REDESIGNING A PHYSICAL DISTRIBUTION AND LOGISTICS SYSTEM: 
THE FEBAL CUCINE CASE STUDY

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ABSTRACT
The authors examine the questions of physical distribution and logistics management in the business industry of modular kitchens by studying the case of the Febal Group, an important brand name at the Italian and European level. More specifically, this work highlights the firm’s critical aspects of the physical distribution system and analyses its importance in the context of a manufacturing planning system that responds to the market using an Assemble To Order (ATO) logic; however there are certain specific features of this case that are particularly interesting. The article focuses on the development of a scenario with a new logic for managing areas that involve transport carriers. A series of algorithms are proposed which could be useful for future implementation of an ICT (Information and Communication Technology) tool for managing and automatically assigning orders to transport carriers and for informing customers of the product’s delivery date. Finally the integration of the solution proposed with a wider ICT toolset developed within the framework of an European project named ECOSELL is presented.

Keywords: Logistics, Physical Distribution, Case study

INTRODUCTION
The European research project named Extended COllaborative SELLing Chain (ECOSELL) focussed on the topic of Extended Enterprises (EEs), which are usually defined as a network of firms belonging to the same value chain and working together in order to offer more value to their customers. Recently, there has been a tendency to create EEs that cross the barriers of a single value chain and link different value chains in a complementary manner thus constructing a meta-value chain in which industrial groups try to sell and distribute their products, taking up the challenge of the total integration of their value chain (Figure 1). The ECOSELL project, centred on the selling chain - i.e. on that part of the value chain that goes from manufacturing to the final consumers, worked through a consortium of 16 partners, eight supplier partners (universities, consultant firms, information technology firms) and eight user partners, amongst which was the Febal Group.

The Febal Group is an Italian important brand name in the business industry of high quality kitchens. It has three production plants and a turnover of more than 50 million Euros. By using and coordinating three separate brand names, the group successfully meets the needs of consumers both in Italy and abroad in all segments of the market and covering the whole set of market activities for

1 Work carried out as part of a European research project ECOSELL - Extended COllaborative SELLing Chain – Contract: GRD1-2001-40692.
kitchen furnishings: design, production, sales and distribution, trade fair participation/organisation and displays.

In the modular kitchen industry, the level of service perceived by the customer is more and more closely connected to external performances regarding time, that is, speed, punctuality and reliability of delivery and, naturally to the quality of the product itself. In this competitive context physical distribution and logistics management assume a fundamental role insofar as quality must be guaranteed right down to the last link of the Supply Chain, i.e. the final consumer. Febal has been asked to improve external performances by setting up possible new scenarios that would allow for radical redesign both of the network and of the firm’s physical distribution and logistics management system. The definition of this alternative scenario has required three steps of analysis:

- analysis of the physical distribution and logistics management system,
- analysis of the logistic flows,
- analysis of the demand management logic.

THE PHYSICAL DISTRIBUTION AND LOGISTICS MANAGEMENT SYSTEM

The firm’s national physical distribution and logistics management system is based on a capillary network of points of sale that cover the whole country, where stocks are mainly brought by a fleet of trucks, but may also be delivered by couriers, or may be collected by the points of sale themselves when they need to replenish their stocks from the central warehouse situated in Pesaro, centre of Italia.

Points of sale

The final consumers choose the kitchen directly at the point of sale which acts as the middleman between the firm and the customer. Sales personnel are responsible for taking the order and then for transporting the purchased kitchen from their salerooms to the final customer where they will install it; the quality of the kitchen will suffer if it is installed incorrectly. The greatest concentration of points of sale is in North Italy, followed by Central Italy. The concentration of points of sale reflects the density of the population: i.e. Regions with higher populations, such as Lombardia, Lazio, Campania and Emilia Romagna have more points of sale. Points of sale are divided by geographical areas according to the morphology of the Italian peninsula and the number of deliveries.
Transport carriers

Kitchens are delivered to points of sale in three main ways:

1) Delivery made by dedicated trucks
   The logistic base of the trucks and vans is at the central production plant in Pesaro; there are owner driver or transport firms who work only for Febal. There are 17 delivery trucks available for transport within Italy and 13 dedicated to deliveries abroad. The firm guarantees one delivery per week to the owner-drivers, but loading the truck is not Febal’s but is the responsibility of the owner-driver.
   The strategic choices reflected in Febal’s current delivery management policies is based on a relationship of knowledge and trust that has developed between the truck driver and the personnel at the point of sale; this is why the same carrier is always assigned to one geographical zone. In other words, two carriers don’t cover the same area. In exceptional cases, when a particularly urgent order must be fulfilled, carriers may serve points of sale that are not part of their usual route.

2) Delivery by carrier firms
   Sometimes, in particularly important or urgent cases, third parties are involved for those deliveries that cannot be added to any of the loads already programmed for delivery.

3) Warehouse collection directly by the point of sale
   Some customers, both at the national and international level, gather the kitchens direct from the production plant.

LOGISTIC FLOWS

Using data collected during a study carried out in 2003/2004 (Nonino and Panizzolo, 2004) relating to effective deliveries, an ABC cross-referenced analysis was developed which combined the percentage of cumulate volumes and of total deliveries. This made it possible to put each Italian Region into one of three groups:

- **Group 1**: is the group of Regions that together absorb more than 60% of the total volume of products delivered and more than 57% of the total number of deliveries made (Lombardia, Emilia Romagna, Lazio and Campania).
- **Group 2**: is the group of Regions that together absorb about 30% of the total volumes of products delivered and about 33% of the total number of deliveries made (Veneto, Toscana, Piemonte, Puglia, Sicilia, Calabria, Friuli V. G., Sardegna).
- **Group 3**: is the group of Regions that absorbs the lowest volume of products and receives the least number of deliveries, about 10% (Umbria, Basilicata, Marche, Abruzzo, Liguria, Trentino A. A., Molise, Valle d’Aosta).

DEMAND MANAGEMENT LOGIC

Febal’s company policy is that trucks should be fully loaded when they leave for their final geographical destination so as to minimise the number of journeys made by the carriers, thus reducing the variable costs of transport. This policy strongly affects both the management of order portfolio and manufacturing planning system. Orders sent in by points of sale are put together according to their geographical location, which is served by one carrier, and then re-arranged according to their delivery date. They are put into production the moment there are enough orders to fill the truck. Production is scheduled in order to reduce the time required to fill one vehicle and is constrained to the delivery date and to the capacity, the load, the truck can carry, sometimes it is also affected by component suppliers’ delivery times. Because of this, when taking orders from customers, Febal gives a delivery date that is further away than it would be had they only considered the time strictly necessary to complete all phases of production and delivery.

The way in which Febal responds to market demands is that of the Assemble To Order-ATO logic (Wortmann, 1983). In this case however, the firm plans purchasing (or production) orders for parts
and sub-assemblies on the basis of forecasts and only decides to carry out the final assembly of the product when it is possible to assign enough orders for delivery to the carrier to fill the vehicle. Thus, when a customer’s order arrives the firm not only carries out the usual checks on material availability and production capacity, but also carries out a further check in order regulate production launches, so as to give each carrier a full load. This is why one could say that Febal operates according to an Assemble To Delivery (ATD) logic, which certainly offers two advantages:

- deliveries always, or almost always, carried out with full loads;
- low warehousing costs for finished products

but it can create problems, mainly the time the carrier may have to wait before a full load is consigned for delivery:

- higher lead times: the time that elapses between receiving the order from the points of sale and delivery is longer than is strictly necessary for gathering components, producing and delivering the product;
- manufacturing planning system itself is not flexible because it is heavily dependent on downstream physical distribution and logistics management;
- the productive capacity of the production plant is tightly constrained.

Moreover, the Febal Group manages a product portfolio which contains not only the Febal kitchen product but also two other brand names that the firm has acquired over the past decade in order to enter other markets. In order to avoid either having to send half-empty trucks or having to set too distant delivery dates, the firm will often make loads up with kitchens from the other two brands which may well be going to the same point of sale and would anyway have been delivered by the same truck. This advantage works both ways: while at times it could be Febal who asks the other two brands for help in filling a truck, at other moments it may be they who turn to Febal to complete their loads. Febal has limited view of the production plans of the other two brands in that the exchange of information only takes place at the moment when it is needed in order to fill a truck. Analysis of the data on deliveries showed that the transport carriers used exclusively by Febal were, on average, filled as follows: 69% Febal products, 31% products of the other two brands.

THE RE-DESIGNING OF THE DISTRIBUTION SYSTEM
The activities linked with ECOSELL project revealed the need to modify the manufacturing and scheduling process in Febal in order not only to reduce costs but also to improve the quality of the service offered to customers. This pointed out immediately the problem of redesigning Febal’s distribution system (AA.VV., 2003).

Different scenarios, characterized by diverse levels of complexity and costs, were evaluated. The scenario called “superimposition of geographical areas” was chosen based on the following considerations: in the first place, currently Febal doesn’t plan to change the distribution structure which outsources the transportation phase and requires that loading and delivering the kitchens be done by dedicated carriers. The reason given for this choice is that the firm wishes to maintain the “trust factor” that has been created within its relationship with the carrier. In the second place, the solution chosen by the Febal is coherent with the nature and the time frame of the ECOSELL European project.

Superimposition of geographical areas
Currently, each carrier is responsible for a predetermined number of points of sales within a geographical area. The idea is to extend the responsibilities of the carrier to the surrounding areas as well (Figure 2). This could be done by extending the geographical areas in such a way as to create areas where they intersect with the adjoining areas that are extended to overlap, thus creating an
“inter-zone”, where points of sale could be served by two or more carriers. In this way, each order is linked to a point of sale and to the latter’s geographical location, and could be delivered by either the main (primary) carrier for that point of sale or by one or two other carriers whom we could call “secondary” carriers, inter-zone carriers. This would make it possible to fulfil orders faster and in a less static manner than today. What complicates this scenario is the fact that an inter-zone carrier will also be the primary or main carrier for another area; this requires a dynamic assignment of orders to carriers based on the criteria described below in the paragraph.

It could be safely presumed that this new distribution system would make little difference either to costs or to the complexity of the system. On the other hand, enlarging geographical areas of competency for the single carriers and more dynamic consignment of the order to the carriers would make both the manufacturing planning system and order management more flexible: the area that is served by each truck would increase as would the percentage of orders that could be loaded onto each truck. This would make it both easier and faster to create full loads for vehicles and, consequently would cut delivery times.

Two main problems must be taken into account when setting up this delivery system. Firstly, how to successfully joint manage orders for the products of three different brands of kitchens and, second, how to assign completed orders to carriers. As mentioned above, the other two firms contribute 31% of the loads on trucks that leave the Febal production plant, but the Febal plant does not receive information about the other two firms’ manufacturing plans in real time. Assigning orders is constrained by an Assemble To Delivery (ATD) logic that sets limits on both any flexibility in planning during the mid-period and in scheduling during the final phases of assembling. The best thing to do is to design and develop algorithms able to manage all orders for all three brands of kitchen and to automate procedures for assigning orders ready for delivery to the carriers and able to take into account the possibility, offered by this scenario, of having primary and secondary carriers available for loads.

Algorithm for setting up the shipment plan
The algorithm (Figure 3), designed and developed in order to resolve the problem described above is a “greedy” type algorithm, called greedy precisely because it is designed to ensure that instructions are carried out fast until the desired result - the shipment plan - is produced. According to the ATD logic, this shipment plan is then used to define the Final Assembly Schedule and for communicating the delivery date to the final consumer. The point of sale sends the order for the kitchen in (input) and will be informed of the delivery date directly (output) thus the algorithm is circular. In the first step the algorithm is designed to gather the orders for each brand of kitchen separately: the customer who wishes to purchase one of the products places the order at the point of sale which then passes this order on to the production plant it deals with. After the orders have been checked for accuracy, a list is generated for each production plant. Then the relative “date of producibility”
is evaluated for each list. This date is set by taking into account both the availability of components and the productive capacity since the order will be fulfilled using ATO logic. When setting a producibility date, obviously any other delivery constraints set by the customer must also be taken into account. This ATP/CTP type of check (Vollmann et al., 1997) is made by the Enterprise Resource Planning (ERP) systems and will not be examined here.

![Diagram showing the algorithm for managing orders and loading vehicles with an ATD logic.](image)

Figure 3 – chart showing the algorithm for managing orders and loading vehicles with an ATD logic.

The three lists, of all the three brands, are then put together in one single list organised on the basis of the producibility dates assigned to each order. Creating one single list makes it possible to process all the orders received by all three production plants simultaneously, which would solve Febal’s previously mentioned problem of not being able to obtain information on the production plans of the other two brands of kitchen in real time. This single list is first examined by the “order-carrier assignment module” and then by the “rebalancing loads module” in order to elaborate the final shipment plan. Before describing the two modules it should be said that the shipment plan is formulated adopting a recursive (or rolling) method using the time model represented in Figure 4.

![Diagram showing times of loading and freezing of manufacturing plans.](image)

Figure 4 – times of loading and freezing of manufacturing plans.
More specifically, suppose the different periods \( T_0 \ldots T_n \) are weeks and \( T_0 \) is the first week. During this week customer orders sent in by points of sale are processed, on a daily basis \( t_{\text{now}} \), and according to ATP/CTP logics, in order to set their date of producibility. At the end of this week \( t_{\text{freeze}} \) the algorithm, designed to elaborate the shipping plan for week \( T_i \), is activated. This is the first period that can be chosen after the frozen interval, an interval which is defined, naturally, by the constraints and the choices of the firm. The interval between today and this future date is the so-called precession or pre-planning period and it is frozen, that is, not subject to change.

**Order-Carrier assignment module**

In this module the order-carrier assignment is done by taking into consideration both the primary and secondary (inter-zone) carriers described above. First, the algorithm tries to find a primary carrier who is available for each order belonging to the list. If this is not possible, the secondary carriers are taken into consideration. In the case where there is only one secondary carrier to whom the order could be assigned, then availability is checked: if this is alright then the order is loaded onto that carrier. On the other hand, if there is more than one carrier available then the decision must be made which carrier the order should be given to. This is done using a dynamic list where carriers are listed in descending order depending on their date of availability \( t_{\text{avail}} \) and, if there is more than one available on the same day, then the algorithm is used to select the carrier who has had the least number of journeys during that solar year. Febal stipulated this condition in order to distribute the number of journeys as equally as possible throughout the whole vehicle park. If there are no carriers available the order is then re-examined with the “rebalancing loads module” described below.

**Rebalancing loads module**

The assignment of loads to primary and inter-zone carriers carried out in the preceding phase is now re-examined in order to determine how full each vehicle is. As already mentioned, Febal operates using an ATD logic and the main aim is sending vehicles out fully loaded. The rebalancing loads module carries out an analysis that aims to re-distribute orders between carriers in order to fill each vehicle as fully as possible, i.e. to the most satisfactory/acceptable level.

The rebalancing loads module is cyclical and activates three sub modules in a cascade, in order to fill each truck to a pre-determined percentage of a full load \( C \). Orders that are still not assigned at the end of these three phases are either delivered by third parties, if they are urgent, or reinserted in a database \( DB_z \). These unassigned orders must then be re-analysed using an ATP/CTP type analysis because a new producibility date has to be set. Furthermore, this analysis must also be able to ascertain where production capacity has become available, given that the space allocated to these unassigned, hence, un-produced orders, can now be allocated to orders that were not originally included in the period being dealt with.

**Dynamic Carrier Sorting**

In this first sub module, first both the orders of carriers whose loads are below the pre-determined percentage \( C \) and those from the database \( DB_z \) are extracted. All these orders are linked to a corresponding carrier, either primary or inter-zone. Each order is assigned a priority rating based on: the producibility date, the point of sale it must be delivered to, the primary carrier that serves that point of sale and any other inter-zone or occasional carriers (delivery by a third party). A table (carriers table) is drawn up based on the primary vector; the order is established by increasing values of an estimation function \( F \). This table, as we will see in the sub module Dynamic Carrier Assignment, is dynamic, or rather, the inter-zone carriers can be re-assigned cyclically. Analysis has revealed a maximum of two secondary carriers needs to be assigned to each point of sale, thus it would seem a point of sale is satisfactorily served by three carriers: one primary and at most two secondary. In particularly urgent cases, where an order cannot be fitted in, third party carriers are used.
Dynamic Carrier Loading

This sub module focuses on individual primary carriers in sequence and first assigns all the orders for which this carrier is primary carrier, and then assigns those for which the carrier would be a secondary carrier. If these orders have already been assigned to the primary carrier under consideration, then a carrier’s use ratio is increased. After each operation that assigns a specific order, the carrier’s load is re-checked and if it has now reached the required percentage then it will be included in the shipment plan and the algorithm moves on to the next primary carrier in the table. On the other hand if, even when all the orders for which this carrier is a secondary one have been taken into account, the total load still does not reach the required level, all the orders that have been assigned to this carrier are put back into the table thus up-dating the use ratio of the carrier. When all the orders have been examined, if a satisfactory percentage (higher than $C$) of full loads has been achieved for all the carriers loaded the cycle ends as it has completed the shipment plan. If there are still orders left over then the algorithm passes to the next stage called Dynamic Carrier Assignment.

Dynamic Carrier Assignment

If in the preceding phase the pre-established lower load limit has not been reached for all the carriers, this third sub-module steps in and increases the degree of superimposition, of overlap, of the geographical areas, so as to find carriers, other than the primary carrier for each point of sale. With this sub-module it is possible to see whether each vehicle/carerrier could make a longer journey. If this is possible then the points of sale that could now be reached are identified and the journey extended to quantity $t_{\text{journey}}$. If the planner does not intend to lengthen the journey then a check is made to see whether the load has reached the percentage the firm established a priori. This, in other words, is the minimum saturation level ($L$) that a carrier must reach in order to have the journey authorised. If $C$ is greater than $L$ the algorithm makes it possible to decrease the percentage of full load.

In the light of the above it is clear that carriers table has been rendered dynamic in order to achieve a load level that is satisfactory for the carriers used. The operation consists of associating new secondary carriers to specific orders and, consequently, to the point of sale the order must be delivered to. This method of assigning loads ensures that the primary carrier which serves a specific area/point of sale will not change over time, whereas secondary carriers can be moved around to meet changing needs. This breaks the one-to-one relationship between the point of sale and the carrier without, however, completely neglecting the trust factor, in that the carriers with the highest use coefficient for that point of sale will always be the first to receive orders for delivery to that point of sale.

INTEGRATION WITH THE ECOSELL TOOLSET

As described in the introduction the ECOSELL consortium is trying to cross the barriers of a single value chain and link different value chains in a complementary manner thus constructing a meta-value chain in which industrial groups try to sell and distribute their products, taking up the challenge of the total integration of their value chains. The ECOSELL project, centred on the selling chain intends to support the offer of a product/service pack, i.e. a combination of different complementary products and services coming from different selling chains by:

- coordinating the selling chain processes from beginning to end;
- providing an excellent level of service by giving customers total reliability over the delivery information through an effective management of the inventories and manufacturing planning systems;
- quickly solving all the issues related to delivery;
• defining parameters measuring the effectiveness of the selling chain, customer satisfaction and perceived quality.

The ECOSELL consortium has designed and implemented an ICT tool, named ECOSELL toolset, in order to allow the meta-value chain management through the integration between separate supply chains. The ECOSELL toolset (Figure 5) is a Web based application developed underneath a modular programming philosophy in order to be able to use each module independently.

![Figure 5 – ECOSELL toolset.](image)

The ECOSELL toolset is composed by five different modules:

- **Collaborative Order Management (COM)** allows the order management process providing support for meta-value chain orders with special focus on a extended ATP/CTP/DTP approach (Available to Promise/Capable To Promise/Deliverable To Promise).
- **Collaborative Exception Management (CEM)** provides collaborative means to define and capture, broadcast, and manage meta-value chain exceptions.
- **Extended Performance Management (EPM)** provides a set of KPI adapted to the meta-value chain performance management.
- **Collaborative Forecast Management (CFM)** improves the forecasting by collecting and publishing information from all the relevant actors of the meta-value chain.
- **Extended Distribution Management (EDM)** provides support for multiple configurable distribution models in a meta-value chain environment.

The infrastructure supports a distributed environment linking a cross-country network through a capture and send of standardised data (for instance XML files) from multiple multi-language channels and devices with a global security level.

The COM (Collaborative Order Management) module of the ECOSELL tool requires to the company (Febal in this case) to provide information about the technical validation of the products requested and the notification of the requested delivery date following customers’ orders. Actually Febal has a lack of information during the order generation phase and the informative system is not capable of defining the exact delivery date; the functionalities, integrated in the proposed ICT tool for the scheduling of Febal’s shipment plan, allow to fully address the requirements of the COM, checking at the same time possible manufacturing or distribution problems (Figure 6).
CONCLUSION

The case study described in this article shows the way the firm studied responded to a specific critical state. This critical state of maintaining *Assemble To Delivery* logic when designing a new physical distribution and logistics management system was resolved by designing a scenario that would not change the existing efficacious manufacturing planning model which is deeply rooted within the firm's strategies and logic. Furthermore, this scenario had to satisfy the requirements coming from the more complex logic of the meta-value chain inside the ECOSELL project.

This article has focused on an elaboration of the scenario which requires the creation of new software that would be able to develop a new logic for the assignment of geographical areas to carriers and for order assignment. This problem, whose solution was difficult to define and design, was resolved by using a greedy high-speed algorithm and a solution which, while it may not be the best, still satisfies all the requirements set by the firm during the design phase, that is, it can elaborate a shipment plan that cuts product delivery times by using a more rational and flexible distribution system.

REFERENCES


