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Mastering Demand and Supply Uncertainty with Configurator Software

Cor VERDOUW, Tim VERWAART
LEI Wageningen UR, Postbus 29703, 2502 LS den Haag, The Netherlands
Tel: +31703358330, Fax: +3170 3615624, Email: cor.verdouw@wur.nl

Abstract: This paper evaluates the role of configurator software in agile supply chains that are characterized by a relatively high degree of uncertainty both in the market and in production processes. Product configuration software is successfully used to manage demand uncertainty. The objective of this research is to assess the feasibility of configuration software to manage also supply uncertainty and to identify development strategies and challenges. The paper builds on a typology of supply chain strategies as a frame of reference. A firm's information systems should match the type of supply chain it operates in. By means of a case-study in a young-plant-growing firm it is concluded that current configurator software does not sufficiently support the flexibility at the supply side required in agile supply chains. Main challenges are better integration with flexible back-office systems, and functionality to support process configuration in addition to product configuration.

1. Introduction

Firms in Flowers & Food industry have to cope with great uncertainty in their production planning because of dependency on the growth of living materials. They may reduce uncertainty by improving process control, but remain vulnerable to weather conditions, pests and other incontrollable factors. Moreover, this type of firm may face a high degree of demand uncertainty among others because of weather-dependent sales and changing consumer preferences, especially if it is upstream in the supply chain. Small firms in this sector can cope with the high degree of both demand and supply uncertainty by improvisation. However, growing firms cannot rely on improvisation by some experienced staff members and have to structure their information processing. Traditional Enterprise Resource Planning (ERP) systems are insufficient to manage high uncertainty both at demand and supply side (see among others [1, 2]).

Product configurator software has proven to be a powerful tool to manage demand uncertainty in other industries [3, 4]. Such software supports configuration of products and preparation of offers and contracts in assemble-to-order and make-to-order environments. It is feasible for mass customization of standardized products [5, 6]. The reason for starting this research was the idea that application of configurator software might provide the required flexibility in Flowers & Food industry.

The present paper describes results of a case-study that was carried out in a rapidly growing 350 staff young-plant-growing firm with production locations in The Netherlands, Brazil, Kenya, Zimbabwe, and Israel. The firm is specialized in some particular species and varieties of young plants, for worldwide delivery. The production process is characterized by long lead times and high uncertainty. Logistics are complex due to the global distribution of production locations. The firm's unique selling point is flexibility in meeting customer demands with respect to product specifications and delivery schedules. Up to now it relied heavily on improvisation by experienced employees to manage the uncertain production processes in relation to the high demand variability. However, the rapid growth

urges the firm to redesign its business processes. Implementation of ERP software and sales configurator software are considered as options to master uncertainty.

2. Objective

The objective of this paper is to assess the feasibility of configurator software for managing high uncertainty of both supply and demand, and to identify development strategies and challenges for, on the one hand, companies operating in agile supply chains and, on the other hand, suppliers of configurator software that want to add value for firms operating in agile supply chains. Therefore it aims to provide conceptual insight in the way configurators can enhance agility, and to assess the applicability of current configurators.

The paper first develops a theoretical framework to analyze the fit of configuration software to different types of supply chains, and describes the roles that product and process configurators could play in agile supply chains. Subsequently it presents the results of a case study, involving a firm operating in an agile supply chain, and a configuration software supplier. The results include strategic development alternatives for firms in agile supply chains. The paper is concluded by challenges to suppliers of product configuration software to enhance its value for agile supply chains.

3. Methodology

There is no best supply chain design. Fisher [7] introduced the idea that supply chain design should match the degree of demand uncertainty. Fisher discriminates between functional and innovative products. For functional products, having low demand uncertainty, efficient or lean supply chains perform best. For innovative products, that have a high degree of demand uncertainty, flexible or agile chains are a better match. Lee [8] extends Fisher's analysis by adding the dimension of supply uncertainty. Lee distinguishes between stable and evolving supply processes. Stable processes are characterized by controllable production, mature technology and settled industry. In evolving supply processes production and technology are under development and more or less unpredictable. Table 1 summarizes Lee's characterization of the demand and supply dimensions.

Table 1: Characteristics of the Dimensions of Demand and Supply According to Lee [8]

Demand Characteristics		**Supply Characteristics**	
Functional	***Innovative***	***Stable***	***Evolving***
Low demand uncertainties	High demand uncertainties	Less breakdowns	Vulnerable to breakdowns
More predictable demand	Difficult to forecast	Stable and higher yields	Variable and lower yields
Stable demand	Variable demand	Less quality problems	Potential quality problems
Long product life	Short selling season	More supply sources	Limited supply sources
Low inventory cost	High inventory cost	Reliable suppliers	Unreliable suppliers
Low profit margins	High profit margins	Less process changes	More process changes
Low product variety	High product variety	Less capacity constraints	Potential capacity constrained
Higher volume per SKU	Low volumes per SKU	Easier to changeover	Difficult to changeover
Low stockout cost	High stockout cost	Flexible	Inflexible
Low obsolescence	High obsolescence	Dependable lead time	Variable lead time

The analysis presented in this paper is based on Lee's framework [8] which matches four types of supply chains with characteristics of supply and demand (Figure 1):

- Efficient supply chains focus on cost reduction and match with low supply uncertainty - i.e. a controllable production process - and low demand uncertainty.

- Risk-hedging supply chains focus on pooling resources to reduce supply uncertainty; this type of chain matches with high supply uncertainty and low demand uncertainty.
- Responsive supply chains focus on flexibility through make-to-order process and mass customization; they match with low supply uncertainty and high demand uncertainty.
- Agile supply chains combine risk-hedging and responsive strategies, aiming to cope with both high supply uncertainty and high demand uncertainty.

Supply Uncertainty	Demand Uncertainty: Low (Functional Products)	Demand Uncertainty: High (Innovative Products)
Low (Stable Process)	Efficient supply chains	Responsive supply chains
High (Evolving Process)	Risk-hedging supply chains	Agile supply chains

Figure 1: Supply Chain Strategies and Demand and Supply Characteristics [8]

Before selecting a supply chain strategy, a firm should determine if reduction of uncertainty is possible and desirable. Reduction of supply uncertainty might, for instance, be realized by improved production control, cooperation with suppliers of technology. Reduction of especially demand uncertainty - for instance by product standardization and reducing the number of available product options - might decrease added value for customers.

A firm's information systems should match the type of supply chain it operates in. For further analysis we distinguish between front-office systems (coping with the demand side) and back-office systems (coping with the supply side). Front-office systems include order management, contract management, sales configurator, demand forecasting, and customer relations management systems. Back-office systems include resource planning and scheduling, stock management, purchasing, and supplier relations management systems.

The type of supply chain determines the required flexibility of front- and back-office systems.

- Efficient supply chains require stable, straight-forward planning systems for both front-office and back-office. The systems must be well-integrated to reduce waste of resources. Back-office systems support large volume production of standardized products based on long-run forecasts. Front-office systems support efficient order processing, long-run contracts and demand forecasts. Traditional ERP systems cover the demands of efficient supply chains.
- Risk-hedging supply chains require the same type of stable front-office systems as efficient supply chains do. However, they require flexible back-office systems, integrated with production control systems and supplier's systems. Disturbance of production or supply of materials should rapidly be observed and lead to re-planning and rescheduling. The rigid planning and scheduling systems of traditional ERP systems may cause problems in this type of supply chain.
- Responsive supply chains place high demands on the ability to combine fluctuations in demand and available supplies with respect to product specifications and lead times. The most common approach to organize responsiveness is mass customization in an assemble-to-order (ATO) production environment [9, 10]. This type of supply chain quickly responses to demand variability by efficient assembling of order-specific products from standard components. It requires stable back-office systems for efficient production of standardized components and rapid assembly. Traditional ERP systems can meet this demand. However, front-office systems require a flexibility usually not

offered by traditional ERP systems. A responsive supply chain may require a more sophisticated sales configurator.

- Agile supply chains require flexibility in both front-office and back-office systems. They demand flexible ERP in the back-office and sophisticated configurator and customer communications systems in the front-office. Tight integration is required between front-office and back-office and with systems of both suppliers and customers.

The framework described in this section, served as the basis for a theory-building single case-study [11, 12]. The case-study firm was selected on the basis of theoretical and practical criteria, particularly: expressed need for agile information systems, typical representative of Flowers & Food industry, and willingness to cooperate.

4. The Role of Configuration Software in Agile Supply Chains

Product configuration software is a tool that guides users interactively through specification of customer-specific products [3, 4, 13] . The customer may specify some configuration of predefined components, and may sometimes specify some features like number, colour, capacity, or size of components and their relative position. Product configurators have been around for some 30 years. A well-known early successful application of artificial intelligence was R1, a product configurator for VAX computers [14].

Currently, product configurators play an important role in responsive supply chains. In interaction with the user, the software generates consistent and complete specifications of customized products, taking into account both the customer's requirements (i.e. functional specifications, delivery times and places, technical specifications, quality requirements) and the feasibility of production and delivery. Along with the product specification, current configurators can produce commercial offers and draft contracts, and schedules and contracts for support and maintenance of the product. The software can be designed for use either by a sales representative of the supplier, or by a customer, e.g. through the internet. In both cases the configuration process results in an order specification that can directly be entered into the suppliers production planning and scheduling systems.

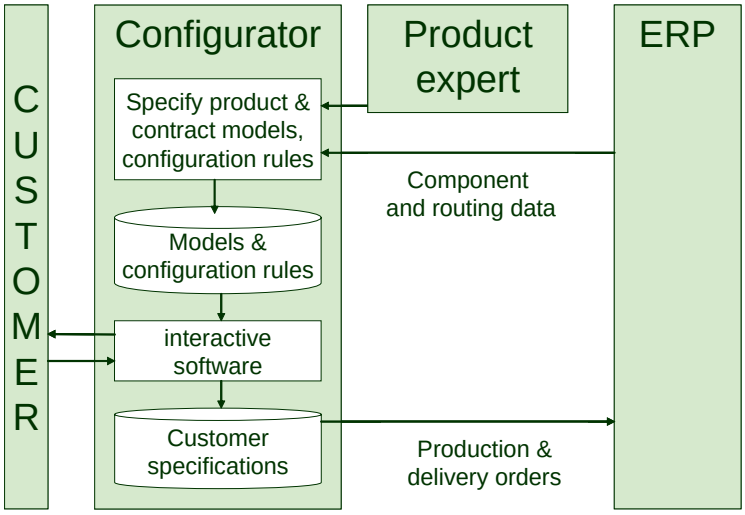

Figure 2: Product Configuration in a Responsive Environment

Current configurators specify the product, not the production process. This makes them excellently fit for demand management in *responsive supply chains*. Figure 2 depicts the data flow for this case. Product experts can enter configuration rules into the configurator's repository. Product data (bill-of-materials, part numbers, prices) and process data (routing, lead times, production cost) can be copied from ERP master data, to ensure that production orders will be in terms that can be interpreted by the ERP system. After configuration,

either directly by the customer or through a sales representative, orders can automatically be forwarded to the ERP system.

Through the application of product configurators, suppliers can realize great flexibility in their front-office systems. However, agile supply chains that require process flexibility because of supply uncertainty, would better be served if configurators could offer process configuration in addition to product specification. Agile supply chains require flexibility in their back-office systems as well as in their front-office systems. Unforeseen events may compel them to repeatedly reschedule their production and purchasing. Changes in production and delivery schedules may require frequent feedback to customers, and change of previously entered orders after communication with customers. Figure 3 depicts the architecture required in this case.

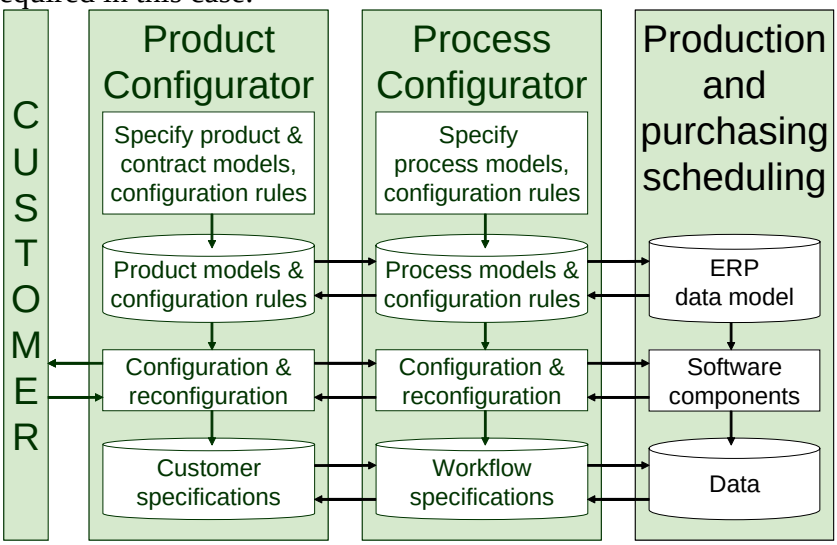

Figure 3: Architecture to Enhance Agility for Coping with Demand and Supply Uncertainty with Configurators

Additional to the architecture for responsive supply chains (figure 2), in agile supply chains unexpected supply events could lead to reconfiguration of the workflow. For instance, components that were originally planned to be produced can be re-planned to be purchased, or suppliers of components can be replaced by others with other delivery processes, or components can be replaced by components that are produced for other orders. If workflow reconfiguration would not satisfy the agreed order specifications, product reconfiguration might be necessary, for instance, by replacing components with other components, or changing delivery dates. This intensive interaction between front-office and back-office and with suppliers and customers, requires process configuration functionality that specifies order-specific workflows, including changes after order conclusion. As such, the process configurator functions as a flexible bridge between the front and back office systems. This requires a solid and flexible integration infrastructure. A service-oriented approach to software configuration might be promising to realize this.

However, dynamic configuration of web services is in it's infancy and has been identified as a research challenge [15]. Once web service composition is a realistic option to implement flexible business processes in the back-office, it still has to be integrated with product configuration software.

To summarize the analysis, it is found that current configurators do not support the combination of order-specific product and process composition. Thus, it can be concluded that agile supply chains are not supported sufficiently by available product configurators.

5. Case-Study Results

The selected young-plant-growing firm was investigated by semi-structured open interviews with managers and employees (9 interviews with a total of 14 persons) and

additional desk research. The results were analyzed by application of the framework. Finally the analysis was tested in 2 workshops about specific software solutions, respectively ERP and configuration software. Employees of the case-study firm and consultants participated in the workshops.

The interviews indicated that the most urgent bottlenecks in the young-plant firm were:

- Knowledge of production processes and options to reconfigure these processes is only implicitly available in the minds of some experienced staff members. This problem can be managed at the firm's current scale of the firm, but it inhibits further growth.
- Information systems are patchy (island automation) and require a lot of manual data re-entering. Information inconsistency leads to larger safety buffers then strictly required, and many redundant data checks and duplicate registrations are performed.
- Mid-term planning is not coordinated with operational data, due to a lack of integration of information systems.

The company is a niche player that specializes in a few "hard" species of young plants. It is the world market leader in two of these species and has a good position in some other species. The firm considers rapid and customized delivery to be its unique selling point. Combined with the dependence on planning staff's improvisation talents, this sets limits to further growth. Currently, the firm has to deal with high demand uncertainty and high supply uncertainty. Customers have specific demands and demand forecasts are unreliable. Worldwide, great fluctuation occurs with respect to quantity and attributes like color. Supply is hard to plan and hard to adjust, because plants are a living product. Some species have a lead-time of 1.5 year. Moreover, processes are insufficiently controlled and information supply is weak.

Supply chain developing strategies of the young-plant firm should aim at reduction or better management of uncertainty in supply and demand:

- Reduction strategies aim to reduce differentiation by standardization and to eliminate the sources of disruptions.
  - Some possibilities of the case-study firm for reduction of demand uncertainty are product standardization, exchange production planning with customers, or stimulate long-term contracts.
  - Some possibilities for reduction of supply uncertainty are reduction of the influence of nature, by more advanced climate and pest control systems, and standardization of production, e.g., by fixed batch volumes, standard trays, or fixed delivery schedules.
- Strategies for uncertainty management leave differentiation and unpredictability as is, but aim to manage it by better organization, horizontal and vertical cooperation, more advanced tools and better utilization of information.
  - Some possibilities of the case-study firm for better management of demand uncertainty are implementation of mass customization systems, application of product configurators, and information exchange with customers to improve forecasting.
  - Supply uncertainty could be managed by continuous re-planning, decreasing of disruptions' impact by intelligent greenhouse systems and stock management, and by maintaining close relationships with suppliers and service providers.

Based on these strategies, the firm's strategic options are positioned in figure 4. They are:

A. Develop towards responsive supply chains: reduce supply uncertainty and improve demand uncertainty management.
B. Develop towards risk-hedging supply chains: reduce demand uncertainty and improve supply uncertainty management.
C. Develop towards efficient supply chains: reduce both supply and demand uncertainty.
D. Improve the current position in agile supply chains: improve uncertainty management of both demand and supply.

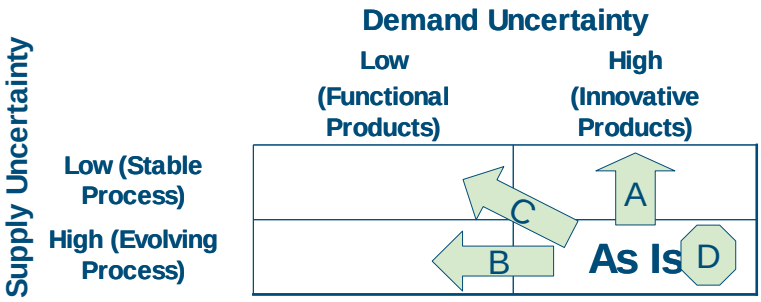

Figure 4: Position and Development Strategies for Case-Study Firm

The choice between uncertainty reduction and uncertainty management strategies is determined by the company-inherent characteristics that determine the reduction possibility and the value the firm wants to add in the market. Especially with respect to demand uncertainty, reduction strategies could reduce the value.

The case-study firm's first priority is to handle supply uncertainty in the back-office: reduce (in options A/C) or manage (in B/D). The choice for reduction would imply the adoption of a traditional ERP system. The choice for supply uncertainty management would require more dynamic production management than a traditional ERP-system can offer.

Application of an existing configuration tool was assessed to be appropriate if the company would decide to develop towards a responsive supply chain (alternative A). If the firm would select a supply uncertainty reduction strategy (A or C), the functionality included in the traditional ERP-software will probably be sufficient, because supply uncertainty is low. This in contrary to alternative B and D which requires flexible back-office systems. Integration of ERP systems and extended configuration software (including process configuration as described in section 4) would fit than.

6. Conclusion and Future Challenges

The research question was how configurator software could contribute to improve information management in the Flowers & Food sector. To answer this question a framework of analysis was developed, based on Lee's supply chain typology. Lee [8] distinguishes four types of supply chains, based on uncertainty of supply and demand. The feasibility of configurator software was evaluated in a young-plant-growing firm, operating in an agile supply chain, i.e. a supply chain with high uncertainty in both demand and supply. Although the case study was performed in the Flowers & Food sector, conclusions may be applicable to agile supply chains in other sectors.

Configuration software can be applied in two ways. First, application of product configuration is relevant for firms that operate in supply chains with high demand uncertainty. If order complexity and product complexity are low, the product configuration functionality built-in in ERP software might be sufficient. Otherwise a specialized product configurator might be required. Second, application of process configuration is relevant for firms that operate in supply chains with high supply uncertainty. The main issue is to integrate the process configuration software with back-office systems, either through inclusion in the ERP-software, or in a service-oriented architecture.

A general conclusion for firms in agile supply chains is that software for both product and process configuration would be valuable. In addition, these firms require intensive interaction, firstly between front-office and back-office, because order fulfillment is not certain to develop according to plan, and secondly with suppliers and customers, because order details and delivery schedules may have to be renegotiated. However, the traditional domain of product configuration software is in responsive supply chains, i.e. high demand uncertainty with reliable and stable supply. Current configurator software does not offer the

flexible process configuration and back-office-front-office-customer communication required for agile supply chains.

The conclusion for the case study firm was that configuration software was not feasible in the permanent re-planning of order fulfillment taking place, and investments should be directed to reducing supply uncertainty and managing it with other means than configurator software.

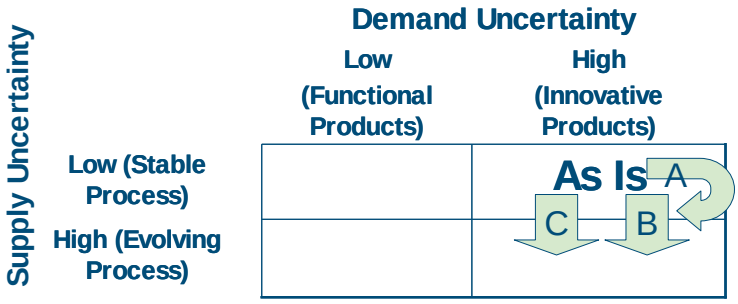

Figure 5: Position and Development Strategies for Configurator Software Suppliers

Figure 5 depicts the main challenges to suppliers of product configuration software to enhance its value for agile supply chains, i.e. to master demand and supply uncertainty:

A. Improve current position in responsive supply chains, e.g. by adding CRM functionality or workflow enactment of multiple partial configurations of one specific contract;
B. Extend product configuration software to agile supply chain by adding functionality for intensive interaction with back office systems, also after contract conclusion.
C. Develop configuration software for managing supply uncertainty by process configuration in agile supply chains.

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