concerning the quantity of information may be viewed in the light of the Jevons Paradox, named after the economist William Stanley Jevons, which refers to the phenomenon that technological progress that improved resource use efficiency tends to increase the rate of consumption of that resource and result in greater overall use [49]. In the information context, the Jevons paradox may occur when efficiency in ICT makes it cheaper and easier to deliver even more information. The resulting increase in information flow has a consequence that information has an ever decreasing marginal impact, leading to a *de facto* deficiency of information rather than sufficiency (<http://arxiv.org/abs/1403.6838>).

Table 2

Informational problems and factors contributing to increased information entropy

Aspect of information	Factors contributing to increased information entropy
Technical (quantity of information)	<ul style="list-style-type: none"> • Increased scope, sources, pace, volume (and noise) and channels of information
Semantic (meaning of information)	<ul style="list-style-type: none"> • Multiple labels creating legitimacy and credibility problem [41**,42] • Conflicting interpretive frames [45] • Many meanings of sustainability [24] • Increasing ‘soft’ metrics of sustainability on ethical aspects
Governance (influence of information)	<ul style="list-style-type: none"> • Ambiguity and contradictions in behavioural rules

Because of free availability and accessibility of scientific information, the costs (and therefore value) of scientific information have declined drastically. Constraints in resources and cognitive capacities, however, have raised the demand for meta-information so as to make sense of the scientific information. The uncertainties in meta-information have resulted in a new form of ignorance that can be called ‘meta-ignorance’.¹

Meta-ignorance arises due to questions about the legitimacy and credibility of meta-information. The best example of this is the lack of credibility that climate scientists have in the US due to concerted efforts to question and undermine the legitimacy of the meta-information (that their analyses are valid). Another example is the widespread meta-ignorance concerning what constitutes a healthy diet (low-fat, fat-free, paleo diet, vegetarian, vegan, etc.). We can distinguish between passive and active meta-ignorance. The passive variant arises from information overload or inability to process information properly. The active variant, sometimes referred to as ‘strategic ignorance’, occurs when people consciously choose to remain ignorant so as to not to subject themselves to the inconvenient consequences of that information [50*].

The semantic problem contributing to the increased information entropy lies in the polysemy of the very term sustainability, the inevitably multidisciplinary nature of environmental studies, and the resulting multiplicity of discourses, concepts, and metrics used by different players for describing and measuring environmental sustainability.

From a governance perspective, factors contributing to the increase in information entropy are the ambiguities we observed in behavioural rules implied by private transparency systems and the contradictions in research and evaluation findings regarding the legitimacy and credibility of meta-information like certification and standards [40,42,47]. Such ambiguities and contradictions reduce the clarity of the ‘sustainability’ message. Note that there is an inherent tension between the increase in transparency and effective governance, since increased flows of information tend to increase information entropy and lead to unpredictable outcome as information gets lost or misinterpreted. Ultimately, the goal of informational institutions is not to increase the flows of information, but to help the consumers of information to make

¹ The observation that ignorance may result from the proliferation of scientific information may seem to contradict the Baconian view of science commonly known in the philosophy of science literature, that is, an ever-growing edifice of objective knowledge, as well as some cruder versions of positivism that considers science as being value-free. We however subscribe to the view held by Karl Popper that science progresses by the successive rejection of falsified theories and scientific methods can never be purely objective and value-free.

more informed decisions [51]. This implies that for informational governance in the agrifood sector to effectively influence behaviour towards sustainability, the information entropy about what is sustainable food and sustainable behaviour should be kept low.

Meta-governance and transaction costs

In conjunction with social institutions, informational institutions play a key role in the governance of environmental sustainability in the agrifood sector through their impact on the flows of information concerning the sustainability of food and food production. The explosive increase in information and meta-information about environmental sustainability has however created distributed and uncoordinated information systems with often incomplete and confusing information about environmental sustainability. There is a growing literature arguing the need for governance of labels and green claims [30,41,52,53]. Public and private governors and those governed alike are taking responsibility for ‘governing how to govern’, that is, meta-governance [25,26,54]. The relatively new concept of meta-governance is, however, an inherent feature of informational institutions (cf. meta-rules) alongside the development of meta-information. The ISEAL Alliance is a good example of private meta-governance initiative that aims to improve the credibility of private standards as governance mechanisms [25].

High transaction costs have been considered a major limitation to standards and labelling schemes [55]. Table 3 summarises the factors of informational institutions in the agrifood sector that increase the transaction costs of actors involved in the informational governance of environmental sustainability in the agrifood sector.

Given the current status of the informational institutions in the agrifood sector, the challenge to effective meta-governance is how to develop institutional arrangements or rules that maintain low information entropy about

environmental sustainability for organisations at lower transaction costs. In this respect, several studies have emphasized the importance of third-party certification schemes [56] and public procurement regulations on private certification systems [57] in improving the effectiveness of certification systems. We have, however, found few studies that explicitly address the link between information entropy and transaction costs, an area that we consider to be of utmost importance for informational governance. It must be borne in mind that certain actors may benefit from an increase in information entropy or transaction costs. For example, the proliferation of certifiers dilutes the exclusivity of a specific certification scheme and creates advantage for incumbent traditional players in the supply chain [25].

Conclusions and further research

Facilitated and accelerated by ICT developments, meta-information concerning environmental sustainability in the agrifood sector has grown immensely in recent years. This has resulted in new and uncoordinated information systems and continuous adjustments in informational institutions. Our review shows that current informational institutions are increasing information entropy (i.e. decreasing the predictability of information) of environmental sustainability and the transaction costs of the actors involved. Despite the promises held by ICT and increasing transparency, there is a risk that informational governance may fail to improve environmental sustainability if the related informational institutions fail to reduce information entropy and transaction costs.

We observe that the institutional aspects of increasing flows of information due to ICT and the impact on sustainability have both received insufficient attention from academics and practitioners. Interpreting developments in ICT and informational governance in agrifood from the perspective of informational institutions lays the foundation for a research agenda where the impact of information and meta-information on environmental sustainability can be addressed more adequately.

Stigler ended the article ‘Economics of information’ with a remark that ‘Ignorance is like subzero weather: by a sufficient expenditure its effects upon people can be kept within tolerable or even comfortable bounds, but it would be wholly uneconomic entirely to eliminate all its effects’. Reviewing the developments of informational institutions, we conclude that the explosive increase in information and meta-information, often in uncoordinated information systems, has created new forms of ignorance – meta-ignorance. The challenge to informational governance within the agrifood sector is to develop informational institutions that not only shelter society from the cold winds of ignorance, but also enable effective decisions to be made in view of its significance for environmental sustainability.

Table 3

Informational institutions and transaction costs

Level of rules	Factors contributing to high transaction costs
Zero-order rules	<ul style="list-style-type: none"> • The plurality of knowledge and interpretative frames that increase the uncertainty of information • Increasing demand for and supply of information on ethical issues that may not be objectively measured or universally acknowledged
First-order rules	<ul style="list-style-type: none"> • Undefined rights to information • Conflicting rights to information and privacy
Meta-rules	<ul style="list-style-type: none"> • Diffused power among multiple actors involved in setting up the meta-rules • Increased need for even higher order meta-rules, for example, meta-meta reviews

Acknowledgements

This research was supported by the Informational Governance Research Program of Wageningen UR to contribute to solutions for the most pressing global environmental problems. The program is co-financed by the Dutch Ministry of Economic Affairs. One of the co-authors was also supported by the FP7 FI PPP FIspace project (<http://www.fispace.eu>).

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
 - of outstanding interest
1. Stigler GJ: **The economics of information**. *J Polit Econ* 1961, **69**:213-225.
 2. Weaver W: **The mathematics of communication**. *Sci Am* 1949, **181**:11-15.
 3. Mol APJ: **Environmental governance in the information age: the emergence of informational governance**. *Environ Plan C Gov Policy* 2006, **24**:497-514.
This is the first paper that introduces the concept of informational governance in the context of sustainability governance.
 4. Grunert KG, Hieke S, Wills J: **Sustainability labels on food products: consumer motivation, understanding and use**. *Food Policy* 2014, **44**:177-189.
 5. Lukose D: **World-wide semantic web of agriculture knowledge**. *J Integr Agric* 2012, **11**:769-774.
 6. Youssef AB, Abderrazak C: **Multiplicity of eco-labels, competition, and the environment**. *J Agric Food Ind Org* 2009, **7**:1-22.
 7. Rööös E, Tjärnemo H: **Challenges of carbon labelling of food products: a consumer research perspective**. *Br Food J* 2011, **113**:982-996.
 8. Azari JR, Smith JK: **Unwritten rules: informal institutions in established democracies**. *Perspect Polit* 2012, **10**:37-55.
 9. Kozenkow J: **New institutional economics: foundations and latest trends**. *Soc Econ* 2013, **35**:87-101.
 10. North DC: **Institutions**. *J Econ Perspect* 1991, **5**:97-112.
 11. Williamson OE: **The new institutional economics: taking stock, looking ahead**. *J Econ Lit* 2000, **38**:595-613.
 12. Trienekens JH *et al.*: **Transparency in complex dynamic food supply chains**. *Adv Eng Inform* 2012, **26**:55-65.
This paper provides a framework for transparency analysis in food supply chain. Challenges specific of food supply chains are highlighted.
 13. Valentinov V, Chatalova L: **Transaction cost social costs and open systems: some common threads**. *Syst Res Behav Sci* 2014, **31**:316-326.
This paper uses the open systems perspective to identify the common systems-theoretic core of two schools of modern economic thought, the new institutional economics and the heterodox institutionalism. It highlights the complementary and paradoxical relationship between the concepts of transaction costs and social costs analysed by the respective schools.
 14. Norde W: **Energy and entropy: a thermodynamic approach to sustainability**. *Environmentalist* 1997, **17**:57-62.
 15. McKinney LA: **Entropic disorder: new frontiers in environmental sociology**. *Sociol Perspect* 2012, **55**:295-317.
This article synthesizes thermodynamic laws with global political-economic interpretations on the environment. It demonstrates the theoretical and empirical importance of entropy as it relates to natural resources and environmental degradation.
 16. Samiei K, Fröling M: **Sustainability assessment of biomass resource utilization based on production of entropy — case study of a bioethanol concept**. *Ecol Indic* 2014, **45**:590-597.
 17. Shannon CE: **A mathematical theory of communication**. *Bell Syst Tech J* 1948, **27**:379-423 623-656.
 18. Foley P, McCay B: **Certifying the commons: eco-certification, privatization, and collective action**. *Ecol Soc* 2014, **19**.
 19. Wognum PM *et al.*: **Systems for sustainability and transparency of food supply chains — current status and challenges**. *Adv Eng Inform* 2011, **25**:65-76.
 20. Hobbs JE: **Information incentives and institutions in the agri-food sector**. *Can J Agric Econ* 2003, **51**:413-429.
 21. King RP, Backus GBC: **The Role of Standards in Promoting Food System Sustainability**. The Food Industry Center, University of Minnesota; 2011:: 1-16.
 22. Leire C, Thidell A: **Product-related environmental information to guide consumer purchases — a review and analysis of research on perceptions, understanding and use among Nordic consumers**. *J Clean Prod* 2005, **13**:1061-1070.
 23. Upham P, Dendler L, Bleda M: **Carbon labelling of grocery products: public perceptions and potential emissions reductions**. *J Clean Prod* 2011, **19**:348-355.
 24. Bolis I, Morioka SN, Sznclwar LI: **When sustainable development risks losing its meaning. Delimiting the concept with a comprehensive literature review and a conceptual model**. *J Clean Prod* 2014, **83**:7-20.
 25. Derkx B, Glasbergen P: **Elaborating global private meta-governance: an inventory in the realm of voluntary sustainability standards**. *Global Environ Change* 2014, **27**:41-50.
This paper studies private meta-governance attempts in the fields of fair labour, sustainable tourism, and organic agriculture, as well as a meta-governance initiative that aims to improve the credibility of private standards as governance mechanisms (ISEAL Alliance).
 26. Kooiman J, Jentoft S: **Meta-governance: values, norms and principles, and the making of hard choices**. *Public Admin* 2009, **87**:818-836.
 27. John P: **All tools are informational now: how information and persuasion define the tools of government**. *Policy Polit* 2013, **41**:605-620.
 28. Davies T: **Open Data Barometer — 2013 Global Report**. Open Data Institute, World Wide Web Foundation; 2013.
 29. Huijboom N, Van den Broek T: **Open data: an international comparison of strategies**. *Eur J ePract* 2011, **12**.
 30. Thøgersen J, Haugaard P, Olesen A: **Consumer responses to ecolabels**. *Eur J Mark* 2010, **44**:1787-1810.
 31. Vanclay JK *et al.*: **Customer response to carbon labelling of groceries**. *J Consum Policy* 2011, **34**:153-160.
 32. Bastian J, Zentes J: **Supply chain transparency as a key prerequisite for sustainable agri-food supply chain management**. *Int Rev Retail Distrib Consum Res* 2013, **23**:553-570.
 33. Bielak AT *et al.*: **From science communication to knowledge brokering: the shift from 'science push' to 'policy pull'**. *Communicating Science in Social Contexts: New Models, New Practices*. 2008:201-226.
 34. Leiserowitz AA *et al.*: **Climategate, public opinion, and the loss of trust**. *Am Behav Sci* 2012, **57**:818-837.
 35. Roe BE, Teisl MF, Deans CR: **The economics of voluntary versus mandatory labels**. *Annu Rev Resour Econ* 2014, **6**:407-427.
 36. Vellema S, van Wijk J: **Partnerships intervening in global food chains: the emergence of co-creation in standard-setting and certification**. *J Clean Prod* 2015, **107**:105-113.
 37. Gutiérrez NL *et al.*: **Eco-label conveys reliable information on fish stock health to seafood consumers**. *PLoS ONE* 2012, **7**.
 38. Steering Committee of the State-of-Knowledge Assessment of Standards and Certification: **Toward Sustainability: The Roles and Limitations of Certification**. Washington, DC: RESOLVE, Inc.; 2012.
This report contains findings of a comprehensive assessment of the state of knowledge of standards and certification. It presents an overview of what is known and what is to learn about the performance and potential of voluntary standards and certification.

39. Christian C *et al.*: **A review of formal objections to Marine Stewardship Council fisheries certifications.** *Biol Conserv* 2013, **161**:10-17.
40. COSA: *The COSA Measuring Sustainability Report: Coffee and Cocoa in 12 Countries.* Philadelphia, PA: The Committee on Sustainability Assessment; 2013.
41. Dendler L: **Sustainability meta labelling: an effective measure to facilitate more sustainable consumption and production?** *J Clean Prod* 2014, **63**:74-83.
- This paper explores how the notion of Sustainability Meta Labelling (SML) has so far been discussed and investigates the prospects for such an overarching scheme to become institutionalised.
42. Marin-Burgos V, Clancy JS, Lovett JC: **Contesting legitimacy of voluntary sustainability certification schemes: valuation languages and power asymmetries in the Roundtable on Sustainable Palm Oil in Colombia.** *Ecol Econ* 2015, **117**:303-313.
43. van Amstel M, Driessen P, Glasbergen P: **Eco-labeling and information asymmetry: a comparison of five eco-labels in the Netherlands.** *J Clean Prod* 2008, **16**:263-276.
44. Smith-Spangler C *et al.*: **Are organic foods safer or healthier than conventional alternatives? A systematic review.** *Ann Intern Med* 2012, **157**:348-366.
45. Fischer C, Lyon TP: **Competing environmental labels.** *J Econ Manage Strat* 2014, **23**:692-716.
46. Mahenc P: **Wasteful labeling.** *J Agric Food Ind Org* 2009, **7**: 1542-2485.
47. Miller AMM, Bush SR: **Authority without credibility? Competition and conflict between ecolabels in tuna fisheries.** *J Clean Prod* 2015, **107**:137-145.
48. Corporate Sustainability Initiative: *An Overview of Ecolabels and Sustainability Certifications in the Global Marketplace.* Nicholas Institute for Environmental Policy Solutions. Duke University. Interim Report Document #2010-10-1; 2010.
49. Polimeni JM *et al.*: *The Jevons Paradox and the Myth of Resource Efficiency Improvements.* London: Earthscan; 2008.
50. Thunström L *et al.*: **On strategic ignorance of environmental harm and social norms.** *Revue d'Economie Politique* 2014, **124**:195-214.
- This article develops a theoretical framework in which people feel internal pressure ('guilt') from causing harm to the environment as well as external pressure to conform to the social norm for pro-environmental behaviour. It contains evidence that some people use ignorance as an excuse to reduce pro-environmental behaviour.
51. O'Brien KA, Teisl MF: **Eco-information and its effect on consumer values for environmentally certified forest products.** *J Forest Econ* 2004, **10**:75-96.
52. Kinjo K, Ebina T: **Paradox of choice and consumer nonpurchase behavior.** *AI Soc* 2015, **30**:291-297.
53. Jungbluth N *et al.*: **Feasibility of environmental production information based on life cycle thinking and recommendations for Switzerland.** *J Clean Prod* 2012, **18**: 187-197.
54. Vermeulen WJ: **Self-governance for sustainable global supply chains: can it deliver the impacts needed?** *Bus Strat Environ* 2015, **24**:73-85.
55. Waldman KB, Kerr JM: **Limitations of certification and supply chain standards for environmental protection in commodity crop production.** *Annu Rev Resour Econ* 2014, **6**:429-449.
56. Chkanikova O, Lehner M: **Private eco-brands and green market development: towards new forms of sustainability governance in the food retailing.** *J Clean Prod* 2015, **107**:74-84.
57. D'Hollander D, Marx A: **Strengthening private certification systems through public regulation: the case of sustainable public procurement.** *Sustain Account Manage Policy J* 2014, **5**: 2-21.