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A TRACEABILITY SYSTEM FOR SUSTAINABILITY TRANSFORMATION IN THE FOOD SUPPLY CHAIN: AN AFFORDANCE THEORY PERSPECTIVE

Research in Progress

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Abstract

A traceability system is an increasingly important tool within the agri-food sector. It provides information visibility across the supply chain. Nevertheless, information provided by most traceability systems is related to food quality and safety. Environmental and broader social related information is limited. In this research-in-progress paper, we applied affordance theory to propose a research model that explains how an electronic-based traceability system provides possibilities for actions/affordances which can be actualised to achieve sustainable supply chains that create economic, environmental and social benefits simultaneously. In this paper, we first identify affordances provided by the traceability system investigated and explain various factors that affect their actualisation. Then we develop a model based on an extensive analysis of literature and interviews with manufacturers and suppliers involved in three food supply chains in Indonesia. The paper also provides practical guidance for implementing an electronic traceability system to transform food supply chains to make them more sustainable.

Keywords: traceability, affordance, sustainability, supply chain

1 Introduction

Nowadays, traceability is considered a crucial factor in food supply chains, mainly due to several food safety incidents. In 2008, the salmonella outbreak from the Peanut corporation in the United States caused one of the largest food recalls in its history following nine deaths and 637 illness (Layton & Miroff, 2009). In 2018, Australia faced a nationwide food contamination scare as needles found inside various kinds of fruits (ABC, 2018). To anticipate these types of incidents, the European Union has made food traceability mandatory to enable quick recall. It requires organisations in the food sector to be able to identify the origin of each of their products (Pappa, Iliopoulos, & Massouras, 2018).

However, the main purpose of this traceability effort has been to ensure food quality and safety (Dabbene, Gay, & Tortia, 2013). Other social and environmental dimensions such as deforestation, the use of harmful materials in farming practices, and underpaid workers have been mainly ignored (Mol & Oosterveer, 2015). Meanwhile, there has been growing expectations that organisations should engaged in sustainable supply chain practices to improve their economic, environmental and social impacts simultaneously. Sustainability considerations in food production and delivery have become a factor affecting consumers' purchasing decision. Thus, organisations in food supply chains are pressured to conduct responsible practices and communicate them to customers (Mol & Oosterveer, 2015).

Surprisingly, traceability for addressing sustainability is underexplored and it is unclear as to what extent it has been implemented. Although food traceability has been widely discussed in the literature (Bosona & Gebresenbet, 2013; Farooq, Tao, Alfian, Kang, & Rhee, 2016), studies that assess both social and environmental objectives have been limited. Similarly, the use of electronic-based traceability system has been limited to ensuring food safety and food quality (Doluschitz, Engler, & Hoffmann, 2009; Farooq et al., 2016) while the use of such systems to trace and track sustainable practices within the supply chain has been rare.

In this study, we define a traceability system as an information system (IS) that is used to identify and trace the history, distribution, and location of food products that take into account the economic, environmental, and social factors. We use the Affordance theory to examine how traceability systems may be used to support sustainability transformation within the food supply chain. Despite its potential to understand the technology-actor relationships required in enabling sustainability transformation, no study has applied affordance theory to investigate a traceability system. The research question of this paper is: *how does a traceability system enable sustainability transformation in the food supply chain?*

To answer this question, an initial model was developed based on an extensive literature review. The model was then refined using preliminary data collected in a field study involving interviews and observations in three food manufacturers and their suppliers in Indonesia that have integrated traceability system into their business processes.

This paper is structured as follows. First, we present a literature review on sustainability and traceability. Then, we explain the methodology used in the study, followed by the introduction of the research model that explains how the traceability system might contribute to achieving a sustainable supply chain. Subsequently, we end the paper with conclusions and outline the next step of our study.

2 Literature Review

2.1 Sustainable Supply Chain Management and Traceability

Sustainable supply chain management (SSCM) is defined as “management of material, information, and capital flows as well as cooperation among firms along the supply chain while taking into account economic, environmental, and social factors which are derived from customer and stakeholder requirements” (Seuring and Müller 2008, p. 2). Based on its definition, the goal of SSCM is to alter the

current operation of a supply chain by simultaneously integrating social, environmental, and economic objectives in its activities (Gold et al. 2009), which is what we referred to in this paper as sustainability transformation. To achieve this, SSCM relies on seamless information sharing across the supply chain to ensure sustainable practices are conducted (Badurdeen et al., 2009). One of the critical forms of information sharing in SSCM is traceability (Pagell & Wu, 2009).

Traceability is the capability to track something (Merriam-Webster, 2019). In the healthcare context, it is concerned with the ability to track drugs, medical devices, disease transmission routes, and associated events (Cheng, Kuo, & Zhou, 2018; Klein & Stolk, 2018). In software development, traceability focuses on ensuring alignment between requirement, design, and source code during software development life cycle (Mohan, Xu, Cao, & Ramesh, 2008; Ramesh & Jarke, 2001). In the food and supply chain contexts, traceability is defined as “the ability to identify and trace the history, distribution, location, and application of products, parts, and materials to ensure the reliability of sustainability claims” (ISO, 1994). Despite its definition, traceability typically supports the social objective of SSCM, especially consumer health and safety (Pappa et al., 2018; Ringsberg, 2015). Traceability ensures food safety and food quality through early detection of foodborne disease, food degradation, and contamination of food products. Few papers address this issue via the use of technology. Farooq et al. (2016) built a system that integrated RFID and sensor to monitor food distribution network in an attempt to avoid food contamination. Doluschitz et al. (2009) developed an IT solution to track the origin of meat and meat product and assess the system mainly based on the economic aspect.

Yet, these studies do not incorporate broader social and environmental considerations such as deforestation, habitat degradation, and farmers welfare, in tracking the origin of a food product. These objectives are still difficult to achieve via existing traceability systems (Wognum, Bremmers, Trienekens, van der Vorst, & Bloemhof, 2011). Only a limited number of systematic analyses of traceability systems for sustainability in the food supply chain has been found (Mol & Oosterveer, 2015). Our research aims to fill the current knowledge gap by investigating how traceability system can be used to achieve sustainable supply chain from the perspective of affordance theory.

2.2 Affordance Theory: Affordance Existence, Perception, and Actualisation

Affordance is defined as “all action possibilities or capabilities latent in the environment, independent of the individual’s ability to recognise them, but always in relation to the actors and therefore dependent on their capabilities” (Stendal, Thapa, & Lanamaki, 2016, p. 1). It arises from an interaction between an actor and technology. It is also situated, which means the perception and actualisation of an affordance are highly influenced by historical, social and organisational settings (Zheng & Yu, 2016).

Affordance theory has been contextualised in various fields such as e-commerce (Bang, Lee, & Han, 2014; Tan, Tan, & Pan, 2016), learning (Canning, Payler, Horsley, & Gomez, 2017), and healthcare (Burton-Jones & Volkoff, 2017; Savoli & Barki, 2016). A number of researchers have conceptualised affordances in various artefacts such as social media (Argyris & Monu, 2015; Zheng & Yu, 2016), e-health IS (Strong et al., 2014), and business intelligence system (Glowalla, Rosenkranz, & Sunyaev, 2014). In IS research, the term affordance is defined as “...the possibilities for goal-oriented action afforded to specified user groups by technical objects” (Markus & Silver, 2008, p. 622). It is a useful lens to examine how people perceive affordance provided by an IT artefact and how they are willing to change their routines to materialise that affordance (Leonardi, 2011). Based on the existing literature, Volkoff and Strong (2018) propose six principles for using affordance theory in IS research. We apply their principles in developing our model, as explained in Section 4.

Few studies have made a notable contribution about contextualisation of affordance theory in SSCM. The studies of Hanelt, Busse, and Kolbe (2017) and Seidel, Recker, and Brocke (2013) suggested, in total, six information technology (IT) affordances in supporting sustainability transformation. Nonetheless, their studies were limited to an organisational boundary. Eitiveni, Kurnia, and Rajkumar (2018) proposed a model that shows how IT can eventually lead to the creation of a sustainable supply chain. Although useful, their study did not investigate a specific IS and still at a conceptual level with-

out empirical evidence. We expand and improve their model by contextualising IT affordances using traceability systems as an example of IS.

3 Research Methodology

This study examines the use of a traceability system in SSCM within the food industry in a developing country. It is a complex and multidimensional phenomenon. Thus, a qualitative study is chosen as it can capture the contextual richness of the real-world settings (Yin 2016). It also requires no control of behavioural events and focuses on contemporary events. Hence, case study is the most appropriate method (Yin, 2009). To maximise the ability to draw conclusions and external validity, this study employs a multiple case study approach. It encompasses three manufacturers and their suppliers that form three case studies, as can be seen in Table 1.

Case	Manufacturer	Role of the interviewee in manufacturer companies	No. of suppliers
1	Company A	Director of Supply Chain Division, Director of Sustainability, Field Officer, Corporate Affairs manager.	Four
2	Company B	Vice President Commercial Sustainability, Field Officer, Sustainability Lead Analyst, Head of Engagement and Grievance Handling, Traceability Head.	Four
3	Company C	IT Technology Director, Supply Development Director	Two

Table 1. Overview of Case Study Participants

The participants were selected based on the availability of sustainability reports and recognition for their sustainability commitment and success shown in publicly available documents. They were contacted via email and phone. Upon permission, interviews were conducted, recorded and transcribed. Otherwise, notes were taken. There were 21 interviews with 2-5 interviewees from manufacturers and one from each supplier. We interviewed the owner in each supplier since they are small organisations and the owners manage the daily operations. We asked about their sustainability practices, their use and adoption of the traceability system. Furthermore, we asked their permission for direct observations of the site and business operations and took notes (Merriam & Tisdell, 2016). We also collected relevant documents for further analysis.

Within-case analysis was conducted using open, axial, and selective coding procedures. Open coding consisted of a number of passes through the data and creation of tentative labels for chunks of data that summarised the meaning that emerge from data. When saturation was reached, we started axial coding by identifying the relationships among themes that had emerged. In selective coding, we identified the categories that completely represent all the data. Then, cross-case analysis was conducted by comparing and contrasting the three cases to obtain more comprehensive and generalisable insights.

4 How Traceability System Affordances Lead to Achieving Sustainability Goals

We contextualise the capability development for SSCM model proposed by Eitiveni et al. (2018) using the context of the food supply chain in Indonesia. We extended the IT affordance construct in their model following the six principles proposed by Volkoff and Strong (2018) as summarised in Table 2.

No.	Principle (pp 236-237)	The application in our study
1	“An Affordance arises from the user/artefact relation, not just from the artefact.”	We separate the features of traceability system and the actor perspective. Together, they provide possibilities for action. We also explain how an actor’s perspective influences the perception and actualisation of the affordances

2	“Maintain the distinction between an affordance and its actualization.”	We explicitly distinguish affordance existence and how it can be actualised.
3	“Focus on the action, not the state or condition reached after taking the action”	We carefully selected the appropriate level of granularity for the affordances that are free from tiresome lower level affordances while still focusing on the action instead of the state after taking the action
4	“Select an appropriate level(s) of granularity for the affordances.”	
5	“Identify all salient affordances and how they interact”	We subtly discuss the interactions among affordances in Section 4.1 such as how monitoring performance affordance enables supporting improvement affordance.
6	“Recognize social forces that affect affordance actualization”	We identified a network of organisational collaborators that provide the social and institutional environment and acknowledge their roles in actualising the affordances

Table 2. How we applied affordance theory in this study (Volkoff and Strong 2018)

The actions collectively may lead to the development of SSCM required capabilities. Consequently, these capabilities may lead to SSCM practices. Finally, these practices collectively contribute to achieving organisational sustainability goals.

The proposed research model is shown in Figure 1 and explained below.

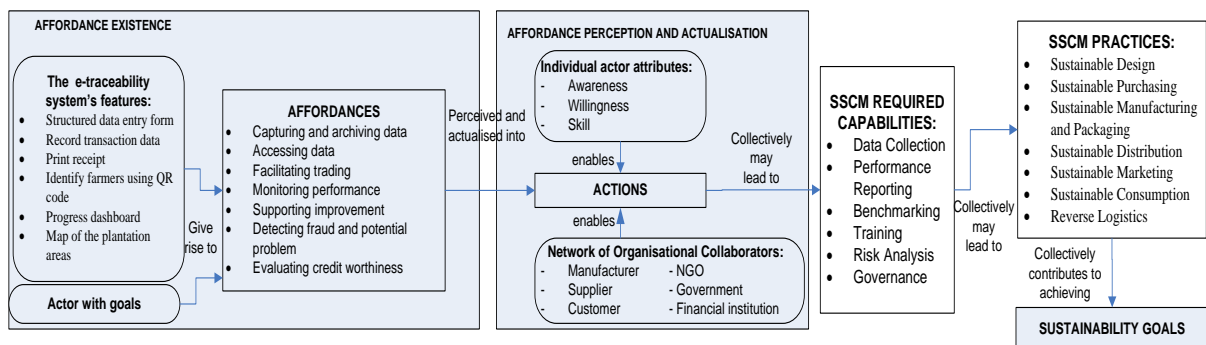


Figure 1. Affordances of the Traceability System Contributing to Sustainability Goals

4.1 Affordance Existence

Cross-case analysis revealed six important features of the traceability system used by the case organisations, such as (1) structured data entry form, (2) record transaction data, (3) print receipt, (4) Identify farmers using QR code, (5) progress dashboard, and (6) map of the plantation areas. These features are available in mobile and desktop versions. All three cases show that when an actor visits a plantation, he can use a mobile device to record the data. This is important because most of the plantations are located in remote areas where transportation and network infrastructure are inadequate.

In all three cases, the actors are smallholder farmers, manufacturers and business customers. For data collection, the manufacturers employed field agents to visit farmers at their plantations. They collected data including farmer profile, the labour involved, finance, environmental practices, sustainability practices adoption, certification, training, and transaction details. They also record the size and the polygon form of the plantation. This data provides traceability to the farm as the formal address of a farm might not be available. Whenever a farmer sells his crops, an actor scans his card, which displayed a QR code, to identify his identity. Then that actor inputted relevant data of the crops. This data was stored and archived for future and further processing. Farmers could access their profile and their transaction details. Manufacturers could track their purchases. Customers could trace the origin of the product up to plantation.

Based on cross-case analysis, we identified seven affordances from the use of the traceability system by the actors. These include:

Capturing and archiving digital data. Our study found that the lack of appropriate data is one of the main barriers in transforming supply chains to be more sustainable. The traceability system provides structured data entry forms and database to allow the capturing and storing digital data. Via the use of this system, the supply chain members have actual data on which they can act upon.

Accessing data from anywhere. Since the traceability system is available in mobile and desktop versions, it allows access to data whenever it is needed which leads to the improvement of timely information visibility across the supply chain. This is especially important to convince the customer that the supply chain is conducting sustainable practices.

Facilitating trading. The traceability system facilitates trading through features such as farmer identification and transaction recording. For each transaction, the farmer's identity is verified through scanning his QR code embedded card. Then, other relevant information such as the amount and quality of the crops are recorded in the system. This affordance, when actualised, contributes to eliminating intermediaries in a supply chain which leads to better income for the farmers.

Monitoring performance. Our study confirmed that one of the problems in achieving sustainability in a food supply chain is the low productivity of smallholder farmers. The traceability system provides a dashboard that shows the performance of these farmers based on their profile and their transaction records. This affordance serves as the basis for recommending improvement.

Supporting improvement. Based on the transactions, certifications, and training data, the system provides recommendations for improvement for each or a group of farmers. Possible training includes sustainable farming practices, financial literacy, and certification preparation.

Detecting fraud and potential problem. The traceability system provides a map of each of the plantation. This map could be overlaid with other types of data such as map of mangrove areas or protected forests. A set of rules can also be programmed into the system to detect fraud such as when a farmer sells crops more than the maximum capability of his plantation.

Evaluating creditworthiness. One of the main barriers to conducting sustainable practices is the investment needed to provide relevant technologies, infrastructures, and expertise. The traceability system records the profile of the farmers and their transaction. This data can be analysed to evaluate creditworthiness of a specific farmer.

4.2 Affordances Perception and Actualisation

Affordance perception is an actor's perception of possibility for actions using a particular object/tool (Pozzi, Pigni, & Vitari, 2014). Case studies analysis revealed that an actor may choose to act upon this perceived opportunity for action creating affordance actualisation. The perception and actualisation of affordances are influenced by several factors such as an individual actor's perspective and a network of organisational collaborators.

4.2.1 The Actor Perspective

In terms of the individual actor perspective, we identified several factors affecting affordance actualisation, including (1) awareness of the ability of the potential of a traceability system to support sustainability transformation, (2) willingness to share data, and (3) skill to operate the system.

Participants from company B stated that previously, several attempts to trace raw materials to plantation had failed. One of the reasons is the remote location of the plantations and its associated infrastructure barriers such as lack of appropriate roads and internet connection. When the traceability pilot project began, field agents were sent to plantation areas to collect data. They were equipped with mobile devices to capture the location and data of the farmers. Since mobile devices are easy to bring,

they can overcome the location barriers. Data can be uploaded later when a network is available. Traceability started with an awareness of the possible action offered by mobile technology to address location barriers as stated by one of our interviewees: *“Some of our locations are very remote. We don’t have an internet connection and phone connection in some areas. A lot of people in the industry doesn’t realise the full potential of IT or the traceability system to overcome this.”* (Vice President Commercial Sustainability, Company B)

Our case studies further indicate that sustainability starts with traceability because it provides the portrait of the real condition. Traceability relies on data collection. Thus, the willingness to share data is crucial. Our data revealed that one of the challenges in traceability is the reluctance to share data. People are afraid to share data with a fear that another party would have taken advantage of them financially. Hence, traceability could not be achieved if people do not want to share their data, as stated by one of our interviewees: *“Transparency is the key. You need to be transparent to address the issue. If there is any problem, to address the issue, you need the information. The effort in getting connected and transparency to farmers is the key.”* (Vice President Commercial Sustainability, Company B)

Our study indicated that the capability to operate the system enhances the actualisation of the affordances offered. Accordingly, when an actor lacks the capacity to operate the system and he does not act upon it appropriately, he will be unwilling to process further. So, it is recommended for a user to seek help when facing difficulty. An interviewee stated: *“We need competence and skill. If all of our [human] resources have the expected competence and skill, we can use the system to oversee the sustainability implementation”.* (Owner, Supplier of Company A)

4.2.2 The Environment: Network of Organisational Collaborators

Cross-case analysis revealed that a network of collaborators is necessary to enable the actualisation of affordances provided by the traceability system in supporting sustainability transformation. This network involves manufacturers, its supplier, customer, non-governmental organisation (NGO), government, and bank. In our study, we found that manufacturers are the main driver of the sustainability implementation in a supply chain. If the top management of the manufacturer has the commitment and long-term goals, beyond immediate economic outcome, they are likely to consider integrating sustainability into their strategy. Then, their commitment would be translated into actionable programs implemented by the employees. Hence, employees should also be trained and motivated to internalise sustainability into their day to day activities.

While our interviewees from manufacturers stated that conducting sustainability within their organisation is relatively less complicated, convincing their suppliers to join sustainability initiative is a challenging task. This is mainly due to the investment that the suppliers should commit, which involves new technologies, capacity building, infrastructures, and business process re-engineering. The manufacturers usually make several efforts such as specifying in the contract about integrating sustainability aspects in some of the suppliers’ activities, conducting supplier development programs, and intensifying the communication with them. However, commitment from suppliers is necessary, since they are the one who should carry out the program.

While manufacturers have been found as the primary driver in the sustainability implementation in the supply chain, it is the pressure from the business customers who ignite the initiative. A customer plays an important part to provide demand for sustainable products. Furthermore, the willingness of a customer to pay (a portion of) the sustainability effort including the traceability system or provide other resources are also a crucial enabler for the sustainability adoption.

Many reactions from customers are influenced by NGOs’ campaigns. NGOs have played a critical part in increasing awareness of sustainability issues such as deforestation, waste, child labour, and social conflicts in a supply chain. In our study, the manufacturers are working with NGOs to address their concerns. Not only, that NGOs can police the sustainability implementation by the supply chain members, they can also support supplier development programs through training and consultancy.

Likewise, the role of the government is equally important. Government acts as a regulator, controller, provider, and facilitator in sustainability transformation. First, the government should provide appropriate regulation about sustainability and traceability. They might pursue further by incentivising the organisations that behave responsibly. Second, they must control the implementation of sustainability since the maturity of organisations is different. Third, the government should provide infrastructure to enable traceability such as telecommunication coverage and roads in remote areas. Finally, the government can also facilitate various stakeholders, even competing organisations, to gain perspectives and capabilities from all relevant stakeholders.

The role of a financial institution has not been mentioned in SSCM literature. In fact, their role is essential. In Indonesia, companies who behave unsustainably could not get loans from banks. When they want to become more sustainable, organisations need to invest in technology, people, and other infrastructure. A financial institution could provide a loan to support this initiative. They might further encourage sustainability transformation by giving lower interest for organisations involved.

5 Conclusions and Further Research

In this study, we have applied Affordance theory to understand how a traceability system can be used in the food supply chain. Traceability in the food supply chain has been studied for decades. Nevertheless, until currently, it is mainly to address social issues such as ensuring food safety and food quality to ensure customer health. We identify the affordances for environmental and broader social objectives exist in the traceability system. We propose seven affordances originating in it that are required in sustainability transformations. We also explore how the actor and environment influence the actualisation of these affordances. We show how these affordances are realised which enable more sustainable work practices. While the results are specific to the traceability system implementation in the food supply chain, it offers a template for affordance actualisation applications in other areas.

Our findings also show that the perception of affordance provided by traceability system influences actors to change their belief and practices. Previously, traceability for sustainability transformation is believed to be extremely difficult due to various reasons including the remote location of plantations. Since traceability system affords actors to capture and access data from anywhere, this view starts to dematerialise. Furthermore, the traceability system is able to detect fraud which discourages actors to conduct deceitful actions.

Understanding the actor perspective might contribute to the IS design. IS designer should make the affordances explicit for the actor to perceive them. Furthermore, our study shows that unwillingness to share data inhibit the actualisation of affordances offered by the traceability system. Thus, we might need to engage relevant stakeholders and communicate with them about the importance of the system and how it will benefit them. This study also highlights the importance of user training to support the actualisation of these affordances.

The actualisation of these affordances to support sustainability transformation is not merely driven by technology, but also a network of organisations. These non-technical aspects might explain the unexpected or unintended outcomes since the effect of IT implementation is not deterministic. At least one organisation needs to drive the sustainability implementation across its supply chain. This organisation should have substantial power over other members. The customer should provide a market for sustainable products. While NGO provides control and resources, the government creates a conducive environment to conduct sustainable practices via the appropriate legislation and infrastructures. Bank provides support and incentive financially.

In the next step of our study, we will analyse affordances arise from multiple IS used in sustainability transformation. Then, we will identify the SSCM practices and the required capabilities. The final model will explain how IS enables the achievement of sustainability goals through sustainable supply chain practices within food supply chains using Affordance theory as a theoretical lens.

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