Complex Adaptive Processes in Building Supply Chains: Case Studies of Fresh Mangoes in Indonesia

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Abstract

Achieving supply chain management among firms in the Indonesian mango industry is a worthwhile goal, for such will provide opportunities for supply chains to better respond to the dynamics of international and domestic markets. This paper discusses supply chain formation for the purpose of addressing the question "how can the mango industry improve supply chain management?" We propose that this question is best addressed by changing the state of the system from segmented supply chains to more integrated supply chains. Complexity theories have portrayed the supply chain as a complex adaptive system whose behaviour is influenced by self organizing mechanisms. On the other hand, governments sometimes intervene in an attempt to create improved supply chains. This paper addresses government intervention whose predetermined goal is supply chain formation by examining two case studies in West Java and East Java, Indonesia. In West Java, the intervention failed to meet its goals and broke down as it could not build trust-based relationships. In East Java, intervention initially failed, but supported by lessons drawn from the West Java case, it is now showing signs of flexibility, agility and robustness, which are features of positive self organising systems. In this case, it is possible that improved supply chain management may be achieved. Based on theory, combined with learning from these two cases, a framework is developed that integrates complex adaptive system characteristics and supply chain management outcomes.

INTRODUCTION

World fruit businesses today are facing two major issues; increasing global competition and increasing consumer awareness of food safety. International agreements, like the ASEAN Free Trade Area (AFTA), Asia Pacific Economic Cooperation (APEC) and World Trade Organization (WTO), aim to reduce tariffs in international markets in order to support the freer flow of goods, services and capital among countries. One widely recognised response to the deep consumer concern about food safety issues has been the implementation of Good Agricultural Practices (GAP) (Ruth and Joe, 2001), which are now a requirement for many horticultural businesses attempting to adapt to the changing global trade environment. In this environment, greater integration along the food chain has been identified as an approach to addressing food safety (Stringer and Hall, 2007). Thus, horticulture supply chains that can guarantee food safety for their consumers have more opportunity to compete in global markets that call for higher quality product.

In conjunction with those issues, the domestic market in Indonesia is also becoming more discerning about product quality, since a growing number of supermarkets and hypermarkets now operate in the larger cities. Moreover, domestic retailers have become more competitive as the government has deregulated investment policy in the retail sector, allowing foreign retailers to operate in Indonesia (Morey, 2004).

Such a competitive business environment requires fruit supply chains to work more closely, but rarely does this occur. There seem to be barriers that prevent fruit chains from working in this way. Market signals, both price and quality, may not be

strong enough for Indonesian fruit supply chains to be attentive to these needs. On the other hand, there is an opportunity for Indonesian tropical fruit businesses, particularly for mangoes, to meet these market needs and in doing so, to provide a more reliable source of income for small scale farmers. Therefore, improving supply chain management (SCM) between firms in the mango industry is a worthwhile goal.

We propose that improved supply chain management requires a "change in the state of the system" from existing supply chains that are disorganised and segmented, towards supply chains that are more integrated and managed as a system. Creating order from disorder is a self organizing process characteristic of Complex Adaptive Systems (CAS) (Dooley, 1997). However, this does not happen if the system is left alone – something has to be done to change the system. Some form of intervention is critical in achieving a desired system state. There are various methods of intervention, including government intervention, which is the focus of this paper. In the case of the Indonesian mango industry, government intervention aimed to improve supply chain management by excluding middlemen. Such an intervention attempts to perturb the supply chain in a simplistic way which could lead to system failure.

THEORETICAL REVIEW

Supply Chain Management

The aim of SCM is to improve coordination and synchronisation along the chain so as to create value for end consumers (Ketchen and Hult, 2007). Value is measured not only in terms of speed and cost, but also by measures such as quality and flexibility. Most studies propose that strategies to strengthen the management of the supply chain also enhance the competitiveness of individual firms in the chain.

In practice, SCM involves six key principles: getting the product right, having a customer orientation, achieving effective distribution and logistics, ensuring effective flows of information and communication, building trust-commitment-based relationships and creating and sharing value (Collins et al., 2004). These principles can be viewed as something to be followed in managing a supply chain; i.e. a normative strategy. However, there is growing concern about other dimensions such as the flexibility and agility of supply chains, features that are more in line with the adaptation concepts in CAS.

Supply chain formation can be understood from a CAS perspective as a model of organizational change. Using CAS nomenclature, each system has its own actors, functions and rules, and works within boundaries in its environment. Supply chains may be formed without reflecting the six key principles, but there is no guarantee that they will deliver better value to consumers or improvements to chain members. The aim of supply chain formation should therefore be to improve the existing condition of a supply chain so as to achieve a higher state guided by the six key principles. Such a process involves adaptation and learning, which requires the system to be flexible, agile and robust.

Complex Adaptive Systems

The major characteristics of Complex Adaptive Systems (CAS) are that they are self organizing and learning (Dooley, 1997); that a large number of interacting elements often exhibit emergent properties; and that elements interact according to schemata or rules (Anderson, 1999). CAS theories view the concept of adaptation as a learning mechanism in response to unpredictable environmental changes, and accept that a CAS gets feedback from and has capacity to influence its environment. In summary, a CAS is a powerful and purposive system, yet its behaviour is not always predictable.

A further question to ask is how a CAS renews itself and achieves better performance. A feature of CAS is that it changes because of co-evolutionary processes in which multiple populations of agents adapt to each other (Axelrod and Cohen, 2000). This requires a combination of interactive (Kauffman, 1993) and autocatalytic processes (Depew and Weber, 1995) to generate complex adaptive behaviours and organizations. In CAS, the system structure is formed as a result of interactions among agents in the system

and is sustained by importing energy from its environment (Prigogine, 2003). While the system is subject to limited control, sharing values and purposes is one way to influence self organization (Dooley, 1997). Lichtenstein (2000, p. 133) defined self organization as "a transformational process initiated by external events, through which a new internally generated order emerges". Self organizing change thus follows a pattern that starts with increased organisation, experiences tension and reaches a threshold beyond which a new configuration emerges.

These features help to explain why it is possible to establish CAS behaviour by changing the landscape or system environment (Anderson, 1999). Self organizing processes may also start when there is a circular exchange of energy with the system environment, known as a feedback mechanism. CAS can thus change their structure in flexible ways according to the dynamics of their environment.

A Supply Chain as Complex Adaptive Systems

A CAS can be viewed as an archetype of supply chains, since the structure of supply chains and CAS overlap. Choi et al. (2001) proposed that supply chain networks are CAS as they have networks of independent actors with given roles who work closely together (e.g. in fruit growing, wholesaling and retailing), in order to meet end consumer's needs in a dynamic environment. They argued that the supply chain network is not the result of purposeful design, but of the interactions with the environment through positive feedback.

RESEARCH FRAMEWORK AND METHODS

We propose a research framework that is grounded in the theories of CAS and SCM. Borrowing from CAS theories, the agents or actors are the basic building blocks and they interact according to their own schemata or shared schemata. These schemata can be seen as rules, strategies, or culture in organizations. Meanwhile, the function of each agent can be defined by its relationships with others (Holland, 1995). For example, a middleman is a buyer for farmers' products hence the function of a middleman is a buyer.

Based on the above, our framework treats supply chain design, formation and management as a self organizing system (Table 1). In the vertical column, the elements of CAS are listed, consisting of agents, functions, rules and system behaviours. Horizontally, the framework lists the six principles of SCM. Each cell in the matrix thus formed represents an opportunity to identify, evaluate or shape the performance of the supply chain as a CAS.

Field research was carried out over three time periods. Primary data was collected from initial interviews with key stakeholders and through group discussions. The objective was for the researchers to gain knowledge about Indonesian fruit industries, including the mango industry, and how the government was intending to become involved in supply chain improvement projects. The second fieldwork period was specific to the mango industry which, through government interventions, had attempted to build supply chain partnerships among exporters and grower associations in two locations - Majalengka, West Java and Situbondo, East Java. These are the two case studies reported in this paper. In each case, group discussions and simulations were used to create and evaluate possibilities for renewing the supply chain system. The third period of fieldwork took place one year later, after the government interventions had run their course and by which stage little or no further support from government was available, particularly in East Java. This fieldwork evaluated the government intervention model and, through facilitation by the researcher, identified pathways for the East Java case study to continue to adapt and improve. Included in this stage were the direct actors in the partnerships targeted by the government interventions, but also a range of other actors in the supply chain, such as other middlemen, processors, transport operators, financiers and packing suppliers.

CASE STUDIES AND MODELS OF SUPPLY CHAIN FORMATION

The Intervention Model of Supply Chain Formation

The partnership between mango farmers, an exporter and the Indonesian Government was the entry point for this study to examine the dynamic process of supply chain formation in a developing country. These stakeholders developed a partnership to improve the efficiency of the mango supply chain. The government worked with stakeholders in a monitoring and facilitating role to build a new system that redefined the functions of the actors and the rules that governed their activities. However, this first model could not be sustained and broke down after a single harvesting period.

The first model reflects a linear model of the supply chain and assumes that the supply chain environment is controllable and outcomes are predictable. Hence it was expected that external force applied to the system could effectively change the existing structure. However, the model did not consider the influence of a dynamic environment, system resilience and response to change. Across the two case studies in West Java and East Java, the first model failed. According to the principles of supply chain management, these attempts to form mango supply chains were unsuccessful in meeting customer and consumer needs in terms of product quality and quantity. Supply chain formation within the two case studies had a low degree of self-organization which led to a lower likelihood of survival. This lack of performance may have resulted from a series of critical events rather than a single process.

Case Study in West Java

Mango orchards in Majalengka are heritage plantings that are often very old. In this area, mango production was not organised commercially until the 1980s, and business has grown, particularly since 1995. The production and marketing of locally popular varieties such as the mango "Gedong Gincu" has attracted considerable local interest. As business has grown, mango growers have shown greater concern for the handling of their fruit. A growing number of local traders and collectors work with growers in marketing mangoes and input suppliers regard this as a promising business. Nine exporters were estimated to be working with middlemen in this area in 2005 and as a result of government programs to enhance plantings, more than 1,000 hectares of mango orchards have been established in this area since 1992. Majalengka is now one of the centres for mango production and mango trading in West Java.

Majalengka farmers interviewed for this study stated that in the last five years, mango growing had increased their income significantly when compared to growing paddy or other crops. In the conventional market arrangement, most growers and traders work individually, except where there was a government program of inducement to reward cooperative effort. Conventional mango supply chains often give low rewards to growers and expose traders to high risk. Hence, the government took action to facilitate one exporter and mango association to work closely in partnership.

In June 2005, the Mango Farmers Association and an exporter signed a two year contract for sales, initially to assist mango farmers in the project area. However, participants described the supply chain formed as being initiated and "designed from the top", and a "half cooked" plan was then negotiated with local government and growers. Three Majalengka farmer groups, including one newly formed group were joined into the Mango Farmers Association to suit the exporter's requirements.

As middleman and supporting services were not incorporated into this system, some functions were conducted by the supply chain members. The Mango Farmers Association worked as negotiator between farmers and the exporter and also implemented quality control. A manager was hired to coordinate sites, to mediate prices between the exporter and farmers, and to pay the farmers. The controller's role was to check operational activities both at the association and also the exporter collecting point. The exporter acted as buyer, provided transport facilities and handling tools, and fruit quality and market information.

Since organizing processes in the supply chain began, increasing tension and stress was evident. The Mango Farmers Association membership grew significantly after the exporter offered credit to association members. Several middlemen who were also growers joined the Mango Farmers Association. They behaved more like middlemen than growers. For example, they did not allow farmers to send mango directly to the association or site manager, but members had to sell mangoes through them at the local market price. The middlemen gained a profit margin from the gap in the price between the local market and the exporter price. Consequently, farmers were not motivated to improve the quality of their mangoes because they did not receive a price incentive.

When the exporter decided to cancel the credit, the association members felt disappointed and almost half of them decided to withdraw from this partnership, while half stayed but with a bifurcation of interest. The situation was made worse by middlemen who influenced mango farmers to keep away from the new players.

Some positive feedback for the new Association emerged from the environment as the new system absorbed a lot of mangoes from farmers and new chain members tried to eliminate middlemen from the mango business. Building the new system may have made farmers better off, but at the same time it made local traders worse off. Under these conditions, the system became unstable since the agents operating in the trading environment became resistant to change.

The exporter brought new rules into the system in terms of quality requirements and a standard price, which impacted on the local market. Mango prices in the local market dropped when the collecting point was closed or vice versa. This was a coping strategy by local traders to survive. However, this strategy did not help traders since exporters also marketed fruit to local supermarkets. Consequently, local traders had to compete with the exporter not only at the village market but also in higher quality markets, resulting in conflict among players. Following this situation, some traders wanted to sell their mangoes to the exporter during the peak season. However, the site manager refused after discussion with farmer leaders. This lead to further conflict; for example, local traders protested to the local government. At the peak of the conflict, the number of mango suppliers decreased by 50 percent. Hence achieving export targets proved very difficult.

Critical events triggered two emerging strategies as compromises. Firstly, farmer leaders often did not apply quality controls so as to retain farmers. Secondly, local traders were permitted to join the system as long as they followed the rules, particularly in relation to quality issues. Both strategies had consequences in terms of fruit quality, product traceability and client satisfaction. Following these compromise strategies, conflict between local traders and the exporter could be minimized. However, these events ended with complaints from foreign consumers about mango quality and the partnership broke down.

This was a self organizing process, working without overarching system controls or a predetermined design. However, the system responded actively to changes in rules, actors and functions. The system and its environment interacted and gave feedback that led to complex behavioural change. The system collapsed as a result of intervention when actors were removed from the system and rules changed, after which it returned to its pre-intervention state as a conventional Indonesian mango supply chain. There is no longer a Mango Farmers Association: only one farmer group still operates. The government supports them in a program to improve mango quality, although they do not have partners through whom to market mangoes to higher quality markets. Some local traders follow the previous example of the exporter in grading and sorting mangoes supplied by farmers.

Case Study in East Java

Situbondo is one of the major mango production centres in East Java. Most farmers produce paddy, corn and legumes, in addition to mangoes that grow with limited management. Since agricultural production cannot meet farmers' household expenses, most of them also work in plantations or the construction industry after the paddy season.

From 1997 to 2002, the government helped establish mango orchards under the IHDUA (Integrated Horticulture Development in Upland Area). This project aimed to establish a standard variety of mango "Arumanis 143", to rehabilitate upland areas and to provide an alternative source of income for farmers. Mango farmers were encouraged to work in groups of 20-25 members. Initially, the project did not work well, as a result of low trust between the community and government under The New Order Regime. This was a top down project designed with limited community participation. As a consequence, the community was often suspicious of government programs.

Mango trees in the project area began to produce in 2004, however, the marketing arrangements did not work well and farmers were generally disappointed. Farmers had a very bad experience with one partner but later secured a new partnership with an exporter and signed a one year contract much like the situation in Majalengka. The exporter applied standard prices to both peak and off-peak mango production that were much higher than the local market prices. The arrangement of the supply chain was similar to West Java. However, only some farmers agreed to follow the rules because of their bad experience with the previous partner. This shows path dependence and the influence of history in complex adaptive systems.

Meanwhile, introducing the new system was well timed since most farmers had sold their mangoes in advance to middlemen. Higher price was one attraction for farmers to follow the rules and sell directly to the exporter at the collection point. However, local traders appeared to provoke farmers not to wrap their mangoes and incited low trust in the exporter in an effort to maintain their business share. As a result, not many farmers joined the partnership, and only 25 percent of farmers sent mangoes directly to the exporter's collection point. The rest of the farmers sold their mangoes to local traders or farmer group leaders in advance, since the farmers needed cash in advance for living expenses during the dry season.

Although a growing number of farmers joined the partnership after the harvesting season, only a small percentage of growers contributed their fruit. Therefore the exporter allowed the site manager to buy additional fruit from local traders and some local traders also supplied mangoes to the collection point. As local traders buy mango from any source and do not apply export quality standards to their fruit, difficulties arose with lower quality and lack of traceability. In December 2005, the exporter decided to close the operation and the fruit were all sold through the local market. The role of local traders was not only as a supplier to the exporter but also as a buyer for mangoes rejected from the export collection point.

The intervention in the system in East Java did not create open conflict with local traders, since the end consumers were different and the changes benefited small traders by reducing the cost of transactions with farmers. Farmer groups worked under a predetermined design, in partnership with the exporter, with full government control and intervention. However, these conditions did not help to build trust within the supply chain and led to the destruction of the new arrangements forged by the intervention.

One year after the partnership was broken there were no regular meetings or social gatherings among farmer group leaders. There was no marketing partner for export and farmers were not concerned about mango handling issues. In order to maintain the farmer groups, group leaders acted as middlemen who rented mango trees and paid for fruit in advance, changing their roles to that of fruit collectors. Group leaders have different functions, not only in marketing, but also in the supervision of farmers. In order to maintain their group, they have the leadership capability to facilitate, organize and mediate on behalf of farmers in the market. Group leaders have shown entrepreneurship in their new roles as they find opportunities and take risks by selling mangoes in the local market. The case study shows how adaptation occurs when there is little government supervision and financial assistance, and no business partner or external conditions prompting change. Even in a situation where the actors only have access to the local market, there is evidence of the operation of a self organizing system. Group leaders try to build trust within groups by finding a market for their members which is essential for

supply chain formation. In order to encourage a new emerging structure, they need energy from new partners who help them supply to higher value markets.

The Alternative Model - Self Organizing Supply Chain Formation

Learning from the intervention model, the approach to supply chain formation strongly influences the extent to which supply chain management can be achieved. Case studies of mango partnerships in West Java and East Java confirm that government intervention in the supply chain that is targeted to eliminate middlemen has failed. The supply chain system and its environment responded to this intervention negatively. Co-evolution produced complex behaviours that led to failure, typical of circumstances where there is low ability for self organisation (Lichtenstein, 2000).

The alternative model of supply chain formation is different to the first model in its features, assumptions and approaches. A self organizing system or spontaneous system has features such as influence responsiveness and learning serves as positive re-enforcement. Hence the model will better reflect the way the supply chain operates and can be used for empowerment of the participants during effective processes of engagement and intervention. The system is flexible, agile and vigorous, so that supply chain management might be achieved.

Interaction between chain members should encourage the consensus building process (Innes and Booher, 1999). We propose that building consensus can link a network of supply chain actors and help participants to perform their individual roles in a larger system. There are some enablers to achieve a self organizing system. One possible strategy is designing a flexible organizational structure, free from bureaucratic issues. Providing a good flow of information and communication is also critical. This has been the role of the facilitator in the two case studies presented here. In order to achieve alignment of all supply chain members, the facilitator or catalyst in this process helped them through a series of group discussions to share the system goals. Participants in both case studies agreed that access to higher quality markets would provide an incentive for them to improve the existing system.

CONCLUSIONS

Supply chain formation follows a pattern of complex adaptive system change. The supply chain system and its environment co-evolve producing complex behaviour. Government intervention in the process of supply chain formation in the two case studies illustrated removed active agents leading to high resistance to change and system reform to preserve vital functions. Individuals and organisations engaged coping and survival strategies to protect their interests and regain their original influence. Learning from these cases, recognition of the self-organizing characteristics of the supply chain system and designing any intervention to account for these characteristics, promises greater likelihood of success for the intervention and better performance for the chain overall.

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Tables

Table 1. Research framework.

Complex adaptive systems	Six key supply chain management principles					
	Getting product right	Customer oriented	Information and communication	Distribution and logistics	Relationships	Create and sharing values
Actor						
Functions						
Rules						
System behaviour						