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# FBD\_Bmodel Digital Platform: a web-based application for demand driven fashion supply chain

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**Abstract.** The new consumption behaviors and environmental awareness are pushing the textile apparel industry to profound transformations. Co-design and production on demand are two success factors for this paradigm shift but require efficient and practical tools for companies. In this context, the European H2020 FBD\_BModel project provides to practitioner a suitable digital platform. More specifically for the supply chain management, efficient and well-known algorithms are implemented in an user-friendly web-based application composed of two modules. The first module aims at selecting suppliers with multi criteria decision making techniques. This is particularly important to deal with a huge variety of products and a large number of small factories with their own features. The second modules proposed a genetic algorithm-based optimization for order scheduling and supplier allocation. In a demand driven strategy, this task is crucial to reach the requirements in terms of cost and lead time. This paper provides a brief description of the methods implemented in the web-based application. A numerical example, based on real data of the industrial partners of the FBD\_Bmodel project, shows the results obtained with the proposed solution.

**Keywords:** Web-based application, multi criteria supplier selection, on-demand production planning.

## 1 Introduction

### 1.1 FDB\_Bmodel project

The textile and clothing industry is an important part of the European economy, but over recent years a large amount of production capacity has shifted to countries with lower wage costs. Nowadays this strategy reaches its limits for many reasons: complex quality management, long and uncertain lead time, and more importantly the consumer's expectations in terms of personalization and, ethic and environmental awareness. In this context, the textile industry has to switch into new business models more consumer focused and demand driven to enhance its competitiveness. For this purpose, an interactive cloud-based digital design and supply chain platform has been developed in the European H2020 FBD\_BModel project ([www.fbd-bmodel.eu](http://www.fbd-bmodel.eu)). This project aims to propose a new digital technology platform to connect different parts of the textile-

apparel supply chain, from fibre, yarn and fabric producers to garment manufacturers, for the development of a new consumer-based business model in the big data era. The platform is composed of two main modules: a co-design module and a demand driven supply chain module. The co-design module enables the consumer to be directly involved in the design process from a set of recommendations, taking account of fitting, hand feel, and wear comfort. The second module, presented in this paper, focuses on optimized allocation of production orders designed in the first module. The supply chain module addresses the issue of small series production on demand which is a very challenging problem for the traditional textile-apparel industry.

To be more specific, small textile manufacturers already exist in Europe, but they are usually isolated from each other, and thus, the proposed FBD\_BModel digital enables different actors in the supply chain to collaborate, from fibre and yarn producers, fabric and garment manufacturers, to designers and production planners. A web-based application (<http://scpms.ensait.fr/>) to support managers' decisions for supplier selection and dynamic planning of production orders by graphical simulations is proposed.

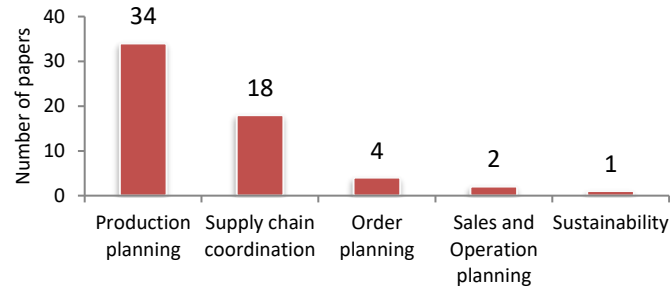
The remainder of the paper focuses on the methods used in the demand driven supply chain module of the FBD\_Bmodel platform. A brief literature review about small series on demand production is presented in section 2. Section 3 describes the proposed methodology in detail. Results obtained with the web-based application are presented in section 4. The conclusion is presented in the last section.

## **2 Literature review**

There exists an extensive literature on supply chain management strategies in traditional fashion industry. However, there is a significant dearth of literature on the study of supply chain management strategies for small-series on demand (make to order) production in fashion industry. This can be mainly due to the fact that small-series fashion is an emerging fashion paradigm. In order to propose suitable solutions for companies, it is crucial to determine what are the major challenges that small-series fashion paradigm generates given the extent of personalization expected by the customers from small-series fashion products and the required level of strategic responsiveness, coordination, and flexibility of all the actors in small-series supply chain, mainly suppliers and retailers.

### **2.1 Small series on demand production in industries**

A systematic literature review is conducted using Scopus database between 2000 and 2020 to collect existing literature on supply chain management in small-series (make-to-order) in industries (not only fashion industry). This approach aims to investigate the different SCM problems. In total, 59 articles have been selected and classified into the main supply chain topics as illustrated in figure 1.



**Fig. 1.** Article distribution as per the main supply chain topics.

## 2.2 Small series on demand production in fashion industry

Following the same systematic literature review approach, the existing literature on the studies on supply chain management in small-series (make-to-order) in fashion industry is collected. This search only yielded to four articles which cover the main two topics given in the figure 1: production planning [1-2] and supply chain coordination [3-4]. In [1], an optimal decision support system for risk management for Made To Order fashion retailers is proposed. The system provides significant insights into how manage the replenishment and develop quick response strategies while negotiating with the suppliers. In [2], an overall cost optimization with genetic algorithm is developed for packaging and distribution of multi sizes fashion products in a Made to Order framework. A multi agent simulation is presented in [3] to demonstrate the advantage of a collaborative cloud-based platform in achieving sustainability in demand driven supply chain. In [4], the authors investigate what are the main factors for successful collaboration in fashion supply chain and how it can drive MTO fashion companies to make optimal decisions.

Based on this literature study, it emerges that the key aspects of small-series fashion SCM are related to production planning and supply chain co-ordination. For this reason, the FBD\_Bmodel project provides to fashion companies a digital platform to enhance collaboration between the many small manufacturers and an easy to use production planning to dynamically allocate orders to the most suitable manufacturers.

Considering the large variety of considered products and the large number of potential suppliers, the production planning is composed of two steps:

- 1- A multi criteria supplier selection system enables the definition of a set of suitable suppliers according to their abilities to fulfill the requirements given to produce one type of garments.
- 2- A production planning system then dynamically allocates the orders to the selected suppliers according to their production capacity and expected delivery dates.

Considering the current financial and technical states of the existing small fashion manufacturing units in Europe, we do not establish a full computerized production planning system at this stage but propose to first optimize their supply chain management so that production activities of different producers can be more efficiently organized.

The figure 2 gives an overview of the FBD\_Bmodel digital platform and the demand driven production planning module.

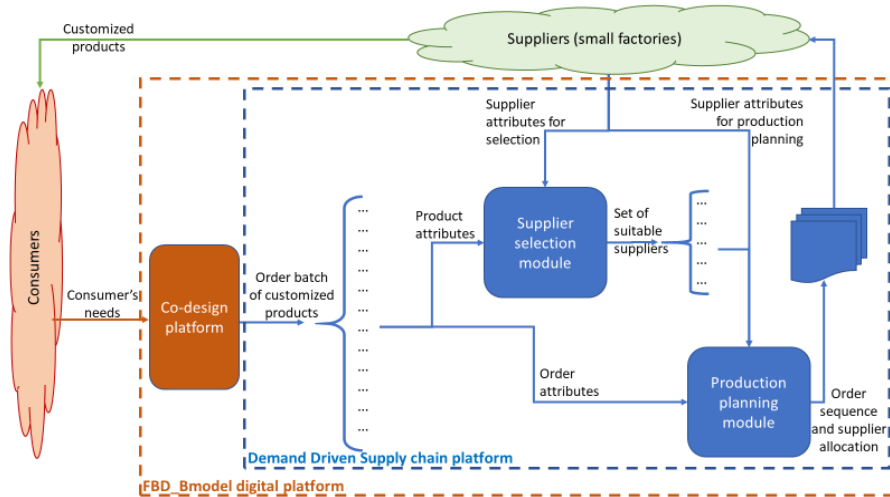


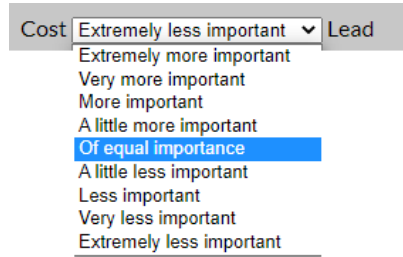
Fig. 2. FBD\_Bmodel platform and demand driven production planning module.

### 3 Methodology

#### 3.1 Multi criteria decision making for supplier selection

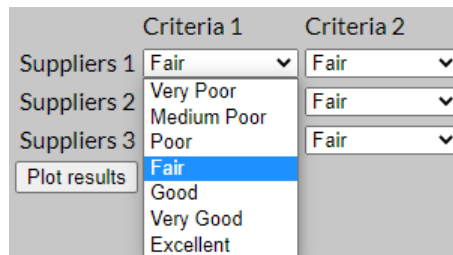
In the context of small-series apparel production, one of the key objectives is to identify the most important criteria, both quantitative and qualitative, from the point of view of sourcing managers.

Thus, the first stage of the proposed web-based application enables the managers to define their own criteria according to their business and expectations. An Analytic Hierarchy Process (AHP) [5] is implemented to weight the relative importance of supplier selection criteria. AHP is one of the most widely applied methods for solving multi criteria decision problems. Its popularity is mainly due to its ability to compare relative performance of actions or alternatives with pairwise comparison. It is also relevant to our scenario in which accurate data on different suppliers are usually missing due to their confidentiality, and experience-based expert evaluations constitute the main information source in the supply chain management. For an easier use, the web-based application relies on the Saaty's linguistic scale for the pairwise comparison as illustrated in figure 3.



**Fig. 3.** Pairwise comparison between the criteria “cost” and “lead time” with the Saaty’s scale in the web-based application

Based on the criteria evaluation by AHP, a TOPSIS method is applied to evaluate supplier’s performances corresponding to each criterion. In the proposed application, the manager evaluates each potential supplier with the Likert linguistic scale (figure 4). Finally, the top  $n$  suppliers are selected for the production planning.



**Fig. 4.** Supplier evaluation for each considered criterion with the Likert scale in the web-based application

### 3.2 Production planning

For the small-series fashion production, it is crucial to allocate customer orders in a real time to the best garment suppliers to reach the business objectives, especially in terms of costs and lead time. In the proposed cloud-based digital platform, information required for the production planning and supplier allocation are available including order attributes, such as product technical features, quantities, expected delivery time, and supplier attributes such as available production capacity, production/delivery cost and time. However, to utilize this information for the decision making related to identifying suitable garment suppliers that contribute to the order fulfilment is often a complex optimization problem.

Considering that suppliers selected by the selection module reach all the requirements (capability, quality, logistic services, packaging,...) for the production of the considered products, the production planning module only focuses on the main operational criteria: cost and lead time.

Thus, to define the optimization problem, three decision variables are considered: delivery date, cost and penalty, where penalty corresponds to extra costs due to late delivery. The objective function is defined as the minimum of the total cost to produce and deliver a given batch of orders considering the expected delivery date of the

customers. The balance between cost and lead time can be set up by the manager with a penalty rate according to his operational and business objectives. A high rate improves the number of orders delivered on time. A small rate generates more cost focused solutions. The optimization process is performed with a Genetic Algorithm (GA). The use of genetic algorithms to optimize production schedules has been widely demonstrated in the literature [6]. Although GAs do not ensure to find the best optimum solution, they provide satisfactory results in a reasonable time for our operational problem. The chromosomes, encoding potential solutions, represent a sequence of the orders of the considered batch as illustrated in table 1. Then, each order is assigned to the supplier given the minimum total cost (production, delivery, penalty for late costs), considering the workload generated by the order already allocated. Thus, this algorithm is able to find the best balance between the cheapest production and delivery costs and the available capacity to ensure a delivery on time.

**Table 1.** A chromosome encoding the order sequence of batch of size  $n$

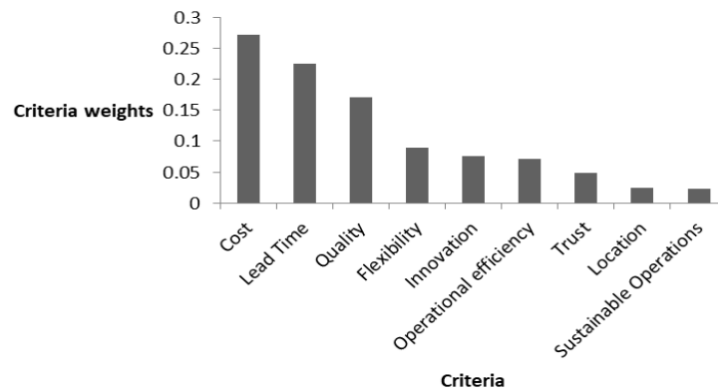
Gene number	1	2	...	$n$
Order ID	$i$	$j$	...	$k$

## 4 Implementation and results

This section presents an example of the implementation of the proposed methodology with the web-based application developed in the framework of the European H2020 FBD\_Bmodel (<http://scpms.ensait.fr/>). This simulation relies on real data provided by the industrial partners of the project.

### 4.1 Supplier selection

The first step consists of weighting the criteria from pairwise comparison performed by the manager with the online application. The figure 5 presents the results obtained with the AHP process on the 9 criteria defined by the manager.



**Fig. 5.** AHP ranking of supplier selection criteria



At this stage, it can be stated that some criteria can be considered as insignificant and deleted. For instance, in the figure 5, the manager could choose to select only the three first criteria (cost, lead time, quality).

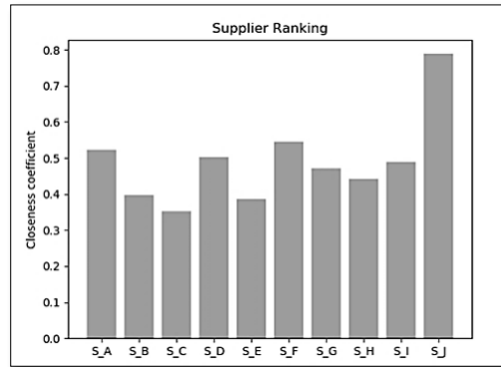


Fig. 6. Supplier ranking by TOPSIS method

From these weights, a TOPSIS method is applied to rank the potential suppliers. The figure 6 shows the results obtained on a database of 10 suppliers. From this result, the manager selects the set of suppliers which are suitable for the production to reach the expected requirements. In this numerical example, the manager has selected 5 suppliers (threshold score of 0.49).

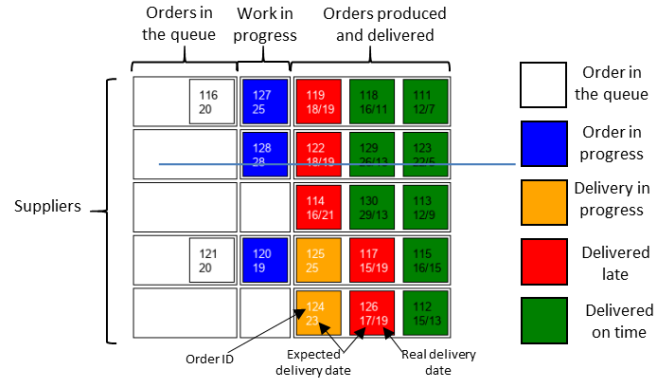
## 4.2 Production planning

For the production planning, the web-based application takes into account the operational attributes of the suppliers: production and delivery costs and times, and real time available production capacity. In this example, a daily batch composed of 30 orders is considered. During the simulation, additional batches can be added periodically or manually. In this case, the optimization process proposes a re-allocation of remaining orders to provide a new optimum solution. The results are displayed in the web-based application through a numerical table (figure 7), a step by step simulation (figure 8) and KPI graphs (figure 9).

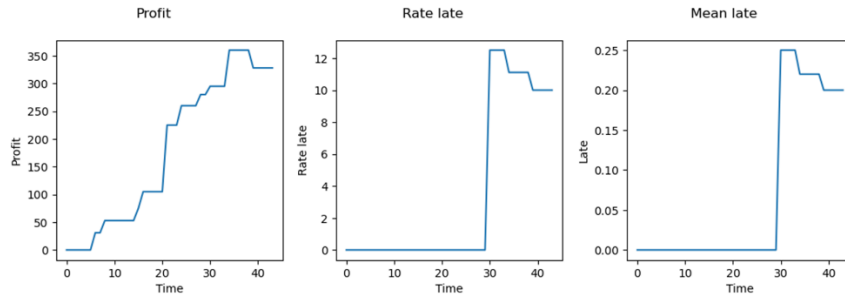
Supplier ID	Orders in the queue	Work in progress	Orders produced and delivered	KPI			
Suppliers data, current time = 33							
id	Next orders	Current orders	Orders done	Time	Profit	%Late	Mean late
11	134; 131; 132; 144; 155	133	125; 122; 115	88	150.0	33.33%	1.33
12	154; 151; 145; 152; 153	135	114; 112	78	140.0	50.0%	3.0
13	141; 143	142	124; 123; 113	80	-140.0	66.67%	6.33
14	None	None	121; 111	32	370.0	0.0%	0.0
15	None	None	None	0	0.0	0.0%	0.0
Mean					520.0	40.0%	2.9
All the commands are displayed.							
A new file will be asked in 7.							

Fig. 7. Production planning simulation presented in a numerical table

The analysis of the figure 9 highlights that the overall profit stops growing from week 30. This means that some orders are delivered late and involves penalty. This simulation can help managers to take the suitable decision in a such situation (reject order, communicate with customers,...).



**Fig. 8.** Graphical step by step simulation tool



**Fig. 9.** KPI plots during the step by step simulation

### 4.3 Result comparison

In order to evaluate the benefit of the proposed methodology, two simulations are performed using the same orders and suppliers. The first simulation, called "MaxProfit", deals with the flow of orders one by one (no batch of orders) and allocates the order to the supplier which ensures the maximum of profit. The second simulation, called "Min-Delay", is similar but the order allocation is based on the reduction of delay. Thus, these two simulations propose a single criterion optimization of a flow of orders, whereas our proposed model provides a multi-criteria optimization of a batch of orders.

**Table 2.** Result comparison between the proposed model and single criterion models

	MaxProfit	MinDelay	Proposed model
Profit (sum)	1866	-108	325
Delay (sum)	5038	0	7

The table 2 shows that the proposed model provides the best balance between the profit and the delay. From a practical point of view, our model also emerges as the only reasonable solution to enable a production on demand. Profit based strategy produces interesting short-term benefits. However, the huge delay will certainly lead to a customer dissatisfaction and long-term losses. The delay-based strategy enables the production of all the order on time, but it generates production and shipment costs higher than sales revenues.

## 5 Conclusion

Face to the new consumption behaviors and environmental awareness, the fashion industry has to change its outdated business model. The personalization of products and the production on demand are the two key success factors to support this change proposed by the European H2020 FBD\_Bmodel project. The digital platform developed in the framework of this project provides to companies the required tools to switch into a demand driven strategy. In this new context, the main issues for supply chain are the coordination between actors and the production planning. The proposed web-based application offers a cloud-based service to coordinate the supply chain with a real time-sharing data. The supplier selection and production planning tools enable the managers to easily implement multi criteria and optimization methods to reach the requirements of their business. The platform is already operational and will be still developed in the framework of the Fashion Big Data Foundation ([www.fbd-bmodel.eu/fashion-big-data-foundation/](http://www.fbd-bmodel.eu/fashion-big-data-foundation/)) which aims at exploiting FBD\_BModel project results.

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