# An integrated planning budgeting model for transportation in a supply chain: A case study for phosphate industry

**Azougagh Yassine, Benhida Khalid and Elfezazi Said**
Laboratory Process, Signals, Industrials Systems and Computing (LAPSSII)
Higher School of Technology Safi, Cadi Ayyad University
Marrakech, Morocco
azougagh.yassine@gmail.com

## Abstract

The supply chain modeling approaches used actually, focus on the diverse logistics activities and neglect the financial aspects into strategic, tactical, and operational levels of this activities.

The purpose of this paper is to develop an integrated planning budgeting model to optimize the combined effects of physical and informational flows as well as those related to financial aspects in a reel supply chain operating in the phosphate field. The specific objective of this model is to determine and to define the optimal budget, in the tactical planning level, to transport different products circulation in the various entities of the supply chain studied considering various constraints related of the specificities of the phosphate field.

**Keywords**
Supply chain, platform logistics, transport, modelling, mixed integer programming.

## 1. Introduction

In an increasingly competitive environment, companies must satisfy customers demands, maintain and improve concurrently their profitability using supply chain management.

Supply chain management is the active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage. It represents a conscious effort by the supply chain firms to develop and run supply chains in the most effective and efficient ways possible.

Today, understanding supply chains is a key resource that can contribute significantly to solve this delicate equation. To achieve this understanding, we must proceed by modeling the supply chain (Olivier, 2013).

Since its inception in the early 1990s (Ellram, 1993), (Towill, 1992), (Stevens, 1989) the search work on supply chain analysis, modeling and optimization has multiplied (Guillen et al., 2007), (Guillen et al., 2006), (Guillen et al., 2005), (Tsiakis, 2001), (Bok et al., 2000). Then the modeling of supply chains activities considering physical, informational and financial flows were treated as separate problems and the modeling approaches developed were implemented in independent environments. These models neglect the consequences of financial flows to optimizing these activities on the one hand. In the other hand the use of these type of models has been advocated in several types of industries: the computer industry (Arntzen et al., 1995), the detergent industry (Ozdamar, 1999), the health industry (Jayaraman, 2001), The pharmaceutical industry (Matta, 2004), the paper industry (Rizk, 2008), the petroleum refinement industry (Lee, 2002) and the textile industry (Imen et al., 2011). At the end of this review, we notice the absence of a reference model that formalizes this type of problems.

The purpose of this study is to establish an analytical planning model of a company operating in the phosphate industry. Specifically, the modelling of logistics flows in a reel supply chain composed on production sites and a logistics platform in order to improve the planning and management of daily traffic flows. Also, to minimize the transportation cost of goods considering all the constraints (the capacity of stocks, cadence of production, the capacity of the transportation equipment and finally the customers demand…). In this study, we consider both tactical and operational decision-making levels, since the strategic level concerns decisions that affect the physical organization of the logistics chain.

The model developed, treat a problem of multi-site, multi-product, multi-depots, multimode transport and multi-periods, which aims to optimize specifically the cost of transportation and keep products availability, continuity of production and loading of vessels and avoid demurrage (late payment).

This paper is structured as follows. Section 2 presents the basic terminology and a literature review in supply chain modelling approaches. Section 3 describes the research method we followed within this paper. Section 4 expose our case study and the model adopted. Finally, we draw conclusion in the last section.

## 2. Basic terminology

In order to better understand the context of this study and to prepare the groundwork for the subsequent study, key terms are defined.

### 2.1 Logistic

Logistic is the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements. Note that this definition includes inbound, outbound, internal, and external movements, and return of materials for environmental purposes (Christopher, 2005), (CLM, 1998).

### 2.2 Supply chain

Supply chain is referred to as an integrated system which synchronizes a series of inter related business processes in order to: acquire raw materials and parts; transform these raw materials and parts into finished products; add value to these products; distribute and promote these products to either retailers or customers; facilitate information exchange among various business entities (e.g. suppliers, manufacturers, distributors, third-party logistics providers, and retailers). Its main objective is to enhance the operational efficiency, profitability and competitive position of a firm and its supply chain partners (Min and Zhou, 2002).

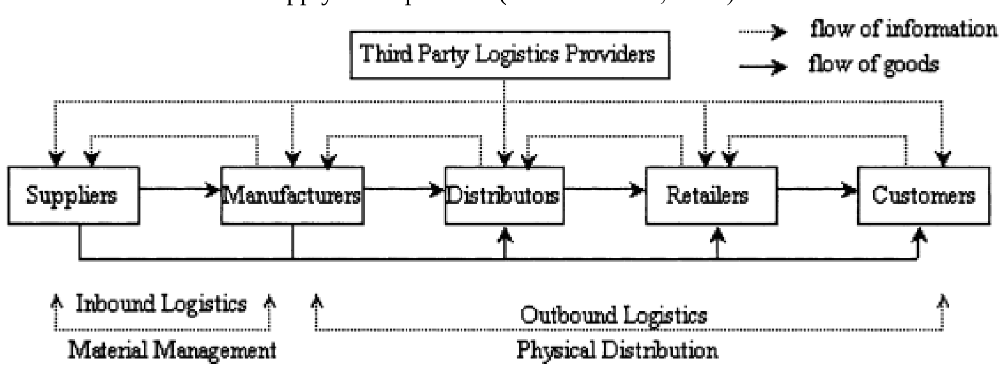


Figure 1. The supply chain structure.

We can define the supply chain as a succession of companies, which contribute to providing a product or service for a customer. By means of exchanging of material flows, and financial information (Gunasekaran and Kobu, 2007).

### 2.3 Logistic platform

Also, we can define the Logistics platforms, conferring to the Council of Logistics Management, as an area within which all activities relating to transport, logistics and the distribution of goods, both for national and international transit, are carried out by various operators. It is run by a single body, either public or private, and is equipped with all the public facilities to carry out the above-mentioned operations (Mocellin, 2006).

### 2.4 Modelling

Modelling is a set of techniques that provides the ability to study and understand the structure and the operating principle of a system. The term model in a technical context is a useful presentation of some objects. It is an abstraction of a reality expressed in term of some formalism defined by modelling constructs for the purpose of the use (Pidd, 1999).

## 3. Literature review of supply chains Modelling approaches

Considering a broad spectrum of the supply chain concept, there are various classification of modelling approaches used to describe and analyze the supply chains. Several reviews of the literature reflect the interest of this research area (Benhida et al., 2016), (Labarthe, 2006), (Kleijnen, 2005), (Lauras, 2004) and (Min and Zhou, 2002).

A taxonomy is presented by (Min and Zhou, 2002) which has classified the models in four main categories: (1) deterministic (non-probabilistic); (2) stochastic (probabilistic); (3) hybrid; (4) IT models. We propose this taxonomy in Figure 2.

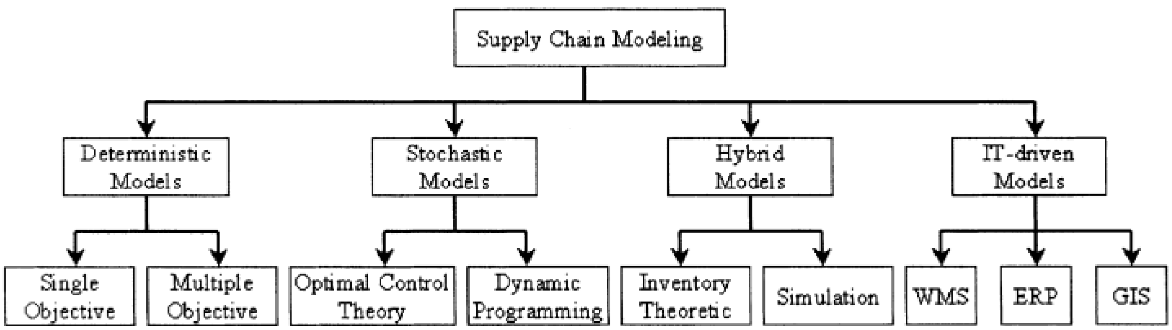


Figure 2. Taxonomy of supply chain model

- Deterministic models assume that all the model parameters are known and fixed with certainty, whereas stochastic models take into account the uncertain and random parameters. Deterministic models are dichotomized as single objective and multiple objective models.
- Stochastic models are sub-classified into optimal control theoretic and dynamic programming models.
- Hybrid models have elements of both deterministic and stochastic models. These models include inventory-theoretic and simulation models that are capable of dealing with both certainty and uncertainty involving model parameters.
- IT-driven models aim to integrate and coordinate various phases of supply chain planning on a real-time basis using application software so that they can enhance visibility throughout the supply chain. These models include WMS, transportation management systems (TMS), integrated transportation tracking, collaborative planning and forecasting replenishment (CPFR), material requirement planning (MRP), distribution resource planning (DRP), ERP, and geographic information systems (GIS).

## 4. Research methodology

The purpose of the present study is to develop an integrated model to minimize the transportation cost to route products between entities in a reel supply chain operating in the field of phosphate. In order to achieve this objective, we followed a structured methodology, based on the work of (Baldwin et al., 2004), (Su and Shih, 2003), (Law and McComas, 2001). This methodology can be summarized as followed (See Figure 3):

- Problem formulating: Define the objectives and the perimeter of the study and clarify the functioning of the system.

- Data collecting: Specify the parameters of the model and collect the information necessary for the functioning of the system.
- Model developing: propose the main objective function and the various constraint of the model.
- Checking and validating the model: determine if the model of simulation is a precise representation of the studied real system.
- Executing the models and analyzing performances: analyze, take back the results and evaluate their impacts on the performances of the systems.

As presented in figure 3, these steps can be iterative. This process continues until the model is considered to be sufficiently valid.

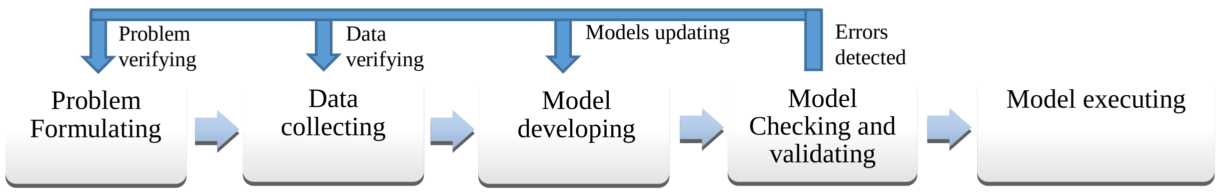


Figure 3. Search methodology

## 5. Proposing the integrated model for supply chain

According to the methodology announced previously, we prepare to develop the integrated model based on a reel case study.

### 5.1 Problem formulating and data collecting

The system studied is a supply chain composed of logistics platform and a chemical complex (Azougagh et al., 2016):

- The logistic platform is designed for exporting finished goods (phosphoric acid and fertilizers) and importing raw materials (sulphur) to/and from various world destinations. This platform is implemented at a port, 13 km from the chemical complex.
- The chemical complex is composed of three main production sites, to produce the phosphoric acid, fertilizers also transformation of the raw material (sulphur).

The following Figure (4) present the configuration of the supply chain studied also the physical flows.

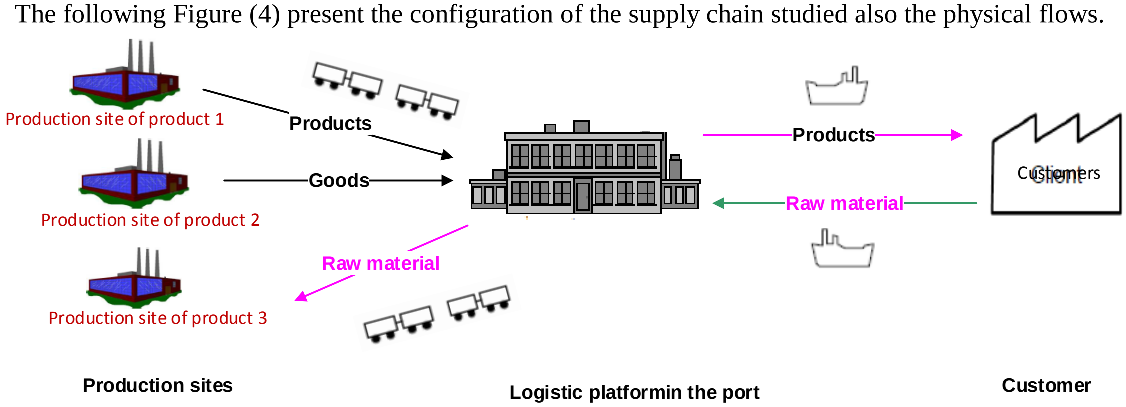


Figure 4. Supply chain studied

The logistic platform is composed (see Figure 5) of two zones, the first area has the role of the reception, storage and unloading the finished products coming from the production sites, while the second area has the role of reception, storage and loading raw materials from suppliers. The storage of products and raw materials is made in large hangars.

The production sites (see Figure 5) is composed of tree production sites and of two zones, the first one is for loading of finished products and the second for receiving and unloading raw materials coming from the port.

The routing of products, in this supply chain, is done normally by rail 24/24 hours. In the case of surpassing the limits of the capacity rail transport and the logistics platform capacity to serve customers demand, the routing is made by dump trucks.

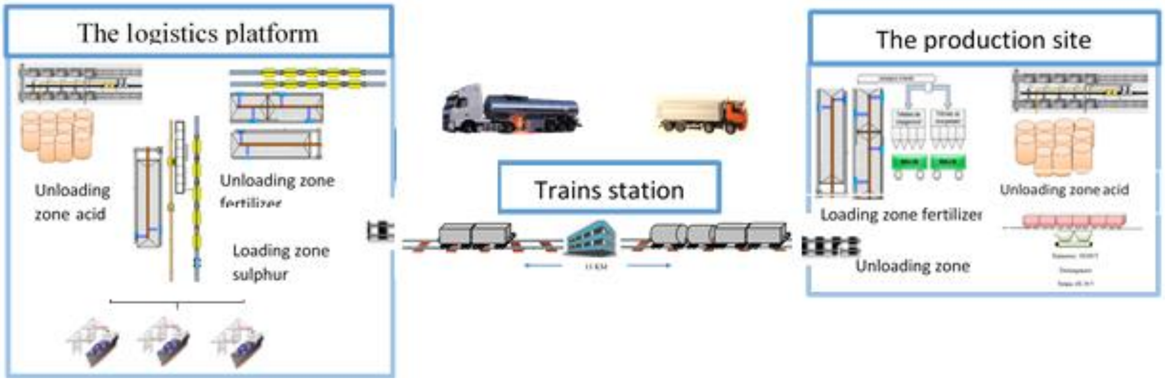


Figure 5. Configuration of supply chain studied.

## 5.2 Model developing

We propose an integrated model, used for making decisions related to cost of transportation of various products in the supply chain studied. This model concern a multi-site, multi-product, multi-depots, multimode transport and multi-periods problem, the time division in this model corresponding to the planning reference period on which the routing of product is established.

This period corresponds to that allowed to load each ship which determined from the stems confirmed by customers.

The notations, parameters and variables used in this model presented in the following:

### 5.2.1 Series

TP: Series of the transportation provider tp $\in$ TP;
P : Series of transported products, p $\in$ P;
T : Number of periods t in the planning horizon t=1, …, T; t $\in$ T;
J : Series of the days in the planning period t, j=1, …, J; j $\in$ J;
E : Series of entities in the supply chain, e=lp for logistics platform and e=ps for the production site, e $\in$ E.

### 5.2.2 Parameters

$ST_{e,p}^{j,t}$ : The quantity of the product p stored in warehouse of the entity e during the day j of period t;
$DPR_{e,p}^{j,t}$ : The quantity of the product p produced in the entity e in the day j of period t;
$DDM_{e,p}^{j,t}$ : The quantity of the product p demanded by customer on the entity e in the day j of period t;
$DMax_{e,p}^{t}$ : The maximal quantity of the product p required by customer in the entity e for the period t;
$QT_{p}^{j,t}$ : The quantities of products p transported during the day j in the period t.

### 5.2.3 Data

$LC^{t}$ : The Labor cost to transport products in period t;
$MC^{t}$ : The Maintenance cost related to routing of products in period t;
$HCE_{Tr,p}^{t}$ : The Hiring cost of equipment used in routing of the product p by the trains during period t;
$HCE_{Ca,p,tp}^{t}$ : The Hiring cost of equipment used by transportation provider tp in routing of the product p by truck during period t;
$STMax_{e,p}$ : The maximal capacity of the product p can be stored in the entity e;

$SafST_{e,p}$ : The safety stock of product p in the entity e;
$InitST_{e,p}^{0,0}$ : The initial quantity (j = 0, t = 0) of the product p stored in the entity e;
$PRMax_{e,p}$ : The maximal capacity of the product p can be produce in the entity e;
$CAPMax_{e,p}$ : The maximal capacity of the product p that can support the equipment (transportation, charging…) of the entity e;
$NRMax_{Ca}$ : The maximal number of daily routes that can make a truck;
$NRMax_{Tr}$ : The maximum number of daily routes that can make a train;
$QTMax_{Ca,p}$ : The maximal quantity of product p that can be transported by truck in each travel;
$QTMax_{Tr,p}$ : The maximal quantity of product p that can be transported by trains in each travel;
M : A constant with big value M = "+ ∞".

### 5.2.4 Decision variables

$TC_p^t$ : The transportation cost of the products p transported in the period t;
$TC_p^{j,t}$ : The transportation cost of the products p transported during day j in period t;
$\text{UTC}_{Tr,p}^{t}$ : The unit transportation cost by trains of the product p in the period t;
$\text{UTC}_{Ca,p,tp}^{t}$ : The unit transportation cost by tracks of the product p in the period t using the transport provider tp;
$QTrv_{Tr,p}^{j,t}$ : The quantities of products p transported by trains in each travel;
$QTrv_{Ca,p}^{j,t}$ : The quantities of product p shipped by trucks in each travel;
$NTrv_{Tr}^{j,t}$ : Number of travel to be made by the trains during the day j in period t;
$NTrv_{Ca}^{j,t}$ : Number of travel to be made by trucks during the day j in period t;
$\alpha_j$: : Binary variable to start or not the mode of transport by trucks.

### 5.2.5 Objective Function

The purpose of the developed objective function (see formula 1) is minimizing the transportation cost between various entities of supply chain studied in a specified period, in order to maximize and to feed the stocks of every entity to satisfy the customers demand.

$$Min(z) = \sum_{t\in T} TC_p^t \quad (1)$$
$$= \sum_{t\in T}\sum_{j\in J}\sum_{p\in P} NTrv_{Tr}^{j,t} \,.\, QTrv_{Tr,p}^{j,t} .\, \text{UTC}_{Tr,p}^{t} + \sum_{t\in T}\sum_{j\in J}\sum_{p\in P}\sum_{tp\in TP} NTrv_{Ca}^{j,t} \,.\, QTrv_{Ca,p}^{j,t} \,.\, \text{UTC}_{Ca,p,tp}^{t} .\, (1-\alpha_j)$$

### 5.2.6 Constraints

To minimize the transportation costs of products, we must be considering various constraints, its mathematical formulations are described as follows:

- **The constraints related to costs of transportation**

The constraints (1) and (2) specify the transportation cost of one ton of product p using trains or tracks in period planning. This cost is equal to labor cost plus the maintenance cost and the transportation equipment rental cost.

$$\text{UTC}_{Tr,p}^{t} = LC^t + MC^t + HCE_{Tr,p}^t \qquad \forall\, t \in T, p \in P \quad (1)$$
$$\text{UTC}_{Ca,p,tp}^{t} = LC^t + MC^t + HCE_{Ca,p,tp}^t \qquad \forall\, t \in T, tp \in TP, p \in P \quad (2)$$

- **The constraints related to quantities transported**

When the daily demand of the products in the logistics platform exceeds the capacity of storage and the capacity of trains, the routing of products is done simultaneous by trucks and trains. For that reason, we used a binary variable $\alpha_j$ that takes the following values:

$$\alpha_j = \begin{cases} 0 & \text{If the routing of products is made by trains and trucks} \\ 1 & \text{If the routing of products is made only by trains} \end{cases}$$

Therefore, to start products routing by trucks, we considered the daily stock $ST_{pr,p}^{j,t}$ at the port as an indicator and the safety stock as a sign to start routing.

So, if the value of the daily stock $ST_{pr,p}^{j,t}$ is below the safety stock $SafST_{pr,p}$, the binary variable take α=1 consequently the term of quantities transported by trucks in the objective function is annulled.

We can formulate these conditions in following constraints (3) and (4).

$$ST_{pr,p}^{j,t} - SafST_{pr,p} \leq M.\alpha_j \qquad \forall\, t \in T, j \in J, p \in P \qquad (3)$$

$$ST_{pr,p}^{j,t} - SafST_{pr,p} > 0 \qquad \forall\, t \in T,\ j \in J, p \in P \qquad (4)$$

The purpose of the following constraint (5) is defining the quantity of products transported in each planning period:

$$QT_p^{j,t} = \sum_{t\in T}\sum_{j\in J}\sum_{p\in P} NTrv_{Tr}^{j,t}\ .QTrv_{Tr,p}^{j,t} + \sum_{t\in T}\sum_{j\in J}\sum_{p\in P} NTrv_{Ca}^{j,t}\ .QTrv_{Ca,p}^{j,t}\ .(1-\alpha_j)$$
$$\forall\, t \in T, j \in J, p \in P \quad (5)$$

- **The constraints related to storage**

To transport products, it is necessary to ensure that the products quantities requested by customers are available in the warehouses of different entities. This condition is presented as following:

The constraint (6) ensures that the quantities of products are always available in warehouses of the production sites.

$$SafST_{u,p} < ST_{u,p}^{j,t} \leq STMax_{u,p} \qquad \forall\, t \in T,\ j \in J, p \in P \qquad (6)$$

In the constraint (7), we ensure that the products quantities are always available in warehouses of the logistics platform.

$$ST_{pr,p}^{j,t} \leq SMax_{pr,p} \qquad \forall\, t \in T,\ j \in J, p \in P \qquad (7)$$

Constraint (8) specify the daily quantity of products in production sites warehouses. It is equal to the products quantity in stock in the day j-1 plus the quantity produced in the day j, less the total quantity transported in the same day j.

$$ST_{u,p}^{j,t} = ST_{u,p}^{j-1,t} + DPR_{u,p}^{j,t} - QT_p^{j,t} \qquad \forall\, t \in T,\ j \in J, p \in P \qquad (8)$$

Constraint (9) specify the daily quantity of products in the logistics platform warehouse $ST_{pr,p}^{j,t}$. It is equal to the products quantity in the stock in the day j-1 plus the total quantity transported in the day j, less the quantity requested by customers in the same day j.

$$ST_{pr,p}^{j,t} = ST_{pr,p}^{j-1,t} + QT_p^{j,t} - DDM_{pr,p}^{j,t} \qquad \forall\, t \in T,\ j \in J, p \in P \qquad (9)$$

In the precedent constraints, it is necessary to consider the initial quantity of products in stocks $InitS_{e,p}^{0,0}$.

- **The constraints related to the production**

To transport the requested products, it is necessary to feed stocks with needed quantities $DPR_{e,p}^{j,t}$ and not to exceed the maximal quantity of daily production $PRMax_{e,p}$. This condition is described as follows (see the constraint 10).

$$DPR_{e,p}^{j,t} \leq PRMax_{e,p} \qquad \forall\, t \in T, j \in J, e \in E, p \in P \qquad (10)$$

- **The constraints related to customer demands**

The demand $DMax_{e,p}$ is determined from the "stems" confirmed by customers, this demand is equal to the sum of daily requests $DDM_{e,p}^{j,t}$ in the period t (see the constraint 11).

$$\sum_{j=1}^{J} DT_{e,p}^{j,t} = DMax_{e,p}^{t} \qquad \forall\, t \in T, j \in J, e \in E, p \in P \qquad (11)$$

The daily demand $DDM_{e,p}^{j,t}$ cannot exceed the maximal capacity (daily flow) $CapMax_{e,p}$ that can support the products routing equipment (see the constraint 12).

$$DDM_{e,p}^{j,t} \leq CapMax_{e,p} \qquad \forall\, t \in T, j \in J, e \in E, p \in P \qquad (12)$$

- **The constraints related to the transport**

The quantities $QTrv_{Tr,p}$ of products transported by trains in each trip cannot exceed the maximal capacity $QTMax_{Tr,p}$ that can support train (see the constraint 13).

$$QTrv_{Tr,p}^{j,t} \leq QTMax_{Tr,p} \qquad \forall\, t \in T,\ j \in J, p \in P \qquad (13)$$

The number of routes done in day j of the period t, cannot exceed the maximal capacity of daily transportation (see the constraint 14).

$$NTrv_{Tr}^{j,t} \leq NRMax_{Tr} \qquad \forall\, t \in T,\ j \in J, p \in P \qquad (14)$$

The same constraints presented above are applied in the case of transport by dump trucks (see the constraints 15 and 16).

$$NTrv_{Ca}^{j,t} \leq NRMax_{Ca} \qquad \forall\, t \in T,\ j \in J, p \in P \qquad (15)$$

$$QTrv_{Ca,p}^{j,t} \leq QTMax_{Ca,p} \qquad \forall\, t \in T,\ j \in J, p \in P \qquad (16)$$

We can recapitulate the model obtained as follow:

$$Min(z) = \sum_{t \in T} TC_p^t = = \sum_{t \in T} \sum_{j \in J} \sum_{p \in P} NTrv_{Tr}^{j,t} . QTrv_{Tr,p}^{j,t} . \mathrm{UTC}_{Tr,p}^{t} + \sum_{t \in T} \sum_{j \in J} \sum_{p \in P} \sum_{tp \in TP} NTrv_{Ca}^{j,t} . QTrv_{Ca,p}^{j,t} . \mathrm{UTC}_{Ca,p,tp}^{t} (1 - \alpha_j)$$

With constraints:

$$ST_{pr,p}^{j,t} - SafST_{pr,p} \leq M.\alpha_j \quad \text{and} \quad ST_{pr,p}^{j,t} - SafST_{pr,p} > 0 \qquad \forall\, t \in T,\ j \in J, p \in P$$

$$QT_p^{j,t} = \sum_{t \in T} \sum_{j \in J} \sum_{p \in P} NTrv_{Tr}^{j,t} . QTrv_{Tr,p}^{j,t} + \sum_{t \in T} \sum_{j \in J} \sum_{p \in P} NTrv_{Ca}^{j,t} . QTrv_{Ca,p}^{j,t} . (1 - \alpha_j) \quad \forall\, t \in T, j \in J, p \in P$$

$$SafST_{u,p} < ST_{u,p}^{j-1,t} + DPR_{u,p}^{j,t} - QT_p^{j,t} \leq STMax_{u,p} \qquad \forall\, t \in T, j \in J, p \in P$$

$$ST_{pr,p}^{j-1,t} + QT_p^{j,t} - DDM_{pr,p}^{j,t} \leq SMax_{pr,p} \qquad \forall\, t \in T, j \in J, p \in P$$

$$DPR_{e,p}^{j,t} \leq PRMax_{e,p} \qquad \forall\, t \in T, j \in J, p \in P,\ e \in E$$

$$\textstyle\sum_{j=1}^{J} DT_{e,p}^{j,t} = DMax_{e,p}^{t} \quad \text{and} \quad DDM_{e,p}^{j,t} \leq CapMax_{e,p} \qquad \forall\, t \in T, j \in J, p \in P,\ e \in E$$

$$\mathrm{UTC}_{Tr,p}^{t} = LC^t + MC^t + HCE_{Tr,p}^{t} \qquad \forall\, t \in T, p \in P$$

$$\mathrm{UTC}_{Ca,p,tp}^{t} = LC^t + MC^t + HCE_{Ca,p,tp}^{t} \qquad \forall\, t \in T, tp \in TP, p \in P$$

$$QTrv_{Tr,p}^{j,t} \leq QTMax_{Tr,p} \quad \text{and} \quad NTrv_{Tr}^{j,t} \leq NRMax_{Tr} \qquad \forall\, t \in T,\ j \in J, p \in P$$

$$QTrv_{Ca,p} \leq QTMax_{Ca,p} \quad \text{and} \quad NTrv_{Ca}^{j,t} \leq NRMax_{Ca} \qquad \forall\, t \in T,\ j \in J, p \in P$$

$$QTrv_{Tr,p}^{j,t}, QTrv_{Ca,p}, DPR_p^{j}, DDM_{e,p}^{j}, \mathrm{UTC}_{Ca,p,tp}^{t}, \mathrm{UTC}_{Ca,p,tp}^{t}, LC^t, MC^t, HCE_{Tr,p}^{t}, HCE_{Ca,p,tp}^{t} \in \mathbb{R}^+$$

$$NTrv_{Ca}^{j,t}, NTrv_{Tr}^{j,t} \in \mathbb{N}^+ \ \text{and} \ \alpha_j \in \{0,1\} \ \forall\, t \in T,\ j \in J, p \in P, e \in E$$

Starting by this global model, we can establish the specific models for each product in the supply chain studied during each planning period.

### 5.3 Checking, validating and executing model

For this part of the search methodology followed, we attempt to resolve this kind of difficult models using the appropriate resolving methods (branch and bound…). Actually, we are in the phase of implementing and validating of the code in a solver software. The results will be communicated in a future work.

## 6. Conclusion

In this study, we defined the supply chain, also we conducted a basic search to develop a planning model, specifically an integrated planning budgeting model, in order to optimize the transportation costs of the various products routed between entities of a reel supply chain. To do that we directed a review of the literature on the modelling supply chain approaches and we based on this study on a case study of a companies operating in phosphate field.

In this paper, we followed a structed methodology and the result is a model that defined the transportation cost of various products by different ways between entities in a supply chain. It is a global model, that defined the specific models for each product during each planning period.

This model is a Mixed Integer Programming, it belongs to NP complete problems. To solve this program, we will use the exact method "branch and bound" in a solver software. The results will be published in our future papers.

In our future work, we suggest to develop a global budgeting model for all entities in the supply chain studied. We also suggest to couple our model to a simulation models for a better understanding of this type of problems.

## References

Arntzen, B.C, Brown, G.G, Harrison, T.P, Trafton, L.L., Global supply chain management at Digital Equipment Corporation, Interfaces, vol. 25, pp. 69-93, 1995.

Azougagh, Y., Benhida, K., and Elfezazi, S., Contribution to the modelling and analysis of logistics system performance by Petri nets and simulation models: Application in a supply chain, the proceeding of IOP Conf. Series: Materials Science and Engineering Vol. 114, no. 1, 2016.

Baldwin L.P., Eldabi T., Paul R.J., Simulation in healthcare management: a soft approach, Simulation Modelling Practice and Theory, Vol. 12, pp. 541–557, 2004.

Benhida, K., Azougagh, Y., and Elfezazi, S., Modelling flows in supply chain with analytical models: Case of a chemical industry, the proceeding of IOP Conf. Series: Materials Science and Engineering Vol. 114, no. 1, 2016.

Bok, J.W. Grossmann, I.E et Park, S. Supply chain optimization in continuous flexible process networks. Industrial and Engineering Chemistry Research, vol. 39, pp. 1279–1290, 2000.

Christopher, M., Logistics and supply chain management: creating value-added networks, Pearson education, 2005.

Council of Logistics Management, http://www.clm1.org/mission.html, 12 Feb 98.

Ellram, L. M., and Cooper, M. C.: The Relationship Between Supply Chain Management and Keiretsu. The International Journal of Logistics Management, vol. 4, no. 1, pp. 1–12, 1993.

Guillen, G. Badell, M and Puigjaner, L. A holistic framework for short-term supply chain management integrating production and corporate financial planning. International Journal of Production Economics, vol. 106, pp. 288–306, 2007.

Guillen, G. Badell, M. Espuna, A et Puigjaner, L. Simultaneous optimization of process operations and financial decisions to enhance the integrated planning/scheduling of chemical supply chains. Computers and Chemical Engineering, vol. 30, pp. 421–436, 2006.

Guillen, G. Bagajewicz, M. Sequeira, S.E t. Espuna, A et Puigjaner, L. Management of pricing policies and financial risk as a key element for short term scheduling optimization. Industrial and Engineering Chemistry Research, vol. 44, pp 557–575, 2005a.

Guillen, G. Mele, F. Bagajewicz, M., Espuna, A et Puigjaner, L. Multiobjective supply chain design under uncertainty. Chemical Engineering Science, vol. 60, pp. 1535–1553, 2005b.

Guillen, G. Pina, C. Espuna, A et Puigjaner, L. Optimal offer proposal policy in an integrated supply chain management environment. Industrial and Engineering Chemistry Research, vol. 44, pp. 7405–7419, 2005c.

Gunasekaran, A., and Kobu, B., Performance measurements and metrics in logistics and supply chain management: a review of recent literature for research and applications, International Journal of Production Research, vol. 45, pp. 2819-2840, 2007.

Imen, S.,et al., Planification séquentielle tactique-opérationnelle d'une chaîne logistique textile, Proceedings de la 9 ième Conférence Internationale de Génie Industriel, France, 2011.

Jayaraman, V., Pirkul, H., Planning and coordination of production and distribution facilities for multiple commodities, European Journal of Operational Research, vol. 133, pp. 394-408, 2001.

Kleijnen, J.P.C., Supply chain simulation tools and techniques: a survey, International Journal of Simulation & Process Modelling, Vol. 1, pp.82-89, 2005.

Labarthe, O., Modélisation et simulation orientées agents de chaînes logistiques dans un contexte de personnalisation de masse : modèles et cadre méthodologique, Thèse de doctorat, Université Laval Québec et Université Paul Cézanne Marseille, 2006.

Lauras M., Méthodes de diagnostic et d'évaluation de performance pour la gestion de chaînes logistiques : application à une filiale internationale dans un groupe pharmaceutique et cosmétique, Thèse de doctorat, L'institut National Polytechnique de Toulouse, 2004.

Law A.M., McComas M.G., How to build valid and credible simulation models, Proceedings of the Winter Simulation Conference, pp. 22-29, 2001.

Lee, Y.H., Kim, S.H., Production-distribution planning in supply chain considering capacity constraints, Computers and Industrial Engineering, vol. 43, pp.169-190, 2002.

Matta, R.D. and Miller, T., Production and inter-facility transportation scheduling for a process industry, European Journal of Operational Research, pp. 158, 2004.

Min, H and Zhou, G., Supply chain modeling: past, present and future, Computers & Industrial Engineering, vol. 43, pp. 231-249, 2002.

Mocellin F., Gestion des entrepôts et plates-formes, Dunod, France, 2006.

Olivier, C. et Létourneau, J., Modélisation du flux patient entre deux urgences, Proceedings de la 10 ième Conférence Internationale de Génie Industriel, La Rochelle, France 13 juin 2013.

Ozdamar, L. and Yazgac, T., A Hierarchical Planning Approach for a Production-Distribution System, International Journal of Production Research, vol. 37, pp. 3759 – 3772, 1999.

Pidd, M., Just modelling through: a rough guide to modelling. Interfaces, 1999.

Rizk, N., Martel, A., D'amours, S., Synchronized production distribution planning in a single-plant multi-destination network, Journal of the Operational Research Society, vol. 59, pp. 90-104, 2008.

Stevens, G., Integration of the Supply Chain, International Journal of Physical Distribution and Logistics Management, vol. 19, no. 28, pp 3–8, 1989.

Su S., Shih C.L., Modeling an emergency medical services system using computer simulation, International Journal of Modeling Information, Vol. 72, pp. 57-72, 2003.

Towill, D. R., Naim, M. M., and Wikner, J., Industrial Dynamics Simulation Models in the Design of Supply Chains, International Journal of Physical Distribution and Logistics Management, vol. 22, no. 5, pp. 3–13, 1992.

Tsiakis, P. Shah, N et Pantelides, C.C. Design of multiechelon supply chain networks under demand uncertainty. Industrial and Engineering Chemistry Research, vol. 40, pp. 3585–3604, 2001.

## Biography

**Azougagh Yassine** is a PHD student in the doctoral study center of the Faculty of Science and Technology, Cadi Ayyad University, Marrakech, Morocco. He is an Industrial Engineer, His research areas of interest are logistics, supply chain, modelling supply chain approaches, optimization supply chain approaches. He has about one year of teaching experience. Also, is a member of the Research Laboratory in Process, Signals, Industrials Systems and Computing.

**Benhida Khalid** is a Professor at Higher School of Technology, Cadi Ayyad University, Marrakech, Morocco, and Director of Licence of Metrology, Quality, Safety, Environment Engineering. His is a member of the Research Laboratory in Process, Signals, Industrials Systems and Computing. His research interests include supply chain modeling, project management, electronics, product and eco design. Also, before joining the field of education, he was responsible for the development of industrial projects in a multinational company in France. Mr. Benhida holds a PhD of Science degree in Electronics Engineering from a French University and State Doctorate in industrial engineering and electronics from Cadi Ayyad University.

**Elfezazi Said** is a Professor at Higher School of Technology, Cadi Ayyad University, Marrakech, Morocco, and Director of Department of Instrumental Technique and Quality Management. His is a member of the Research Laboratory in Process, Signals, Industrials Systems and Computing. His research interests include supply chain management, Lean Six Sigma, production and operation management. Mr. Elfezazi holds a PhD of Science degree in industrial Engineering.