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Continuous Handling of Uncertainty in Food Chains: Using the House of Risk Model in Ecosystems

Per Engelseth*, I Nyoman Pujawan**, Mirwan Ushada***

**Molde University College, Norway*

***Sepuluh Nopember Institute of Technology, Surabaya, Indonesia,*

****Universitas Gadjah Mada, Yogyakarta, Indonesia*

**Corresponding author: per.engelseth@himolde.no*

ABSTRACT

The house of risk model represents an approach to mitigate risk through systematically analysing data risk agents based on empirical findings through prioritizing them. Food production is associated with uncertainty both within the production system as well as in environment. Given the state of current technology, including its rapid development impacting on connectivity in supply chains, the house of risk model is considered through this conceptual study applying an ecosystems approach on how to mitigate risk in food chains in their many-faceted environmental setting. Ecosystems thinking is rooted in a normative quest to secure sustainability. It also is at the operations level a complex system. It is pointed out that an ecosystems approach encompasses mixed methods, including both deterministic and complex systems. The nature of this complementarity is discussed. The study provides a list of four issues regarding using the house of risk model within an ecosystem: (1) ethical, (2) development, (3) operations and (4) discourse.

Keywords: Ecosystems, House of Risk, Uncertainty, Complex systems, Supply Chain Management, Food chains.

Introduction

Uncertainty is a form of human perception. It is associated with a feeling of not knowing the outcomes of alternative actions. This is due to no or limited information concerning an issue at hand, in an immediate focus of attention demanding sensemaking to move forward in food production systems. Uncertainty has economic impact given the role of human decision-making to manage organizations and produce customer-valued service. In supply chain management (SCM), dealing with uncertainty is found both at the managerial and production level. Overall, manging production is embedded in a sense of meaningful actions; it is as Parsons (1960) states, taking place in an institutionalised context; led by a unifying discourse. This very real feeling of business culture, where the discourse on how to manage, soothes some of the anxiety that may be appropriated as uncertainty in supply chains. Managers become somewhat like slaves of their past embedded in memory. However, most mangers still do search for a more objective way to deal with this anxiety regarding uncertainty in cases of supply chain decision-making. This has much to do with professional training, that one needs to think “outside the box” of the often-mundane commonplace operational routine to compete in a

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capitalistic marketplace. There is a need for management tools that move planning into the micro-level of process in a complex system. This is dependent on quality information connectivity. This movement of planning into the ecosystem, a system that embraces both supply chain complexity and its sustainability, is the overall topic of this paper.

In food production, it is pertinent to address the particularities of uncertainty and how this may impact on both manging and operating food chains. In food chains uncertainty prevails in its own way. The following provides a picture of why this is true. In a study by Engelseth (2015) of local strawberry production uncertainty was found in this relatively short supply chain structure as associated with first at the longer-term coping with variation in seasonal production start and termination, as well as the overall volume and quality of a year's production. At the operational level mangers dealt daily with variations in weather impacting on supply the first day, and demand the second day, given that distribution involves production for the following day. Since rain leads to reduced harvest, and also leads to reduced demands, and weather is unpredictable, mangers therefore needed to coordinate both variation in yesterday's production with variation in the present days demand. The creates challenge when yesterday's weather is not the same as today's. Then mangers need to promote surplus production or negotiate with customers to receive less supplies of strawberries. This is just one simple example of how the biological material a food product as a distributed goods are embedded in what may be termed as an "ecosystem".

Risk management is a viable path to deal with uncertainty from a deterministic, often called "scientific", approach. This implies a quest to control uncertainty by understanding it based on historical data. This historical data may be statistics or founded on survey data on perceptions of supply uncertainty. The house of risk (HOR) model is one such tool that may help managers cope with uncertainty by better discerning between the probability and severity of the risk. Since risk management fundamentally implies rationalizing uncertainty, making it more objective, it represents an information tool that helps mangers prioritize their management resources at hand to cope with uncertainty. The HOR model is founded on the house of quality model, found in Lean thinking, exemplified by the Toyota production system. The lean approach, involving heuristics developed in business practice following a particular quality management approach (Deming 1982), then reported on in academic literature (Holweg, 2007), is however, not easy at face value to consider either as complex or deterministic.

The problem with reductionist founded deterministic models is that they never can encompass the complete spectre of risk events as they seeming coincidentally occur. They create a plan to be implemented some time later. This may be too slow in contemporary food chains. This is especially the case in supply chains, such as many food chains, where volatility is very high due to many reasons including variations in supply, demand, production and information, as well as environmental change. There will in food chains always be a quite high risk of risk model failure. The analytics of a deterministic planning model may be conceptually quite beautiful, but the usefulness limited when events are characterised by a high degree of surprise. This paper therefore also discusses the negative potential that the HOR model may fail to avoid production error which it seeks to reduce or hopefully eliminate.

Alternatively, production may be managed from a complex systems approach. In a complex system, management must consider how to handle processes where components are continually in flux regarding not only the more easily measurable time, place and form features, but also how they are pooled as well as how they are perceived. In this system, production is in a constant state of change due to interaction between people, artefacts and the environment. The role of information in a complex system moves analytical focus to rather than supporting planning producing documents to guide production, to instead support managing processes in a state of continuous emergence. An ecosystem is as such a "complex system", especially so since it takes the inherently unruly environment as a key factor in the system. A supply chain viewed as an ecosystem integrates the functionality of nature and society into the system and is therefore, from an analytic perspective, complex.

Can then a deterministic risk management model somehow be combined with an ecosystem understanding of manging food supply? Noble et al. (2008) argue that is perfectly possible. This discerns, following Checkland (1981) systems research approaches as either hard (deterministic) or soft (complex). Following an analytical time line these approaches may be timed. The hard approaches, such as risk management tools, may provide ex-ante understanding of a phenomenon. In a manner, this means that planning may be used in soft systems thinking, as a tool to better understand the uncertainty, making it an analysed risk. This is a reaching out to understand the complementarity of hard and soft systems methodology, how they can together provide better understanding in coping with food supply chain uncertainty. We seek accordingly to tear down the silos of deterministic analytics and complex systems thinking.

In this paper we elaborate first on particularities of food production form a supply chain perspective with focus on uncertainty. This provides the empirical backdrop for further literature review. Then we present the HOR model, and how this model is used in food chains. This is followed with a discussion of ecosystems and why this form of complex systems thinking is pertinent in food chains. Since the HOR model is associated with Lean thinking, a discussion of this approach in relation to ecosystems thinking is also provided. Finally, synergies of coupling the HOR model with ecosystems thinking is discussed providing a research model for guidance in future studies. It is envisioned that ecosystems thinking provides a workable way to apply the HOR model, and that given state of the art information technology, implying potential for increased stakeholder connectivity, this deterministic model provides the framework of such complex systems model.

Uncertainty in the food chain

First, we elaborate on particularities of the food supply chain. It is a network of interests wherein purposes, technical inter-linkage, supply chain membership and inter-firm borderlines have in current times increasingly fuzzy properties. This implies a need to develop understanding on how to coordinate this type of production (Simatupang et al., 2002). Food is in many economies produced at an upstream level through a traditional economy involving predominately smallholder agents; fisheries, hunters and farmers. In many developed countries heavily relying on food production, it is modern and large scale, organisationally resembling manufacturing.

How then does a traditional and usually simple mode of food production interact with increasingly-sophisticated urban food consumers downstream in the food chain? Is there any difference in consumer acceptance regarding acceptance of food production in cases where large scale modernistic production of food is applied? Clearly, the need to integrate to interact in a food chain is called for regardless whether production is traditional or modernistic leaning. This, however, is a challenge given first, the disparity between characteristics of the agents in the chain, and secondly, an often-long distance, both culturally and geographically, between the upstream food producer and the end users. Food supply is increasingly globalized, and this increases the food supply chain integration challenge.

Following Forrester (1961), poor integration also implies a risk of information distortion. Lee et al. (1997) propose information sharing as are remedy for this type of information distortion found in long-linked supply chains typical of manufacturing. Food chains do not necessarily involve manufacturing, but they are fundamentally characterised by predominant sequential interdependencies (Thompson, 1967). This implies the one activity is dependent of the effectuation of a preceding etc. This is typical of all physical distribution such as the case of foods. To encompass the particularities, contingency theory focusing on interdependencies typical of an industry, provides theoretical guidance on managing food supply operations. These interdependencies are expressions of power; reasoning why business relationships are arenas for securing trade (Emerson, 1961). Power is accordingly not the same as coercion, but may be an outcome. Power may equally represent the potential to get things done, to produce efficiently customer-wanted service.

From a contingency theory viewpoint (Thompson, 1967), modernistic food production applies *long linked technology* and involves sequential interdependencies between predominately large-scale production facilities, "from farm to fork". Engelseth (2017) points out, as a variation of food supply, that local food production is more like services production due to its shortness (few or no intermediaries the marketing channel), implying reciprocal interdependencies predominant in simpler local food production with a potential to automate the production processes implying increased pooled interdependencies. In cases of predominately reciprocally interdependent production the quality of mutual adjustment to tailor a service is evident, while in cases of predominately pooled interdependencies, mediating technology such as information systems using

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standardized resources help integrate dispersed agents and other resources to produce quality. In cases of reciprocal interdependencies development is sought through improved interaction, while in pooled interdependency development is sought through enhanced interconnectivity. In cases of the predominating modernistic food production using long linked technology, the flows as the space of technology-driven production operations need to be enhanced.

A production flow, such as predominant in modernistic food supply, consists of a series of labour tasks. This can be done, according to Thompson (1967) through range of varying approaches to improve flow coordination. including planning and optimization, levelling production such as in the Toyota product system. Coordination, can also, following Forrester (1961) and Lee et al (1997) technically be enhanced through enhancing agent connectivity. In cases of sequential interdependent supply, the aim is to better coordination, the smooth flow with limited inventory buffering, while in pooled interdependencies, the aim is to interconnect, including the customer. Information system development, including its human resources, is here key.

In long-linked technology the end-user is the last hand (recipient) in the chain, vital since this is the ultimate quality control. In long linked food chains, often involving food processing (manufacturing), production quality can be measured as transformation of the time, place and form features of the goods (foods) through sequential steps (Alderson, 1965). Efficiency is associated with costs of the transformation, while effectiveness is associated with how happy the end-user is within the delivered food product for consumption. All these forms of production involve use of business relationships, but their role varies. Interaction in these dyads involves both information sharing and collective learning, which, according to Simatupang et al. (2002), are two vital aspects of achieving synchronized coordination. Depending on the type of interdependency, information needs differ in securing food quality.

Given that uncertainty is associated with information quality, the type of information used to reduce uncertainty, to manage risk varies, primarily a result of understanding what type of supply chain is at hand. In modernistic food supply uncertainty is associated with manging the flow, in local food production, either the quality of interaction or automated interconnectivity, instead, helps manage risk. The length of the food chain accordingly, matters regarding how it should be organized and managed.

The HOR model

The HOR model is inspired by the “house of quality” model found within what is commonly termed “Lean thinking” (Womack and Jones, 2003; Holweg, 2007). More precisely, the house of quality is associated with quality function deployment (QFD). Yoji Akao, the original developer of QFD stated that it is a "method to transform qualitative user demands into quantitative parameters, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process."(Akao, 1994). This is accordingly a reductionist approach, attempting to explain entire systems in terms of their individual, constituent parts and their interactions. Analysis to develop processes is sought by understanding and developing the process layer or organizations influenced by context. In the case of QFD, technology and user needs are the combined the point of departure for research and development.

Reductionism provides context determined outcomes of process development. In practice, QFD is founded in reductionist thinking since a blueprint for process development is sought. This determinism is, however weak, since focus is directed to micro-elements in the system and the feature that these elements are changeable. This also implies a fundamental view that determinism and complexity do represent dyads, they are rather expressions of a continuum for interpretation rather than rigid classification.

In essence, the variation of quality characteristics, their perceived values together with their interconnectedness in a system, provides a roadmap to production process development. The house of quality model provides accordingly an indicator regarding how to more precisely change processes to enhance quality based on surveyed quality perceptions taken from the network of supply chain stakeholders. QFD provides accordingly an informational resource through the survey of organizational practitioners involved in a common production process and this information provides grounds for following calculations guiding management to develop product quality through developing production quality.

The HOR model represents modelling adaptation following QFD principles. It follows the same fundamental line of thought in using the house of quality model. The main difference is that the topics encompassed in the HOR model are associated with “risk” rather than “quality”. The fundamental notion in the HOR model is that “…proactive SC risk management should attempt to focus on preventive actions, i.e. reducing the probability of risk agents to occur” (Pujawan and Geraldin, 2009, p. 955). This proactiveness is sought through analytics that produces information for mangers to base their decision-making to design process on so that (1) they better handle risk events by either avoiding them, or (2) reducing their negative economic impact when that actually occur. The HOR model consists of two models: HOR1, a model that determines which risk agents are to be given priority for preventive actions and HOR2, a model that gives priority to those actions considered effective but with reasonable money and resource commitments. The first model is technical, the second economical. This implies that process development to manage risk is not considered acceptable an all costs. Application of HOR1 involves (for further detail see Pujawan and Geraldin, 2009): (1) risk identification, (2) risk severity assessment, (3) risk agent identification, (4) create a matrix to describe the relationship between each risk agent and each risk event, (5) calculate the aggregate risk potential of agent, and (6) rank the risks. Application of the HOR2 model involves (for further detail see Pujawan and Geraldin, 2009): (1) select a number of risk agents with high-priority rank, (2) identify risk mitigating actions, (3) determine the relationship between each preventive action and each risk agent, (4) calculate the total effectiveness of each action, (5) assess the degree of difficulties in performing each action, (6) calculate the total effectiveness to difficulty ratio, and (7) assign rank of priority to each action.

This analysis provides for business practitioners detailed systemic ex ante knowledge of risk e.g. a food supply chain. The question remains how to implement this approach better in the continuous management of business process. This implies thinking more about continuous lean thinking inspired relatively manual Kaizen approach as well as a more complexity sensitive approach to production process development. Also, the issue of enhancing process sustainability, the long-term environment-sensitive understanding, is still limited in the HOR model and should form ethical viewpoint be addressed. In the next sections, we first address this latter issue regarding ecosystems. This is followed by consideration of the applicability of lean thinking in relation to both the HOR model use as well as considering this from an ecosystems perspective.

Ecosystems thinking

Ecosystems represents a variation of systems thinking. “General systems thinking emphasizes connectedness, context and feedback. Research questions identify and explain interactions, relationships, and patterns” (Kay, 2009, p 7). One of the key features differentiating ecosystems from mainstream systems thinking is the normative quest for environmental sustainability. From a supply chain management (SCM) perspective this means that production is driven governed by norms of sustainability. While industrial systems engineering tends to focus on the workings of machines or production systems, an ecosystems approach will accordingly widen the scope of investigation to importantly encompass society and the natural environment. Humans being a partaker in this environment, with conceptions that impact and are impacted by both economic and natural environment imply that the societal factor also has importance in an ecosystem. Clearly, production systems are also social systems, although they aide at a micro-level in relation to the wider element of society.

Widening the cope of investigation through applying an ecosystems approach increases the number of agents and artefacts interconnected in the system. Foremost, given the unruly character of nature, as well as the somewhat indeterminate character of human perception and cognition, this widening increase system complexity. First because the number of objects interconnected increases, but also because some objects are not manageable, while others, such as agents, perceptions are the result of interaction. This means that complexity is a key feature of an ecosystem. Furthermore, ecosystems as research approach encompasses mixing methods (Checkland and Scholes, 1990; Midgley, 1992; Holling, 1995; Waltner-Toews and Wall, 1997). This resembles the fundamentals of case study research strategy. Ecosystems research is however not limited to studying real phenomena in their actual context, but they still often may be case studies. Ecosystems may also be studied as regions, nations and the planet Earth as a whole.

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This study embraces this complex systems approach where the aim is to create information systems enabling continuous change, a system sensitive to emergence. Complexity can be defined, following Rzevski and Skobelev (2014, p. 5) as: " …a property of an open system that consists of a large number of diverse, partially anonymous, richly interconnected components, often called agents, has no centralized control and whose behaviour emerges from the intricate interaction of agents and is therefore uncertain without being random". Rzevski and Skobelev (2014) also point out that the key features of complexity are openness, diversity, partial autonomy and interconnectedness of agents, lack of centralized control, and emergence. This component interlinking means that interdependence is a prime feature of complex systems. However, in relation to interdependencies described in contingency theory (Emerson, 1961; Thompson, 1967; Stabell and Fjeldstad, 1998), interdependencies are power structures within a process where individual or a series of business relationships represent the immediate context.

Complex systems consider interaction not as a process itself, but as interaction between animate and non-animate objects within the process. Furthermore, complex systems represent an important approach to developing information systems to support production in various forms Rzevski and Skobelev (2014). We have already indicated that food production may be organised as either predominately sequential, pooled or reciprocal interdependencies. This provides guidance towards that information systems need to be adapted to the predominate given interdependency. Alternatively, the interdependencies may be changed (Engelseth, 2017). Prior to developing production as a complex system, the system may be simulated, first applying soft systems methodology (Checkland and Scholes, 1990), then simulated following agent based modelling methodology (Gilbert, 2008). This is especially of value in cases where radical change is considered. In cases of incremental change, the emergence is built into the complex system ontology.

Engelseth (2017) points out how, from a management viewpoint while in production (operations), a way to solve this tension between the economic production system and the combined forces of the societal and natural environment context of production, is to view decision making as focused on economic factors where societal and natural environment concerns are "filtered" through these most close economic considerations. "Ecosystems are usefully understood as comprising of multiple nested hierarchies" (Waltner-Toews and Kay 2009, p. 241). This represents the complexity of the ecosystem, a divergent interacting organization of varied purpose. This also is what comprises of the institutional aspect of ecosystems, operational purpose is conglomerate and in change. "Management is an activity of translating the vison into reality. It involves the development and implementation of strategies to promote or discourage specific forms of self-organization" (Waltner-Toews and Kay, 2009, p. 244).

Self-organization is considered an inherent part of an ecosystem, it is complex, however, management upholds a role to steer activities in relation to values, importantly, sustainability. Economic organizations strive to survive in a competitive marketplace, therefor upholding their existence is a natural primary concern given the commonplace capitalist mode of organizing most economies in the world today. This implies an ecosystems approach that upholds complexity, but discerns managerial sensemaking as activity where decisions are a result of a coalition of economic (including technical), societal and natural environment concerns. The purpose of an ecosystems from this view is to create an information system following complex systems methodology that helps management guide production as an emergent phenomenon; incremental change. Monitoring, governance and management are the core activities carried out in an adaptive ecosystems approach in the institutional context of sustainability as norm (Waltner-Toews and Kay, 2009). This implies closeness to the conceptually narrower analytical frame of complex systems methodology (e.g. Rzevski and Skobelev, 2014). A production process may be monitored for development (Boyle and Kay 2009). Monitoring encompasses in a food chain that production is in line with ecosystems values, importantly a general aim of sustainability. However, a range of other indicators may be defined in an ecosystem and monitored. Ecosystems are complex, therefore: "Emphasis is placed on monitoring the self-governing processes that cause structures to emerge rather than measuring only what one can see" (Boyla and Kay 2009, p.291). This implies that although not explicit, "risk management" is encompassed in an ecosystems approach. Mitigating risk is however focused on studying the causes of events rather than outcomes at the process level; managing risk as a supply chain feature embedded *in* the system.

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This approach does not rule out radical change, and such change may be supported by research following deterministic methodology. However, the outcome of such ex ante knowledge will then be to change the structure of the information system to better handle production process emergence. This research will accordingly not be wholly deterministic even though it is carried out to create informational documents such as research reports etc. Deterministic enquiry is limited to nested analysis within a complex systems whole, importantly to support more radical change of the production system. This is because this research-based knowledge documentation that may include agent based modelling and simulation, are mere stepping stones in a continuous development to support handling production primarily as an emergent phenomenon. “There are no definitive experiments, no final, unassailable truths. We are learning as we go” (Waltner-Toews and Kay, 2009, p. 254).

Lean ecosystems?

In this final section, we briefly cross counter mainstream lean thinking. The reason for this is two-fold. First the focal HOR model of this investigation, given its roots in QFD, is firmly rooted in lean thinking. The HOR model is also focused on creating production change through increased understanding of production risks. Secondly, the discussion on ecosystems has shown that process emergence are core features of this approach. Lean thinking is likewise focused on incremental production change.

Lean manufacturing is based on developments of TPS (Toyota Production System) (Holweg, 2007). This involved at first JIT (Just-in-time) manufacturing with focus on the technicalities of pull-based automobile production within a factory coordinated with “just-in-time” deliveries from suppliers at various stages of the assembly line. Lean manufacturing represents an evolution of manufacturing principles developed through TPS. The term “lean” was first coined by John Krafcik in a fall 1988 article, "Triumph of the Lean Production System," published in the Sloan Management Review and based on his master's thesis at the MIT Sloan School of Management. Krafcik had been a quality engineer in the Toyota-GM “NUMMI” joint venture in California before coming to MIT for MBA studies. This study revealed the “Japanese” principles of lean production were deemed universal (Womack et al., 1990, p. 9). Krafcik's research was continued by the International Motor Vehicle Program at MIT, which produced the international best-seller book co-authored by James Womack, Daniel Jones, and Daniel Roos called ‘The Machine That Changed the World’ (1990). From the 1990-ies universal principles of lean operations, enterprise and networks (Bell, 2006, p. 37), have been applied to improve product flows in a range of different industries. However, the core focus is still the application of lean in product-transforming operations. Lean manufacturing involves following a set of core manufacturing principles where the fundamental aim is waste reduction. Liker (2004) expresses in his book “The Toyota Way” that lean business principles involve 1) long-term philosophy, 2) the right process will produce the right results, 3) add value to your organisation by developing your people and partners, 4) continuously solving root problems drives organizational learning (kaizen). A range of studies reveal practical adoption and development following lean principles (Holweg, 2007). Lean has clearly been a success story in production development. From an academic perspective, however, improvements are manual, based on local intuition and application of heuristics. Because lean implies a vast amount of reciprocal interdependency, development emerges through intense technology, the frequent interaction in the firm guided at core by the lean principles of waste (muda) reduction. Following Bell (2006), a lean production system demands a flexible information system designed to support the focal human interaction, teamwork, that characterises incremental character of lean process development.

While lean production systems are fundamentally sceptical to use of new information technology (IT) (e.g. Liker, 2004) before it has been proven in actual and rather widespread use, complex systems are seemingly more “all about” moving the borderlines of IT enabled production system design. In a complex systems approach, processes are sough automated. This automation is, however rooted on local systems, focusing on a core object and its navigation through the system. Herein lies the incrementality of complex systems. In lean production systems focus in on agent sensemaking mainly in interaction with other agents. It is a people-led process using manual tools such as posters hung on the wall, whiteboards etc. to stimulate idea generation through teamwork, such as in Kaizen events”. In such events brainstorming is a key feature, several minds,

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mainly those directly involved with the production at-hand, interact in search for creative ideas for production process development. As in ecosystems, focus is not on absolute truths, but in “learning as we go”, as expressed by Waltner-Toews and Kay (2009, p. 254). In complex systems, however, development is sought automated. In such cases people are merely a part of the system, and not necessarily the core feature of this system. However, when designing the complex system, people play a role more in line with lean process development.

Merging complex systems with lean implies based on this discussion evidently use of lean principles mainly to support relatively more radical change. Lean, with its roots in total quality management (TQM) (Deming, 2000), provides a customer-oriented aim of production to seek quality as perceived by an end-user. Production is accordingly aligned with this aim in TQM. Furthermore, while complex systems seek process automation, as long as the human factor is a part of this process, lean principles of labour empowerment to motivate for continuous change will play a role in securing production quality. Therefore, lean principles may provide guidance in relation to how to design, implement and use complex system information software. This is especially related to organizing the design process and then motivating the use including providing guidelines to how to organize the still existent manual parts of sensemaking found in a complex system.

Finally, when considering lean production systems from the wider format of an ecosystems approach, this directs attention to the role of society and nature. Clearly, lean with is roots in systems engineering, is at its conceptual core not very environment-oriented. It does encompass long-term thinking, but mainly about the production system as an economic phenomenon. Nature is habitat “out there” in lean. Liker (2008), in his book, however, points to the importance of culture in making lean systems work. There is a focus on habitat at the workplace to secure productivity, ergonomic production and counter the incidence of demoralising work. There is clear importance of society, and this importance also weakly touches into concerns for the natural environment since people, the workers live in such a context; a clean factory in a clean environment creates motivated workers seems to be the lean logic in Liker’s (2008) book. This interaction is, however, not considered systemically.

Typical of lean thinking, is that as it expands its conceptual reach, the new realms of lean seem more to be realms of importance that are not interconnected with each other. It is at the core time-based manufacturing stem that system thinks most strongly prevails, in its contingencies, these are seemingly only mentioned, and how to reach an environmentally and socially sound production system that creates quality for the society as a whole is not systemized. An important aspect when considering ecosystems thinking, is that production quality is more than quality perceived by the customer. This quality is considered in relation to both society and nature. This provides grounds for researching the sustainability of lean production systems using an ecosystems approach. It also opens up for considering in research how in practice proven lean principles of production organization may be complimentary to a process emergence view of production, designed and carried out as an ecosystem; a sustainable complex system to produce.

Analysis

Several issues have through this conceptual investigation emerged regarding application of the HOR model in food chains from an ecosystems view. These are:

1. Ethical: HOR model use to design sustainable food production
2. Development Delimitation of the role of the HOR model to design production in food supply chains.
3. Operations: Integrating the use of HOR model elements in complex food production systems.
4. Discourse: Using lean institutionalized behaviour (culture) to support features of ecosystem design and quality food production.

Changed use of the HOR model may apply between one or preferably all the listed issues. Note that applying an ecosystems approach is not completely objective since it is driven by norms regarding sustainability. A wish to “save our planet” is a subjective consideration that normally is founded on degrees of objective research data. This gives the ecosystems approach at face value a different flair in comparison to mainstream managerial approaches to develop production systems. The following sections provide a brief summing up of each of these HOR use issues when applying an ecosystem understanding of production.

Ethical

The ethical aspect of the ecosystems approach is its heart. This is the aspect of ecosystems that needs to be monitored since these norms may be lost in self-governing complex systems. Its main goal when applied to productions systems is to improve sustainability. It is clearly possible to apply some of the other aspects of the ecosystems approach and discard this feature. Societal and natural environment concerns may be integrated from a predominately business economic viewpoint, expanding the supply chain horizon without considering the from a long-term perspective where human well-being is the greater good. This would then necessarily have to be done by omitting the “ecosystems” label”. The ecosystems approach would then be reduced to be an idea generator for business process development. In food chains, as discussed, sustainability should be considered an inherent foundation regarding how to design such production. Food production is interwoven with nature, and produces a biological product. Developing the HOR model to be more sensitive to ecosystems factors of society and nature would involve revising the current risk agent classification to consider the embeddedness of these factors in nature and society. The development of risk agents is associated with sustainability aims that need to be monitored. Clearly some pertinent factors are already included in the model such as “natural disaster” and “seasonality factor” (Pujawan and Geraldin 2009, p. 960). However, these concerns, and more, should be seen not solely from a limited busses economic perspective, but from a wider sustainability perspective that also certainly should encompasses economic concerns. Furthermore, new risk agents adapted to the embeddedness of food production in nature and society may be added, such as (1) the impact of daily weather fluctuation on the provision side, or (2) food culture change on the demand side. The following discusses the main four aspects of developing the HOR model for research and development of food ecosystems.

Development

A reason to change the production system designed in accordance with ecosystems values would be that monitoring detects risk factors that are not in line with this aim. The HOR model has in discussion been described as a deterministic approach. This conflicts with the complex systems approach to production typical of ecosystems thinking. Complex systems methodology, focusing on incremental change in the system, however, tends to neglect that occasionally a human developer need to step outside this conceptual box to redesign or develop the system. A complex system seems not developed for such external impact given its focus on system self-governance and self-improvement. Clearly this utopic vision of complex systems methodology, given the still weakly developed state of artificial intelligence, is unrealistic today. There may be a need for radical change. This may be associated with improving an implemented information system used to support food production in a supply chain, whether flowing complex systems methodology or not. A complementary role of the HOR model is accordingly associated with system design. This implies using the model much in its original state, adapted to food chains and sustainability aims as described in the section above.

Operations

Introducing HOR elements into an ecosystem applying complex system information system architecture is possibly the greatest of these three challenges. This involves designing the ecosystem to encompass risk agents. In practice, this involves mitigating uncertainty by manging risk within the complex system. In complex systems agents are programmed for automated sensemaking of a wide array of sensed environmental inputs. This data may be improved by considering risk agents as part of this sense making, and develop automated computational reason that may asses risk based on sensory data that is reflected upon in relation to accumulated risk statistics. This provide fast, local risk management. Also, the system may then provide statistics in accordance with the HOR model to intermittently debrief management on the status quo of risk

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management in the food supply chain. Clearly, this issue involves information system design as a first step, followed by self-adjusting system development following HOR principles. Monitoring that operations are in accordance with sustainability aims provides grounds for considering food production process development.

Discourse

Discourse represents the intuitional aspect of production encompasses human discourse; mindsets, culture etc. that guide action. In our high-tech reality researcher, along with managers tend to forget, a bit naively spoken, that people still matter. In supply chains, the production system is with our current state of information and production technology never fully automated. People are still using machines to inform and produce; they still have power to decide, especially in the less mundane production question. Lean production systems development has proven the importance of empowered labour. The same can be said regarding motivated managers. The institutional layer in production continues to be important. The difference is, from an analytical perspective, that observations of the role of people changes when production is designed and managed as an ecosystem. People need to adhere to the norms of sustainability, and they need to feel important so that they are motivated to actively take part in food production as something they feel is societally important; something local, a part of a work community. They need to feel that producing food matters from their role as manager or labour. The schism between labour and management should follow the lean norm of servant leadership as a supporting rather than coercive agent. Principles of teamwork learned from lean practices (E.g. Womack et al 1990, Liker 2008) to create community at the workplace are valuable experiences that need to be developed to keep an ecosystem running to produce quality foods and in the long-term perspective, and to help develop it.

A few concluding remarks

Limitations are mainly concerned with the conceptual nature of the study. Further research should therefore be associated discussing first the analytical framework prosed ion applying the HOR model in food ecosystems. Prior to empirical investigation, the propositions can be refined. The study also points out foundation for further research. The four aspects of using the HOR model in food ecosystems represents foundation for research. Considering these simultaneously would demand considerable resources. Therefore, it is recommended that research choose one of the aspects as analytically focal and regard the others as contextual. This would in a same empirical case provide four complementary studies. These studies may then be interwoven into a whole when findings are sought documented. Studies will still include qualitative surveys based on the HOR model adapted to food chains and ecosystems thinking, more or less following the already proven path of inquiry when using the HOR approach to mitigate risk. A challenge will be to create understanding regarding IT, a body of knowledge in continuous and sometimes disruptive change, and how to use this technology in food ecosystems. Finally, understandings derived from this study may also be adapted for use in other industrial sectors such as manufacturing, engineering and various forms of services as well as the public sector.

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