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Information Exchange in Supply Chains: The Case of Agritech

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Abstract: We propose to analyze the supply chain not (just) as interconnected firms where products move from primary production, through processing, down to final consumer (user), but rather as collaborating firms that exchange information in order for each to function. This opens the analysis of supply chains up for institutional economic analysis and also allows one to acknowledge that information can be used strategically. Yet, information exchange can also be hampered because of a supply chain's structure—we focus on this. The difficulty of exchanging information is particularly important when an industry and its supply chain newly emerges or is disrupted. In such circumstances the way in which information is presented and used is not institutionalized yet in a way that works for the parties involved. We show the relevance of this approach to understanding supply chains by referencing the agrifood supply chain as it is on the cusp of being disrupted by the extensive use of Information Technology.

Keywords: supply chain, information exchange, institutions, agrifood, strategic behavior

JEL Classification Codes: L70, M11, N50, O30, Q10

New or disrupted industries are generally created or re-shaped (in large part) because of the use of Information Technology (IT). A key resource for such industries will be information or data (Ozcan and Eisenhardt 2009), but an answer to the questions (Which data? Presented how? And combined with what other data?) can remain unclear for a long time. As an industry emerges or is disrupted, a new market information system and a new coherent set of institutions that constitutes the industry needs to emerge after the disruption (cf. Anand and Peterson 2000; Dolfsma 2019).

We study the soon to be disrupted agrifood industry as it is at the verge of using information technology on a large scale. Precision farming and IT supported food processing and distribution is expected to help substantially increase production to feed the world, reduce environment pressures, and reduce food waste, while at the same time improving its quality. Agriculture is turning increasingly hi-tech—Agritech—and so traditional farmers,

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food processors, and distributors must start to cooperate with parties that to them are very new and different players.

We suggest studying the agrifood industry or perhaps better phrased "supply chain" not by looking at how products move from stage to stage, but by considering what information is exchanged at each interface.[1] Uptake of IT in agrifood is not very pervasive yet, in part, we argue, because the information exchange in the supply chain is not operating properly yet. Agrifood supply chains are notoriously complex, with many (small) players and time-sensitive production, processing, and distribution. Using insights from information economics and (value) network analysis (Peppard and Rylander 2006; Allee 2008), we show how parties are seeking to find out how to shape collaboration between them. What are the players one needs to connect to, to obtain what resources (i.e., information)?

Information Exchange in Supply Chains

For an industry to function, a sufficient number of players in each stage should operate well (i.e., firms should be profitable). In addition, however, and this is the focus of our article, at the interface between stages players should be willing and able to exchange the required information. If and when information exchange benefits players at the interface of different stages, we assume that information exchange will occur. We focus on the situation in which firms might not be able to exchange the required information, for instance, because it is not available in the form that is needed by another firm. The likelihood of information not being available, or not available in a form that others can understand and use, is larger when an industry and its supply chain newly emerge or disrupt.

Figure 1 is a stylized presentation of (part of) a supply chain to suggest a listing of possible problems that could arise in exchanging the kind of information that is needed to make a supply chain operate. The figure suggests that information exchange in a supply chain can be lower than needed or expected for a number of different structural conditions that are unrelated to firms' willingness to exchange. Referring to Figure 1, we suggest a number of such structural conditions.[2]

The sheer number of players in a stage (situation F) can make information exchange between stages more difficult, in particular if a focal firm needs to interact with multiple firms in the adjacent stage. In addition, some firms in that adjacent stage outsource more activities than others (Situation C; cf. Teece 1986), and so it is possible that firms decide to be active to different degrees in their stage of a supply chain. This can create difficulties for information exchange for instance with the focal firm.[3] The likelihood that information is exchanged by a focal firm with a player in an adjacent stage in the supply chain is relatively high if it has an agreement with this other firm (situation D). The focal firm can then, however, use that information in the dealings with other players in an adjacent stage in the supply chain as well, of course, to its benefit. The further exchange of the information can benefit the firm originally interacted with by the focal firm too, and potentially to the detriment of the focal

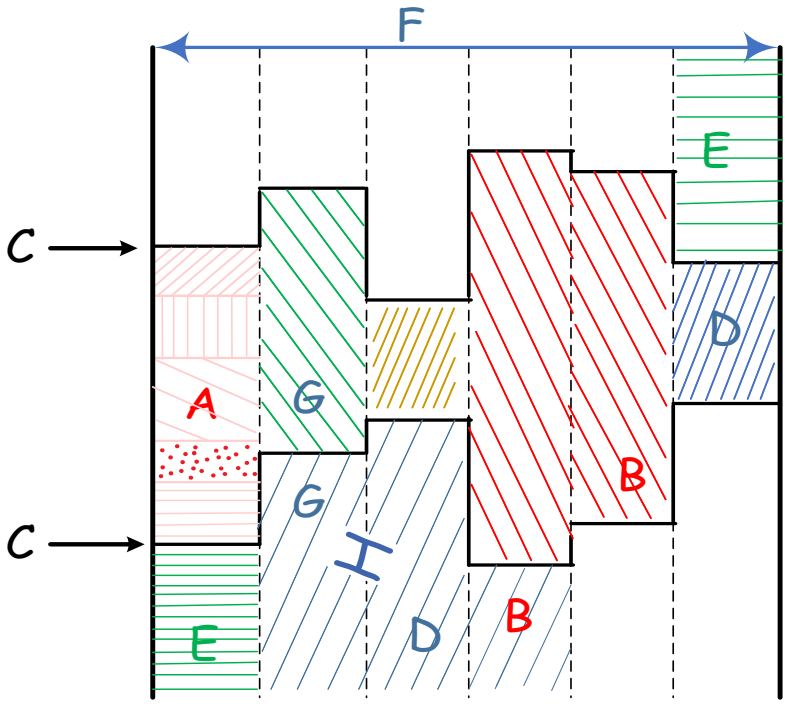
[1] When data-bits are produced and used within a single stage in the supply chain, we refer to it as "data." When data-bits are exchanged between stages in the supply chain, or possibly between players in the same stage in the supply chain we refer to this as "information." Information is transformed data with interpretation added to it, potentially strategically laden. Collecting and transforming (interpreting) data comes at a cost.

[2] The presence of any of these potential structural conditions for a supply chain can be used by firms when developing and deploying their strategy.

[3] Alternatively, if a stage is dominated by a single firm, it can impose a level of outsourcing on firms from an adjacent stage in the supply chain (situation H).

firm as the competitors of the focal firm might be strengthened because the competitors indirectly received information about the focal firm via a joint business partner.

Figure 1. Information Exchange in a Supply Chain



Notes: Lines C separate stages in supply chain; fill pattern and line style indicate extent of firms' economic activities; number of columns in a stage indicates number of competing firms; letters indicate potential information exchange issues.

If a single firm is quite a dominant player (situation H), that firm can impose standards for information exchange between stages.[4] Further, if the economic activities in a stage are fragmented (situation A), the overall need for information exchange is increased substantially, with ample opportunities for information exchange to be hampered.[5] In case the need for information exchange between players in adjacent stages in the supply chain is such that the need of either of the two is fully covered in terms of breadth, information exchange is likely to be adequate (situation G). If, however, the focal firm needs to involve more than one firm in an adjacent stage of the supply chain to work with, there is likely to be information exchange inadequacies (situation B).

Finally, multiple parties need to exchange information with one another and therefore information may not be fully exchanged and a focal firm is likely to deal with competing firms in the adjacent stage.[6] Additionally, a focal firm may need information from another

firm that is not in an adjacent stage (situation E). Such information is likely to be more difficult to obtain than information from players in an adjacent stage.[7] Recognizing the need for information exchange between stages in a supply chain, some firms have created extensive kinds of collaborations with firms in next step stages, possibly extending the benefits of (situation G), but potentially not (yet) (situation D).

What is Happening?—Some Economics

Viewing supply chains as systems wherein information needs to be exchanged for them to work, brings both the strategic perspective as well as the institutional perspective into a discussion which is otherwise mostly focused on the logistics aspect of moving produce around. We will focus on the institutional economic perspective in this article.

Mainstream economics has embraced the view that information can be a product in markets that function very differently from textbook markets (see Stiglitz 2000). It has also gradually started to embrace the idea that markets need specific institutions to function: institutions in support of markets.[8] What we are talking about here involves two other ways in which a specifically institutional perspective adds to our understanding. The institutional perspective comes into the discussion in at least two additional ways (cf. Dolfsma 2019).

First, when market players, even when collaborating closely are dependent on what information they glean from other players, information becomes a good that comes at a price. Having information can give a player a strong position in the market—something that is particularly true in newly emerging or drastically changing markets or industries (Ozcan and Eisenhardt 2009). Players that are able to, and also in a position to, collect important information *about* the market, its players, and its products, can leverage that information to strengthen their competitive position. Examples of firms that were able to position themselves into a very strong competitive position are Google (Alphabet) and Amazon—such firms may be called Info-firms (Dolfsma and Van der Eijk 2018). Such firms are not as dominantly present in agrifood yet, although there are misgivings about the dominant presence in agrifood of large retailers (Gereffi, Humphrey and Sturgeon 2005) and telecom firms might obtain such a dominant position in the future.

The second way in which an institutional economic perspective comes into the discussion is because information *itself* is institutionally embedded (Anand and Peterson 2000). Information needs to be given a particular shape that is recognizable and usable to the players in a market and across a supply chain. The shape in which information is presented in is not self-evident—it can be shaped or changed by what one might call institutional entrepreneurs to favor some players over others (e.g., Munir and Philips 2005). For final consumers, for instance, it can be very difficult to track the origin of the food they eat and to determine how environmentally friendly, animal friendly, or in line with fair trade ideas the food is. Information about food is presented usually on labels visible on the outside of a product. In many product classes, however, there are competing labels, each using different ways in which information is summarized for final consumers and how it is presented visually (Bontems, Monier-Dilhan and Réquillart 1999).

[7] An example of this is the information of production circumstances of farm produce that consumers might want to see on the products they buy in the supermarket.

[8] Hence talk about "institutional voids" when a country does not have the formal institutions that western, liberal economies have (cf. Olthaar et al. 2017).

The Agrifood Industry

We suggest perceiving of a supply chain as a system in which at each stage information needs to be exchanged between parties in order for the system to function properly. This perception is particularly useful when trying to understand the transformation towards widespread use of IT in agrifood for several reasons. These reasons relate to agrifood being an a-typical industry.

This is an industry, first, in which some stages have many and other stages have few players. Secondly, time is of the essence when processing and distributing the products this industry makes—due dates for food may approach rapidly and the seasonality of the production. As a third reason we would signal that the industry itself has a high symbolic value for many people, for historical and cultural reasons but also because the produce made sustains us bodily as individuals and mentally too. Quite a few people derive an identity from what and how they eat, and how they prepare food (Pietrykowsky 2004). Fourthly, one also sees varying organizational forms in agrifood much more frequently than elsewhere in the economy (cf. Ménard and Klein 2004). In particular, family-owned businesses prevail in some stages of the supply chain. Cooperatives are also much more common in agrifood than elsewhere. Fifth, for these reasons agrifood is a relatively heavily regulated industry, with regulations coming from multiple concerns, and therefore ministries.[9] A sixth way in which agrifood stands out compared to other industries are the circumstances in particular during the first stage of production in the supply chain; these are much more uncertain because of weather variation and market volatility (Isakhanyan and Dolfsma 2020). A result of all of these is, finally, that the agrifood industry has long been a relatively conservative industry in most places.[10]

Agrifood Supply Chains as Information Chains—Agritech

The agrifood industry is a very specific one. If it is to feed 8 billion people in a manner that the planet can sustain, it is to do so in the very near future in a way that is very different from how food is grown, processed, and distributed now. Information Technology will play a substantial role in this transition that will sooner or later happen. At the moment, however, it is not happening at the speed that some pundits had predicted (Feng et al. 2020). In this section we will explain what is holding the arrival of extensive high-tech agrifood (Agritech) back by drawing on the institutional economic insights presented in brief here.

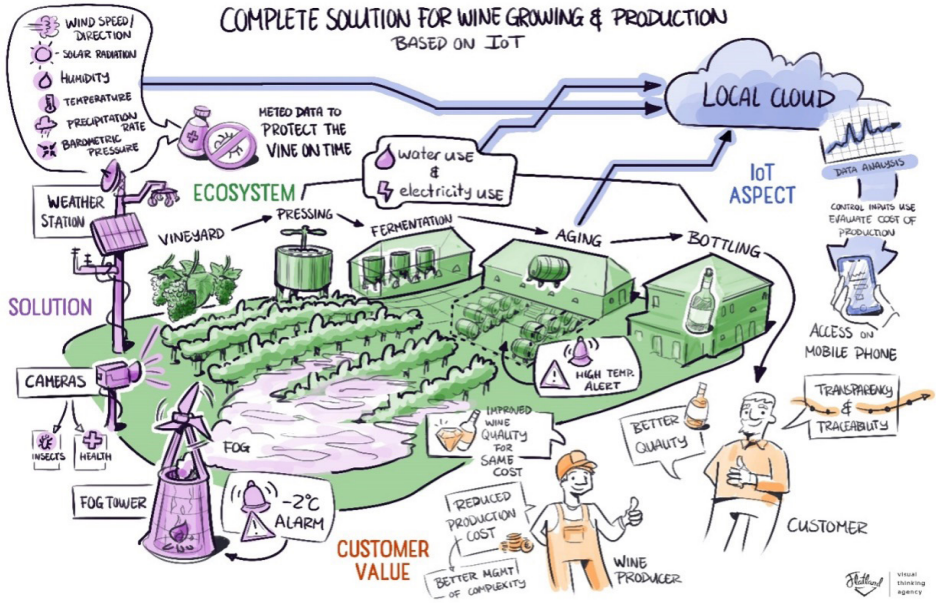
As the use of IT in agrifood grows, the amount of data made available will grow exponentially with it. Even if the extent to which players in different stages in a supply chain remain equally dependent on information made available to them by others remains the same, at least in a transition period before standards and routines have settled, the coordination challenges will be substantial.

[9] The agrifood industry in general, and agriculture in particular, is land-use intensive, and, also because of how its production is set up, uses much natural resources and negatively impacts the environment otherwise. Agrifood is a large and according to many observers a strategic industry. Food quality is closely monitored. Because regulation comes from different ministries, the instructions provided are likely to clash, leading to what Dolfsma (2011) has referred to as government failure.

[10] Information exchange is relatively more constrained in agrifood in general for these reasons. In industries where coordination or information exchange between players, especially at different stages in a supply chain, is relatively hampered, the pace of innovation is likely to be lower (cf. Galvin and Molker 2001).

The production of wine may serve as an illustration (Figure 2).[11] The European Union (EU) is the most important producer of wine in the world. More than 2.4 million vine growers that work in the vineyards cover about 3.6 million hectares land in Europe and represents 5% of the agricultural output value. The EU wine industry is composed by a constellation of small and medium enterprises and traditionally involves a broad range of other professionals such as consultants, service providers, marketing experts, etc. However, nowadays, the wine sector is under pressure because of the global economy having to compete with countries like China. New cultivation methods are needed, or niches to be found and developed, such as that of organic wine.

Figure 2. Digitization of Viticulture



Source: © Flatland Artists

Precision viticulture and remote vineyard monitoring are the two most promising technologies, by using Internet-of-Things (IoT) technologies. Remote sensing and control actuators, information collection (both in vineyards and cellars), together with big data analysis and management, and precise decision-making increases efficiency. Through IT, resources can be used efficiently to reduce production costs and make a higher quality wine. Soil (humidity, by location), climate (temperature, rainfall), phenological stage of a plant, presence of pests, and plant health and product quality in a vineyard can be monitored extensively and in real time. Plants can be given water, nutrients, and possibly pesticides as they need it individually, rather than for an entire vineyard indiscriminately, and some interventions can be done without the active involvement of the farmer. Harvesting, for

[11] This section draws extensively on research project IoF2020, Internet of Food and Farm 2020 (e.g., Verdouw *et* al. 2017).

instance, can be automated and need not involve individuals who pick the grapes.[12] The use of IoT technology in wine-growing on fields, fermentation and aging in cellars, and bottling and transportation to final consumers are interconnected. Farmers can decide to press, ferment, age and bottle the wine themselves, or these steps can be done by others. During each of these steps data can be collected and presented to the firm. For fermentation to be improved, for instance, the quality of the grapes used for the wine is best known, drawing on the data generated when the grapes grew. If fermentation is controlled better, the quality of the wine will improve, and the bottling can be timed better. Information about when bottles are ready for transportation to distributors or retailers is required by the transportation firm. The wine producer needs to know how the transporter needs the wine delivered for them to be collected—perhaps not in bottles stocked in boxes on pallets, but perhaps to be shipped in a tank truck. Precision agrifood and processing has the potential to improve wine production's supply chain from vineyard to consumers, reducing the use of chemicals for plant protection through a precise use of treatments. The information exchange between grower and processors is important to guarantee the quality of wine to the consumers, especially if the focus is on the premium wine market with exceptionally nuanced and highly valued taste, but can be difficult to establish.

Conclusions

The supply chain is not (just) a composition of interconnected firms where products move from primary production, through processing, down to final consumer (user), but also a set of collaborating firms that generate, store, transmit, and exchange information in order for each to function. This opens the analysis of supply chains up for institutional economic analysis and also allows one to acknowledge that information can be used strategically. Yet, information exchange can also be hampered because of a supply chain's structure—we focus on this. The difficulty of exchanging information is particularly important when an industry and its supply chain newly emerges or is disrupted since the way in which information is presented and used is not institutionalized yet in a way that works for the parties involved. We show the relevance of this approach to understanding supply chains by referencing the agrifood supply chain as it is on the cusp of being disrupted by the extensive use of Information Technology.

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[12] Agrifood being a complex production system, the IT challenges here are substantial. Overcoming the challenges in agrifood does not, however, involve extensive machine—human being interaction, and so the chance of accidents in which humans are injured is reduced. Agrifood is a good testing ground for the development of relevant IT.

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