SUPPLY CHAIN DESIGN: A CASE STUDY ON THE ADDITION OF NEW POTENTIAL CUSTOMERS

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ABSTRACT

The work presents the results of a research work developed in cooperation with a third part logistics company operating in Calabria (South Italy) in the field of the beverage distribution. The paper focuses on a supply chain design problem; the main objective is to select new supply chain customers trying to minimize the impact on the service level provided to the actual customers. In particular the authors take into consideration three different routes within the actual distribution scenario (a route has to be regarded as a multi-drop mission performed by a single vector and serving multiple customers), testing for each route the potential addition of a certain number of new customers and observing the effects on the service level.

Keywords: third part logistics, supply chain design, distribution systems, modeling, simulation

1. INTRODUCTION

The main goal of a logistics and distribution system is to delivery the right quantity of items, at the right place and at the right time, trying to reduce transportation costs without affecting the service level provided to customers.

The globalization effects requires to each company operating in the supply chain to increase competitiveness and the value added of the business strategies. In this case optimal logistics and transportation increases customers' satisfaction, thereby guaranteeing better competitiveness and business survival in increasingly competitive markets.

There are many examples in which inadequate supplies and communications caused the decrease of business market shares associated to revenues reduction and lower quality of services to customers. Consider the case of the Nokia and Ericsson mobile phones and the case of the Land Rover Discovery (refer to "Creating a Resilient Supply Chains: A Practical Guide", 2003).

At the beginning of 2000, the Philips was the sole suppliers of mobile phones components for both Nokia and Ericsson. A problem to the power lines caused a fire that destroyed one of the most important Philips plants. As consequence Philips stopped production and distribution of mobile phones components caused economic damage to both Nokia and Ericsson (even if the economic impact on Ericsson was more severe, about 400 millions of dollars, because the Ericsson top management trusted Philips and did not react to the problem by searching additional suppliers). A similar situation was experienced by Land Rover when UPF-Thomson stopped deliveries, the economic impact was severe as well as the effect on the service level provided to final customers.

Among the various tools at present available for planning, analysing and managing logistics and distribution systems, simulation plays a critical role. Logistics simulation models are used for planning and analysing supplies and information flows and to test different possible scenarios such as changes in transportation modes (by rail, ship etc. or multi-pick and multi-drop strategies), supply management policies, products demand fluctuations, inventory control policies as well as addition of potential new final customers.

The present work considers the supply chain design problem in terms of addition of new customers. The authors believe that additional customers should be selected trying to reduce as much as possible the impact on the service level provided to the actual customers. The case proposed in the paper regards the distribution system of a third part logistics company. The logistic platform – located in Calabria, South Italy and served by the third part logistics company – is made up of 50 customers and two distribution centers. Connections among distribution centers and customers are assured by road transportation. The reach the main goal of the research work (understanding the impact of the addition of new customers on the service level), the authors use Modeling & Simulation and advanced statistic methods as decision support tool.

Before getting into details, a brief overview of the paper is reported. Section 2 presents the actual supply chain configuration reporting information on the distribution system and deliveries. Section 3 describes the implementation of the simulation model. Section 4 presents the supply chain design problem analysis and the results of the approach proposed by authors. Finally the last section highlights the scientific contribution of the research work and reports the research activities still on going.

2. ACTUAL SUPPLY CHAIN CONFIGURATION

The research work has been developed in cooperation with a third part logistics company operating in the distribution of beverages. In the sequel is reported an accurate description of the supply chain actual configuration.

Items deliveries from suppliers to distribution centers are performed by using one vector (a truck) for each supplier. In effect, each supplier has its own distribution system. Inside each distribution center, items are subdivided and successively mixed in order to create the items assortment required by each customer. The deliveries from distribution centers to final customers are performed by means of multi-drop missions in which, a specific group of customers is served by the nearest distribution center and by one vector in order to reduce distribution and transportation costs. In effect the final customers are grouped in five different geographical areas, let $C_{i,j}$ be the *j-th* customer belonging to the *i-th* geographical area and let DC_1 and DC_2 be the two distribution centers.

Table 1: Geographical Areas and number of final customers for each area

Geographical Areas	Identifying Code	Number of Customers
South Calabria	GA_1	11
North Calabria	GA_2	10
Middle Calabria	GA_3	9
Middle-West Calabria	GA_4	8
North-West Calabria	GA_5	12

The Figure 1 shows the actual configuration of the supply chain, from suppliers to final customers. Note that, as mentioned into the introduction, the third part logistics company being considered in this paper takes care of logistics and transportation between distribution centers and final customers.

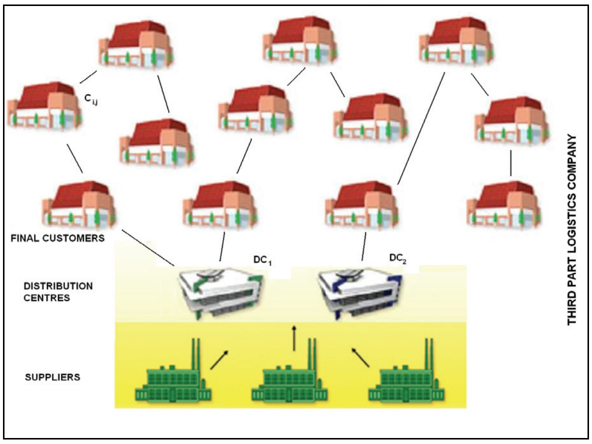

Figure 1: Supply Chain Actual Configuration

Customers' purchase orders are based on demand forecasts and emitted once per day 6:00 pm. Deliveries from distribution centers begins at 8:00 am of the morning ahead. Purchase orders are sent to the nearest distribution center that organizes and gets ready the requested items for shipment. Inventory management of and items re-order at distribution centers are based on re-order level policies and demand forecasts. Delivery missions from distribution centers to final customers (performed by the third part logistics company) are organized as follows. Trucks arrive at distribution center at 04:30 am. The trucks loading schedule depends on the truck tour total length (expressed in kilometers): the greater is the total length the higher is the priority of that truck.
Note that the main objective of the third part logistics service is to guarantee the right product in the right place, in the shortest time. Customer satisfaction level strongly depends on the delivery times: shorter delivery times mean higher customers' satisfaction level. Among performance indexes a key role is consequently played by the mean service level provided to customers. In effect this index measures customer satisfaction and it's defined as function of the delivery time.

In particular the service level is equal to one (maximum customer satisfaction) if the delivery is before 09:30 am, the service level decreases, (as well as the customer satisfaction), with the increase of the delivery time. Equation 1 expresses the service level of the *i-th* customer belonging to the *j-th* area ($SL_{i,j}$), as function of time *t*.

$$SL_{i,j} = sl^{-t} \qquad (1)$$

The parameter *sl* defines the decrease degree of the service level as the time goes by (expressed in minutes starting from 09:30 am). The value of such parameter is determined by empirical data considering the lost revenues due to the delay in the deliveries after 09:30 am.

3. SUPPLY CHAIN SIMULATION MODEL: IMPLEMENATION, VERIFICATION AND VALIDATION

Supply chain design problems require the understanding of complex interactions between many stochastic factors and variables (i.e. demand forecast, stochastic lead time, demand intensity and variability, transportation alternatives, etc.). Modeling & Simulation (M&S) has to be regarded as the most suitable approach for recreating the complexity of the supply chain and for testing alternative supply chain configurations trying to achieve the minimization or maximization of a certain performance measure or acceptable trade-offs between conflicting objectives.

The simulation model, developed by using the discrete event simulation software eM-Plant, recreates each supply chain actor (supplier, distribution center, customers, third part logistics company, etc.) by using ad-hoc modeled classes. Each class has been developed by using the Simple++ simulation language and is then instantiated in the simulation model main frame in order to recreate the supply chain actual configuration.

During the simulation runs all the supply chain activities are performed at run-time: i.e. by entering the object class of a customer it is possible to visualize purchase orders emission and items unloading operations, while by entering the object class of a distribution center, it is possible to visualize purchase orders management and trucks loading operations. The Figure 2 shows a table reporting mission information for the Middle-West Calabria area: for each final customer information on customer identifying code, city travel time, unloading time, delivery time and service level are displayed.

Tour	Customer	City	Travel Time	Unloading Time	Delivery time	Service Level
Middle-West Calabria	GA41	Cs (Carrefour)	16.9758	6.1970	7:20:42.5962	1.00
	GA42	Camigliatello	31.2714	7.1998	7:59:22.3345	1.00
	GA43	Longobucco	53.7303	7.5414	9:00:14.3572	1.00
	GA44	Longobucco	1.8092	8.5051	9:10:46.0199	1.00
	GA45	Bocchigliero	1:10.5785	7.1777	10:28:31.3896	0.86
	GA46	Campana	27.1037	6.6474	11:02:16.4565	0.79
	GA47	Savelli	29.4834	8.2515	11:40:00.5516	0.72
	GA48	Lorica	53.8006	6.6770	12:40:29.2097	0.62

Figure 2: Simulator table reporting missions information

Before using the simulation model for testing alternative supply chain configurations in terms of addition of new customers, the authors carried out the Verification and Validation of the simulation model. The process of determining that the simulation model implementation accurately represents the initial conceptual model has been carried out by using the debugging technique (simulation model verification). In effect this step is strictly related to model translation and the debugging technique (Dunn, 1987) helps in finding and correcting all the errors in the programming code.

Concerning the Validation phase, note that the system under consideration is a *terminating system*, (Banks, 1998); the length of each simulation run (24 hours) is fixed and is a consequence of the model and its assumptions. In this system the only checkable factor is the number of replications. The correct number of replications has to guarantee a simulated confidence interval of the performance measure being considered (the service level provided to customers) similar to the confidence interval of the real system. Such confidence interval can be expressed in terms of mean squares error. Considering the stochastic distributions implemented in the simulation model we can assert that the model is subjected to experimental error with normal distribution, $N(0, \sigma^2)$. The best estimator of $\sigma^2_\cdot$ is the mean squares error that can be evaluated by using equation 2:

$$SL_{mse}(t) = \sum_{h=1}^{n} \frac{(SL_h(t) - \overline{SL}(t))}{n-1} \qquad (2)$$

where $SL_h(t)$ is the value of the Service Level at instant of time t during the replication h and $h=1,\ldots,n$ is the number of replications. The number of replications chosen is 8; such number of replication assures a negligible mean squares error for the service level provided to customers.

4. ALTERNATIVE SUPPLY CHAIN CONFIGURATION: ADDITION OF NEW FINAL CUSTOMERS

The supply chain design problem requires the analysis of the impact on the service level generated by the addition of new customers on two geographical areas. The areas being considered by the analysis are the South Calabria (GA_1) area and the Middle Calabria (GA_3) area: the analysis aims at considering 8 additional customers for the GA_1 area and 4 additional customers for the GA_3 area.

The effect of the addition of the customers in each area, has been investigated by using the factorial experimental design, in which each factor is an additional customer characterized by two possible levels: *Present* (*P*) and *Absent* (*A*). Note that two different factorial experimental designs have been carried out: in effect the addition of new customers in the GA_1 area does not affect the service level of the customers of the GA_3 area and vice-versa (the multi-drop missions in each geographical area are performed by two different trucks).

Check of all possible combinations of the factors levels requires 2^p simulation runs (p, number of factors). In the case of the GA_1area, p=8, then there are 256 possible combinations requiring 256 simulation runs. Each run has to be replicated 8 times as mentioned in the previous section, (256x8=2048 replications). Carrying out 2048 replications, it's possible to evaluate the impact on the service level of all the effects (1st order effects, two-factor interactions, three-factor interactions, four-factor interactions and so on until the sole eight-factor interaction). However, in many real situations the system is dominated by the main effects and by the low order interactions. The high order interactions are negligible. Consequently it is possible to obtain useful information about the system decreasing the total number of replications. In general a 2^p factorial experimental design may be run in a $1/2^l$ design called a 2^{p-l} *fractional factorial design*. Considering the high order interactions negligible, the system can be analyzed with a 2^{8-3} fractional factorial design, carrying out only 32 simulation runs against 256 simulation runs required by a complete design. At the same time only 16 simulation runs can be used to run a complete design relative to the GA_3 area (in effect 2^4 = 16 simulation runs).

Table 2 reports the design of experiments matrix and the simulation results for the GA_1 area (similar results have been obtained for the GA_3 area) in terms of mean service level. Note that for each factors level combination, 8 different replications are reported.

Table 2: Experimental Design Matrix and simulation results of the GA_1

$GA_{1,12}$	$GA_{1,13}$	$GA_{1,14}$	$GA_{1,15}$	$GA_{1,16}$	$GA_{1,17}$	$GA_{1,18}$	$GA_{1,19}$	Simulation Results (Service Level)							
A	A	A	A	A	A	A	P	0.836	0.837	0.835	0.836	0.834	0.838	0.839	0.835
P	A	A	A	A	P	P	P	0.801	0.786	0.790	0.793	0.788	0.782	0.796	0.790
A	P	A	A	A	P	P	A	0.810	0.806	0.801	0.805	0.808	0.809	0.802	0.801
P	P	A	A	A	A	A	A	0.830	0.830	0.842	0.840	0.833	0.828	0.830	0.831
A	A	P	A	A	P	A	A	0.826	0.820	0.829	0.819	0.821	0.830	0.822	0.820
P	A	P	A	A	A	P	A	0.818	0.821	0.819	0.823	0.814	0.817	0.813	0.805
A	P	P	A	A	A	P	P	0.800	0.790	0.792	0.798	0.781	0.787	0.793	0.786
P	P	P	A	A	P	A	P	0.788	0.791	0.789	0.780	0.780	0.789	0.787	0.774
A	A	A	P	A	A	P	A	0.820	0.810	0.815	0.813	0.821	0.823	0.819	0.821
P	A	A	P	A	P	A	A	0.812	0.811	0.818	0.820	0.822	0.814	0.818	0.810
A	P	A	P	A	P	A	P	0.797	0.782	0.798	0.802	0.804	0.781	0.803	0.790
P	P	A	P	A	A	P	P	0.780	0.781	0.792	0.780	0.776	0.782	0.779	0.776
A	A	P	P	A	P	P	P	0.772	0.769	0.791	0.792	0.767	0.781	0.773	0.770
P	A	P	P	A	A	A	P	0.789	0.801	0.783	0.791	0.799	0.786	0.801	0.789
A	P	P	P	A	A	A	A	0.813	0.821	0.823	0.818	0.810	0.808	0.818	0.819
P	P	P	P	A	P	P	A	0.781	0.779	0.787	0.792	0.784	0.777	0.773	0.781
A	A	A	A	P	A	A	A	0.839	0.841	0.838	0.835	0.840	0.846	0.845	0.843
P	A	A	A	P	P	P	A	0.810	0.803	0.810	0.819	0.799	0.801	0.796	0.803
A	P	A	A	P	P	P	P	0.785	0.777	0.785	0.771	0.772	0.771	0.788	0.789
P	P	A	A	P	A	A	P	0.809	0.796	0.810	0.819	0.802	0.799	0.808	0.800
A	A	P	A	P	P	A	P	0.790	0.782	0.803	0.791	0.799	0.806	0.808	0.799
P	A	P	A	P	A	P	P	0.785	0.788	0.791	0.779	0.776	0.777	0.784	0.791
A	P	P	A	P	A	P	A	0.794	0.801	0.806	0.811	0.787	0.801	0.799	0.795
P	P	P	A	P	P	A	A	0.806	0.791	0.808	0.799	0.794	0.784	0.805	0.802
A	A	A	P	P	A	P	P	0.782	0.789	0.806	0.791	0.789	0.785	0.798	0.781
P	A	A	P	P	P	A	P	0.784	0.788	0.779	0.785	0.772	0.776	0.781	0.789
A	P	A	P	P	P	A	A	0.791	0.792	0.808	0.809	0.801	0.798	0.806	0.791
P	P	A	P	P	A	P	A	0.798	0.792	0.803	0.784	0.786	0.786	0.798	0.793
A	A	P	P	P	P	P	A	0.783	0.791	0.798	0.786	0.782	0.781	0.783	0.782
P	A	P	P	P	A	A	A	0.804	0.803	0.799	0.811	0.796	0.802	0.812	0.810
A	P	P	P	P	A	A	P	0.782	0.777	0.782	0.789	0.781	0.779	0.773	0.780
P	P	P	P	P	P	P	P	0.743	0.741	0.752	0.758	0.750	0.743	0.751	0.740

4.1. Supply chain design problem: simulation results analysis

The simulation results in output from the fractional factorial design have been studied by using the Analysis of Variance (ANOVA). As reported in Montgomery (2003), the ANOVA expresses the total variability of the performance measure being considered (the mean service level provided to customers) as sum of different terms. Each term is the variability of a factor. The greater is the variability of that factor the higher is the impact on the performance measure. In effect, by using a Fisher statistics the ANOVA checks for each factor two different hypotheses: (i) the factor has no impact on the mean service level (usually called H_0 hypothesis); (ii) the factor has an impact on the mean service level (usually called H_1 hypothesis).

The ANOVA also allows to define an analytical model (called meta-model of the simulation model) that expresses the mean service level as function of the factors being considered. Let SL_i be the mean service level for the *i-th* geographical area and let $GA_{i,j}$ the factors. Note that each factor can take only two values: *A* and *P*. The analytical model requires to use for each factor numerical values. To this end, let us introduce the following correspondence: *A* (-1) and *P* (1). Finally let β_{ij} the coefficients of the meta-model. The equation 3 expresses the *SL* in terms of the factors $GA_{i,j}$.

$$SL_i = \beta_{i,0} + \sum_{j=1}^{j=k} \beta_{i,j} GA_{i,j} + \sum_{j<k}\sum \beta_{i,jk} GA_{i,j} * GA_{i,k} + \\ + \sum_{j<k}\sum_{k<l}\sum \beta_{i,jkl} GA_{i,j} * GA_{i,k} * GA_{i,l} + \varepsilon \quad (3)$$

- $i = 1,3$ – identifying index of the geographical area;
- $j = 12,\ldots,19$ or $j = 10,\ldots13$ – identifying index respectively for the South Calabria new customers and Middle Calabria new customers

Note that equation 3 is not a continuous function; in effect *A* and *P* respectively mean new customer absent (no addition of the new customer to the multi-drop delivery mission) and new customer present (addition of the new customer to the multi-drop delivery mission). Consequently equation 3 can be used only for evaluating the value of the mean service level when the factors take the values “-1” or “+1”. Obviously the evaluation of the service level (by using equation 3) when the factors take the value “0” has no sense.

4.2. Analysis of Variance for the GA_1 area

Table 3 reports the results of the Analysis of Variance for the GA_1 area. As well known from the theory of ANOVA the non negligible effects are characterized by the *P-Value* lower than 0.05 (α = 0.05, confidence level used in the analysis of variance). For further information on the Analysis of Variance please refer to Montgomery (2003). The predominant effects – that is the effects generating a non negligible variation of the mean service level – are the first order effects and some effects of the second order.

Table 3: Analysis of Variance for the GA_1 area

Term	Effect	Coef	SE Coef	T	P
Constant		0.79839	0.000404	1977.56	0.00
$GA_{1,12}$	-0.00748	-0.00374	0.000404	-9.27	0.00
$GA_{1,13}$	-0.01055	-0.00527	0.000404	-13.06	0.00
$GA_{1,14}$	-0.01184	-0.00592	0.000404	-14.67	0.00
$GA_{1,15}$	-0.01455	-0.00727	0.000404	-18.02	0.00
$GA_{1,16}$	-0.01028	-0.00514	0.000404	-12.73	0.00
$GA_{1,17}$	-0.01328	-0.00664	0.000404	-16.45	0.00
$GA_{1,18}$	-0.0163	-0.00815	0.000404	-20.18	0.00
$GA_{1,19}$	-0.02016	-0.01008	0.000404	-24.96	0.00
$GA_{1,12}$*$GA_{1,13}$	0.00225	0.00112	0.000404	2.79	0.01
$GA_{1,12}$*$GA_{1,14}$	-0.00008	-0.00004	0.000404	-0.10	0.92
$GA_{1,12}$*$GA_{1,15}$	-0.00059	-0.0003	0.000404	-0.74	0.46
$GA_{1,12}$*$GA_{1,16}$	0.00077	0.00038	0.000404	0.95	0.34
$GA_{1,12}$*$GA_{1,17}$	0.00039	0.0002	0.000404	0.48	0.63
$GA_{1,12}$*$GA_{1,18}$	0.00156	0.00078	0.000404	1.94	0.05
$GA_{1,12}$*$GA_{1,19}$	-0.00242	-0.00121	0.000404	-3.00	0.00
$GA_{1,13}$*$GA_{1,16}$	-0.0003	-0.00015	0.000404	-0.37	0.71
$GA_{1,13}$*$GA_{1,19}$	-0.00014	-0.00007	0.000404	-0.17	0.86
$GA_{1,14}$*$GA_{1,15}$	0.00092	0.00046	0.000404	1.14	0.26
$GA_{1,14}$*$GA_{1,16}$	-0.00041	-0.0002	0.000404	-0.50	0.62
$GA_{1,14}$*$GA_{1,18}$	0.00183	0.00091	0.000404	2.26	0.03
$GA_{1,14}$*$GA_{1,19}$	-0.00137	-0.00069	0.000404	-1.70	0.09
$GA_{1,15}$*$GA_{1,16}$	-0.00148	-0.00074	0.000404	-1.84	0.07
$GA_{1,15}$*$GA_{1,19}$	-0.00105	-0.00052	0.000404	-1.30	0.20
$GA_{1,16}$*$GA_{1,17}$	0.00053	0.00027	0.000404	0.66	0.51
$GA_{1,16}$*$GA_{1,18}$	0.0007	0.00035	0.000404	0.87	0.39
$GA_{1,16}$*$GA_{1,19}$	0.00009	0.00005	0.000404	0.12	0.91
$GA_{1,17}$*$GA_{1,19}$	-0.00009	-0.00005	0.000404	-0.12	0.91
$GA_{1,18}$*$GA_{1,19}$	-0.00027	-0.00013	0.000404	-0.33	0.74
$GA_{1,12}$*$GA_{1,13}$*$GA_{1,16}$	0.00069	0.00034	0.000404	0.85	0.40
$GA_{1,12}$*$GA_{1,13}$*$GA_{1,19}$	0.00078	0.00039	0.000404	0.97	0.33
$GA_{1,12}$*$GA_{1,14}$*$GA_{1,15}$	-0.00016	-0.00008	0.000404	-0.19	0.85

Note that all the first order effects have an impact on the mean service level provided to customers. It means that each additional customer considerably affects the service level. The customers to be added to the supply chain should be selected trying to minimize the effect on the service level. To this end the authors use the analytical model provided by equation 3. In order to find out the coefficients of the analytical model, the Analysis of Variance has been repeated for the GA_1, deleting insignificant factors (those factors characterized by *P-Value* > 0.05). Table 4 reports the coefficients of the analytical model for those factors affecting the service level.

Equation 3 can be used for plotting the variation of the service level in case of addition of a new customer. Figure 3 shows the effect on the service level when a new customer is added. Note that some customers, as for instance $GA_{1,12}$ and $GA_{1,13}$, have a lower impact on the service level than other customers, such as $GA_{1,18}$ and $GA_{1,19}$. Equation 3 and Figure 3 can be used for selecting the best customers to be added to the supply chain.

Table 4: Coefficients of the input-output analytical model for the GA_1 area

Term	Coef
Constant	0.798391
$GA_{1,12}$	-0.00374
$GA_{1,13}$	-0.00527
$GA_{1,14}$	-0.00592
$GA_{1,15}$	-0.00727
$GA_{1,16}$	-0.00514
$GA_{1,17}$	-0.00664
$GA_{1,18}$	-0.00815
$GA_{1,19}$	-0.01008
$GA_{1,12}$*$GA_{1,13}$	0.001125
$GA_{1,12}$*$GA_{1,18}$	0.000781
$GA_{1,12}$*$GA_{1,19}$	-0.00121
$GA_{1,14}$*$GA_{1,18}$	0.000914
$GA_{1,14}$*$GA_{1,19}$	-6.88E-04
$GA_{1,15}$*$GA_{1,16}$	-7.42E-04

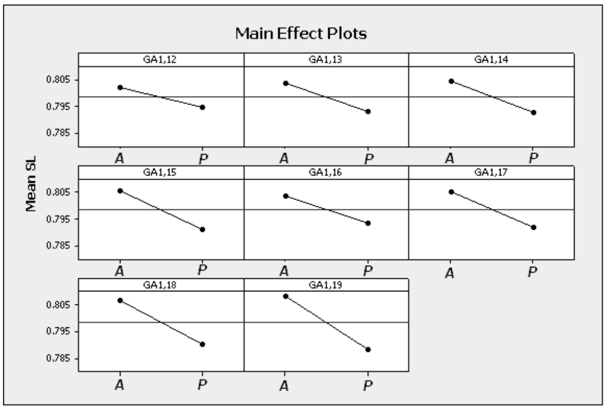

Figure 3: Main effects plots, SL versus addition of new potential customers in the GA_1 area

4.3. Analysis of Variance for the GA_3

As in the previous case, the results obtained by using the supply chain simulator in combination with the factorial experimental design and the Analysis of Variance are extremely interesting, because they allow to correctly select the best new customers of the supply chain. The analysis for the GA_3 area points out that localities such as $GA_{3,12}$ and $GA_{3,13}$ generate a remarkable reduction of the mean service level (see Figure 4) in comparison to $GA_{3,10}$ and $GA_{3,11}$. The addition of such customers has a negligible effect on the mean service level provided to all the customers of the same multi-drop mission. Furthermore the accurate selection of the supply chain final customers – on the basis of the impact on the mean service level and in relation to the demand forecasts in terms of purchase orders – helps in keeping under control the transportations costs and to guarantee efficient logistics and transportation processes.

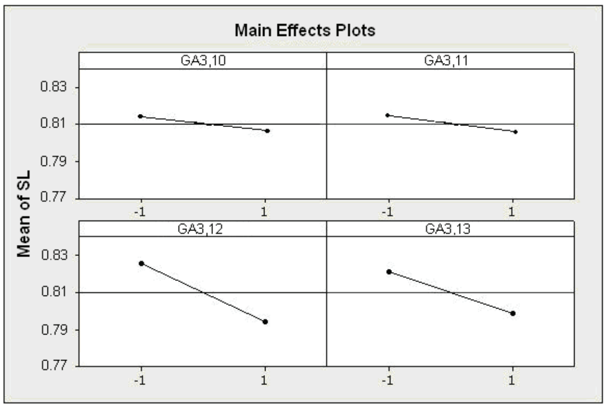

Figure 4: Main effects plots, SL versus addition of new potential customers in the GA_3 area

5. CONCLUSIONS

The research work proposed in this paper has been developed in cooperation with a third part logistics company operating in South Italy (Calabria) in the field of beverage distribution. The main goal was the selection of new potential customers trying to minimize the effect on the mean service level. To this end the authors decided to implement a supply chain simulator and use the simulator in combination with design of experiment and analysis of variance. In particular specific analysis have been carried out considering two different geographical areas and investigating, for each area, the effects on service level generated by the addition of respectively 8 and 5 new customers.

The approach based on Analysis of Variance allows to evaluate (for each area considered) the variation of the service level when a customer is added to the multi-drop delivery mission. The best customers have to be selected among those generating the smallest variation of the service levels. The addition of new final customers that have a negligible impact on the mean service level helps in maintaining high efficiency of the logistics and transportation processes.

Further researches are still on going using the same simulator for optimizing the distribution strategies from suppliers to distribution centers.

REFERENCES

Banks J., 1998. *Handbook of simulation*. New york: Wiley Interscience.

Beamon, B. M., 1998. Supply chain design and analysis: models and methods, *International Journal of Production Economics*, 55 (3), 281-294.

Broekmeulen, R. A. C. M., 2001. Modelling the management of distribution centers. In: *Food Process Modeling*, edited by Tijskens, L. M. M., Hertog, M. L. A. T. M., Nocolai, B. M. Cambridge: Woodhead Publishing Ltd.

Bruzzone, A.G., Bocca, E., Longo, F., Massei, M., 2007. Logistics Node Design and Control over the Whole Life Cycle based on Web Based Simulation. *International Journal of Internet Manufacturing and Services*, 1(1), pp. 32-50.

Buzzone, A.G., Longo, F., Massei, M., Saetta, S., 2006. The Vulnerability of Supply Chains As Key Factor in Supply Chain Management. *Proceedings of Summer Computer Simulation Conference*, July 30th – August 03rd, Calgary Canada.

Chan, F.T.S., Chan, H.K., 2005. Simulation modeling for comparative evaluation of supply chain management strategies, *Journal of Advanced Manufacturing Technology* 25, 998–1006.

Creating a Resilient Supply Chains: A Practical Guide, 2003. Report produced by the *Center for Logistics and Supply Chain Management, Cranfield school of Management*.

Curcio, D., Longo, F., Mirabelli, G., Papoff, E., 2007. Pharmaceutical Routes Optimization using Artificial Intelligence, *Proceedings of Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications*, September 6-8, Dortmund, Germany.

De Sensi, G., Longo, F., Mirabelli, G., 2007. Inventory policies analysis under demand patterns and lead times constraints in a real supply chain. *International Journal of Production Research*, 99999:1, 1 – 20, doi:10.1080/00207540701528776

De Sensi, G., Longo, F., Mirabelli, G., Papoff, E., 2006. Ants Colony System for Supply Chain Routes Optimization. *Proceedings of Harbour, Maritime & Multimodal Logistics Modeling and Simulation,* October 4th – 6th, Barcelona, Spain.

De Sensi, G., Longo, F., Mirabelli, G., Papoff, E., 2006. Spreadsheets Based Tool for Supporting Demand Forecasting in Distribution Centers, *Proceedings of the International Workshop on Modeling and Applied Simulation*, October 13th – 15th, Savona, Italy.

Dunn, R.H., 1987. The quest for software reliability. In: *Handbook of software quality assurance*, edited by G.G. Schulmeyer and J.I. McManus, 342 – 384, New York: Van Nostrand Reynold.

Farahani, R. Z., Elahipanah, M., 2008. A genetic algorithm to optimize the total cost and service level for just-in-time distribution in a supply chain. *International Journal of Production Economics*, 111, 229–243.

Ingalls, R. G., 1998. The value of simulation in modeling supply chain. *Proceedings of the Winter Simulation Conference*, pp.1371-1375 Washington D.C.

Longo, F., Mirabelli, G., 2008. An Advanced Supply Chain Management Tool Based on Modeling & Simulation. Computer and Industrial Engineering, 54(3), 570-588.

Mentzer, J.T., Konrad, B.P., 1991. An efficiency/ effectiveness approach to logistics performance analysis. Journal of Business Logistics, 21(1), 33–62.

MontGomery, D.C., Runger, G.C., 2003. *Applied statistics and probability for engineers*. Third Edition.
Persson, F., Olhager, J., 2002. Performance simulation of supply chain designs, *International Journal of Production Economics*, 77, 231-245.
Sabri, E. H., Beamon, B. M., 2000. A multi-objective approach to simultaneously strategic and operational planning in supply chain design. *Omega*, 28, 581–598.

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