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A study on financial aspect of supply chain management

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ABSTRACT : *The more common approaches used in the SCM consider only the physical logistic operations and ignore the financial aspects of the supply chain. The main objective to incorporate financial aspects in supply chain management is to strengthen managerial decisions concerning financial flows in supply chains, while empirical knowledge about financial supply chain management (FSCM) is in its early stages. This paper presents a model for FSCM which financial planning in addition to operation planning is decided in it. The main contribution of this paper is to define two approaches for Financial Supply Chain Management and to compare them. This financial approaches are: Traditional financial approach and new financial approach. Traditional financial approach integrates physical goods flows and financial flows. New financial approach considers in making decisions other financial indicators such as market to book value, liquidity ratios, capital structure ratios, and return on equity, sales margin, turnover ratios and stock security ratios, among others. Moreover, the new approach applies the change in equity instead of the traditional approach measures of profit as the objective function to be maximized in the presented model. To show the attributes of the presented approaches, the results of the new approach and the traditional approach is compared. The findings indicate that the traditional approach leads to lower change in equity compared to the financial approach. Also, the results clearly reveal the better improvement of using the new approach over the traditional approach, and convince the decision makers to take advantage of the new approach.*

KEYWORDS: *supply chain management; financial supply chain management; traditional financial approach; new financial approach*

I. INTRODUCTION

The field of supply chain management(SCM) concerns itself with the collaboration and coordination of several stakeholders to optimize the flow of goods, information, and finance along the entire supply chain 1. While firms often collaboratively manage flows of goods and information with their supply chain partners, they do not do so when it comes to cash flows. In SCM the financial flow exists as well as the physical product flow in an inverse direction. Financial operations are supplementary to the physical product flow and ensure financing of logistic operations. However, optimizing the physical product flow is one of the most important key for each company to be successful in the competitive market. There are various studies which are covered this section. Some of the recent studies which is covered most of the realistic constraints is presented by Jafarzadeh et al. 2 and Margolisa et al. 3. Both of them provide efficient models which can achieve a solution close to global optimal one and can guarantee the maximum amount of overall profit, because they take into account all realistic aspects. Jafarzadeh et al. 2 investigate the multi-objective no-wait two stage flexible flow shop problem with considering sequence related setup time for each job, probable rework, ready times for all jobs and rework times in both stations as well as non-uniform machinery constraints and simultaneous consideration of minimization of maximum job completion time and average lateness time objective functions. Margolisa et al. 3 present a multi-objective network design model and accompanying optimization-based decision support methodology for supply chain architects. Their model determines (i) production capacities for each commodity's supply nodes, (ii) flow capacities for each arc in the network, and (iii) an operational plan that determines production quantities and locations as well as flow routing for each commodity. Their methodology helps to evaluate the trade-off between total network cost minimization and maximizing overall supply chain network connectivity.

While there are very powerful studies in the optimizing the physical product flow such as provided instances and many others, there are lack of studies investigating financial operations and physical product flow. For supply chain developments, more than 15% of firms already engage in advanced methods of managing financial flows along their supply chains. These methods are considered to be financial supply chain management, which is defined as optimized planning, managing, and controlling of supply chain cash flows to facilitate efficient supply chain material flows. FSCM thus requires the interaction of financial managers and supply chain managers with in the company, a well as collaboration beyond the borders of the firm withservice providers (e.g.banks), suppliers, and customers 4. Now some companies such as Intel, General Electric, and Deutz have considered the financial aspects and have integrated financial and physical flows 5. Intel asserts integration of physical goods flows and financial issues through a clear system of information. GE improves their accounts payable 12% by an electronic invoice system, which helps the company to forecast cash flow requirements. Moreover, Deutz, a German motor manufacturer, addresses the financial flows, and optimizes their inventory levels along with accounts payable, receivable, and payment delays. On the other hand as pointed out by Shapiro 6, the financial considerations is one of the most significant issues in SCM. However, the literature integrating financial flows with physical product flows in the SCM, especially in the CLSC area, remains scare 7. Moreover, researchers usually take into account the financial aspects as financial factors (i.e. return rates of investment, taxes, exchange rates, transfer prices, and local content rules), while few studies address financial flows as asset-liability management with a holistic framework.

In this regard, this paper presents a mathematical model to design a financial supply chain with two approaches, traditional and new financial approach. This model considers financial aspects as incorporating the balance sheet (i.e. current and fixed assets and liabilities) and a set of budgetary constraints representing balances of cash, debt, securities, payment delays, discounts, and so forth. In fact, the objective of the present paper is to maximize the change in equity instead of the traditional measure of profit. Moreover the model considers three echelons in the forward direction (i.e. echelons constituted by the flow arcs among the entities of suppliers, plants, distribution centers, and customers) and three echelons in the backward direction (i.e. echelons constituted by the flow arcs among the entities of customers, collection centers, repair centers, and disposal centers).

Briefly, this study proposes a multi-echelon and multi-period model and integrates the both decisions (strategic and tactical) and approaches (traditional and new approaches) in a holistic framework. The remainder of the paper is structured as follows: Section 2 reviews the existing financial studies in SCM, and then addresses the FSCM practices to extend the scope to the entire supply chain of the firm. Model assumptions and limitations are described in Section 3. We present the mathematical model for design a financial supply chain in Section 4. Section 5 presents FSCM approaches and explains the traditional approach versus the new approach. Section 6 illustrates a numerical example and discusses the computational results. Finally, we report the conclusions of this paper in Section 7.

II. LITERATURE REVIEW

Despite the importance of financial aspects in SCM, few researchers have addressed the financial considerations in the literature. Moreover, the majority of these studies consider the financial aspects as endogenous variables, and only very few studies consider these aspects as exogenous variables used in constraints and in the objective function. In the following, we review the studies regarding the financial aspects in the SCM context. Wang et al. 8 address a facility location problem with budget constraints, where three heuristic approaches, i.e. Greedy algorithm, Lagrangian relaxations, and Tabu search, are presented to solve the problem. Badell et al. 9 address a financial and operating scheduling/planning modeling framework, simulating the output of MRP models and cash flows; the latter was to substitute the delayed information of accounting systems. The main contribution of this paper is incorporation of the joint integration of enterprise finance with the company operations' model to improve overall earnings and reach stock-holder-oriented objectives. Guillén at al. 10 presented a mathematical model which simultaneously optimizes the activities of operation and finance. The purpose of the present paper is to introduce budgetary considerations into a basic SC model in which the change in equity to be optimized in the integrated model. Puigjaner and Guillén-Goslbez 11 address supply chain optimization at the operation level in a multi-agent framework. From the viewpoint of financial issues, the paper considers the investment, interest rate, the accounts receivable, payments, cash, and debt in the presented model. Hammami, Frein and Hadj-Alouane 12 presented a strategic–tactical model for design of a supply chain network in the delocalization context with the financial decisions, i.e. transfer pricing and transportation costs allocation. A solution approach based on Lagrangian relaxation is adapted to solve the proposed model. Lainez, Puigjaner and Reklaitis 5 presented a model with a focus on the process operations and the product development pipeline management (PDPM) problem in which financial aspects, i.e. tax rate, debts, working capital, the accounts payable, and the accounts receivable are also considered. Sodhi and Tang 13 extended the existing modeling by regarding the financial considerations through asset-liability management (ALM).

This study surveys the different modeling and solution approaches of ALM problem and investigates the place of ALM problem in supply chain planning. Protopappa-Sieke and Seifert 13 presented a model which decides on the optimal purchasing order quantity with respect to the capital constraints and payment delays. The results show the importance of payment delays and also demonstrate the impact of capital on the total operational cost, the return on capital investment, and the total financial cost. Longinidis and Georgiadis 14 proposed a model for design of a supply chain network. The paper extends the existing models in the literature by incorporating the financial issues as financial ratios and considering the demand uncertainty as scenario analysis. Moussawi-Haidar and Jaber 15 considered the problem of finding the optimal operational (how much to order and when to pay the supplier) and financial decisions (maximum cash level and loan amount) by integrating the cash management and inventory lot sizing problems. They presented the problem as a nonlinear program and proposed a solution procedure for finding the optimal solution. To review the financial studies in supply chain and to specify the distinctiveness of this paper from others in the literature, we categorize the models in accordance with context, general features, financial features and goals as well as some descriptions. As presented in Table 1, most researchers address Receive-Payment planning in supply chain. In contrast, few researchers consider other areas of financial in their work.

Table 1: Review of the financial studies in supply chain

Ref.	**Context**	**General features**				**Financial features**				**Goals**	
		Period		***Product***		***Budget***	***Exchange, interest rate***	***Receive Payment planning***	***Financing (Loan, Cash, …)***	***Profit /Cost***	***Change in equity***
		Single	***Multiple***	***Single***	***Multiple***						
8	Facility location	*		*		*				*	
9	Planning and scheduling		*	*				*	*	*	
10	Production planning		*	*			*	*	*		*
11	Operational planning		*		*		*	*	*		*
5	Inventory management		*		*			*		*	
13	Inventory planning		*		*	*	*		*	*	
16	Inventory control		*	*		*		*		*	
6	Supply chain Design (forward)		*		*		*			*	
4	Financial supply chain management		*		*		*	*	*	*	
17	Closed-loop supply chain design		*	*			*	*	*		*

In this regard, Financial Supply Chain Management (FSCM) requires the interaction of financial managers and supply chain managers within the company, as well as collaboration beyond the borders of the firm with service providers (e.g. Banks), suppliers, and customers. As opposed to traditional financial flow management, which typically follows the rationale of optimizing the cash flow of a single firm, FSCM extends the scope to the entire supply chain of the firm [4]. Typical methods of FSCM are summarized in Table 2.

Table 2: FSCM practices

Practice	Explanation
Buyer credit	Term financing providedto finance suppliers (e.g.advance payments or deposits)
Inventory/work-in-progress financing Reverse factoring	Buyer provides loan to supplier to finance workin progress The supplier obtains a credit from a bank and pays the interest according to the buyer's interestrate.The buyer pays the loan principal to payment terms
Supply chain finance	An automated solution that enables buying firms to use reverse factoring with their entire supplier base, often providing flexibilityand transparency ofthe payment process
Electronic platforms	Systems offered by third parties to electronically connect trading partners with financial institutions to automate payment processes
Letters of credit	**Afinancial** institution provides guarantee to exporters by replacing the importer's risk with its own default risk
Bank loanfor financing thesupplychain	Short-term or medium-term financing provided from a bank involving working capital and pre-export finance

The purpose of this study is to maximize the change in equity with respect to constraints of balance and capacity in both physical product flows and financial flows. To show the proposed model with its details, we present the formulation of supply chain network in the following section.

Research model assumptions and limitations : In research model, concerning physical goods flows, in the forward direction the suppliers are responsible for providing the raw material to manufacturing facilities. The products are shipped from plants to customers via distribution centers to satisfy the customer’s demand. In the backward direction, the returned products from customers are shipped to collection centers for testing and inspection. After testing the products in collection centers, the remanufactured products are shipped to the plants, the repairable products are shipped to the repair centers, and the disposable products are shipped to the disposal centers. Taking advantage of this strategy, excessive transportation of the returned products is reduced, and the returned products are directly transferred to the relevant facilities. In addition after repairing the products in repair centers and remanufacturing in the plants, the returned products are shipped to distribution centers.

The proposed model in this paper considers the following assumptions and limitations:
- The model is single-product.
- The model is multi-period.
- The locations of suppliers, customer zones, and disposal centers are known and fixed.
- The potential locations of plants, distribution centers, collection centers and repair centers are known.
- The flow is only permitted to be shipped between two consecutive stages.
- The capacities of facilities are restricted.
- The quantities of all parameters are deterministic.
- The return rate for each customer depends on the customer demand.

Concerning FSCM issues, the components of the balance sheet including current and fixed assets and liabilities are considered in the model. The model decides about financial planning (i.e. cash, debt, securities, payment delays, discounts, and so forth) and financing source (i.e. cash, loan, and pledging) with regard to the relevant costs. Under an agreement to achieve an open line of credit, the bank imposes minimum cash due to the compensating balance, and also restricts the maximum allowable debt which the firm has borrowed from the bank. Further, it is assumed that the accounts payable associated with raw material, production, handling may stretch or delay in time periods. Discounts for prompt payment can be obtained if purchases are paid in time and cannot be taken if the payments are stretched.

Notation

Set

S	Set of suppliers
P	Set of plants
D	Set of distribution centers
C	Set of customers
E	Set of collection centers
R	Set of repair centers
L	Set of disposal centers
T	Set of time periods

Parameters

Transportation cost per unit of returned product shipped from customer c to collection center e in period t

Transportation cost per unit of product shipped from distribution center d to customer c in period t

$Demand_{ct}$	Demand of customer c in period t
Dis_{lt}	Disposal cost per unit at disposal center l in period t
Div_t	Dividends in period t
EC_{et}	Fixed cost of establishing collection center e in period t
ED_{dt}	Fixed cost of establishing distribution center d in period t

Transportation cost per unit of returned product shipped from collection center e to disposal center l in period t

Transportation cost per unit of returned product shipped from collection center e to plant p in period t

EP_{pt}	Fixed cost of establishing plant p in period t

Transportation cost per unit of returned product shipped from collection center e to repair center r in period t

ER_{rt}	Fixed cost of establishing repair center r in period t
Hop_{pt}	Holding cost per unit at store of plant p in period t
Ins_{et}	Inspection and collection cost per unit at collection center e in period t
ir	Interest rate
Mat_{st}	Material cost per unit purchased from supplier s in period t
$MaxCrd$	Maximum debt allowed from bank
$MinCash$	Minimum cash imposed from bank
Ope_{dt}	Operating cost per unit at distribution center d in period t
$Others_t$	Other net cash obtained in period t
PDC_{pdt}	Transportation cost per unit of product shipped from plant p to distribution center d in period t
$Price_{ct}$	Price per unit for customer c in period t
Pro_{pt}	Production cost per unit at plant p in period t

Transportation cost per unit of returned product shipped from repair center r to distribution center d in period t

Rem_{pt}	Reproduction cost per unit at plant p in period t
Rep_{rt}	Repair cost per unit at repair center r in period t
SPC_{spt}	Transportation cost per unit of material shipped from supplier s to plant p in period t
Scu_t	Marketable securities of initial portfolio maturing in period t

Technical discount coefficient relevant to the payment of material costs executed in period t incurred in period $\acute{t}$

Technical discount coefficient relevant to the payment of production/reproduction costs executed in period t incurred in period $\acute{t}$

Technical discount coefficient relevant to the payment of handling costs executed in period t incurred in period $\acute{t}$

Technical discount coefficient relevant to the payment of transportation costs executed in period t incurred in period $\acute{t}$

η	Percentage that accounts receivable pledged corresponding to this value
$\lambda_{t\acute{t}}$	Technical coefficient related to sale of marketable securities
$\mu_{t\acute{t}}$	Technical coefficient related to investment of marketable securities

Decision Variables

CEQ_{cet}	Quantity of returned product shipped from customer c to collection center e in period t
$CScu_{t\acute{t}}$	Total marketable securities sold in period t maturing in period $\acute{t}$

$Cash_t$	Cash in period t
$CrdCash_t$	Net cash obtained by money borrowed or repaid to the credit line in period t
$Crdline_t$	Debt in period t
DCQ_{dct}	Quantity of product shipped from distribution center d to customer c in period t
ELQ_{elt}	Quantity of returned product shipped from collection center e to disposal center l in period t
EPQ_{ept}	Quantity of returned product shipped from collection center e to plant p in period t
ERQ_{ert}	Quantity of returned product shipped from collection center e to repair center r in period t
$ExnCash_t$	Exogenous cash in period t
$FExpns_t$	Expense of establishing facilities in period t
$HExpns_t$	Expense of handling product in facilities in period t
	Payment for total costs of handling product in facilities executed in period t for accounts payable incurred in period t
$IExpns_t$	Expense of holding inventory in stores in period t
IPQ_{pdt}	Quantity of product shipped from store of plant p to distribution center d in period t
$IScu_{tt}$	Total cash obtained in period t by the marketable securities invested in period t
$Loan_t$	Amount of cash borrowed to credit line in period t
$MExpns_t$	Expense of material in period t
$MPay_{tt}$	Payment for total costs of material executed in period t for accounts payable incurred in period t
PDQ_{pdt}	Quantity of product shipped from plant p to distribution center d in period t
$PExpns_t$	Expense of production/reproduction in period t
PPQ_{pt}	Quantity of product shipped from plant p to its store in period t
	Payment for total costs of production/reproduction executed in period t for accounts payable incurred in period t
Plg_{tt}	Amount of accounts receivable pledged within period t incurred in period t
$Profit$	Profit of enterprise
RDQ_{rdt}	Quantity of returned product shipped from repair center r to distribution center d in period t
RIP_{pt}	Residual inventory at store of plant p in period t
Rec_t	Account receivable in period t
$Repay_t$	Amount of cash repaid to credit line in period t
SPQ_{spt}	Quantity of material shipped from supplier s to plant p in period t
$ScuCash_t$	Net cash received or paid in securities transactions in period t
$TExpns_t$	Expense of transportation in period t
	Payment for total costs of transportation executed in period t for accounts payable incurred in period t
ΔE	Change in equity of enterprise
ΔLA	Change in long-term assets of enterprise
ΔLL	Change in long-term liabilities of enterprise
ΔSA	Change in short-term assets of enterprise
ΔSL	Change in short-term liabilities of enterprise

Binary Variables

$$W_{pt} = \begin{cases} 1 & \text{if plant p is established in period t,} \\ 0 & \text{otherwise;} \end{cases}$$

$$Y_{dt} = \begin{cases} 1 & \text{if distribution center d is established in period t,} \\ 0 & \text{otherwise;} \end{cases}$$

$$Z_{et} = \begin{cases} 1 & \text{if collection center e is established in period t,} \\ 0 & \text{otherwise;} \end{cases}$$

$$V_{rt} = \begin{cases} 1 & \text{if repair center r is established in period t,} \\ 0 & \text{otherwise;} \end{cases}$$

III. MODEL FORMULATION

The constraints of the model are involved integration logistical constraints relevant to the goods flows and the financial constraints relevant to the financial flows. Logistical constraints insure the balance of good flows and the capacity of facilities with financial flows. Model constraints indicate to two different financial approaches included traditional approach and new approach.

$$Cash_t = Cash_{t-1} + ExnCash_t + CrdCash_t + ScuCash_t - \sum_{t \lesssim t} MPay_{tt} - \sum_{t \lesssim t} PPay_{tt} - \sum_{t \lesssim t} HPay_{tt} - \sum_{t \lesssim t} TPay_{tt} - Div_t + Others_t \quad \forall t, \quad (1)$$

Eq. (1) states that the cash in each period is computed based on the cash in the previous period ($Cash_{t-1}$), the exogenous cash derived from the sales of products, the fixed assets, and the pledging of accounts receivables ($ExnCash_t$), net cash obtained by money borrowed or repaid to the credit line ($CrdCash_t$), net cash received or paid in securities transactions ($ScuCash_t$), the payment for costs of material, production/reproduction, handling, and transportation executed in period t for accounts payable incurred in the previous periods ($MPay_{tt}$, $PPay_{tt}$, $HPay_{tt}$, $TPay_{tt}$), the dividends (Div_t), and net cash resulted from any other source ($Others_t$).

$$ExnCash_t = Rec_{t-t_{del}} - \sum_{t-t_{del} \le t < t} Plg_{t-t_{del}t} + \sum_{t-t_{del} < t \le t} \eta . Plg_{tt} \quad \forall t, \quad (2)$$

$$\sum_{t \le t \le t+t_{del}} Plg_{tt} \le Rec_t \quad \forall t, \quad (3)$$

Eq. (2) shows that the exogenous cash in each period is equal to the sum of the accounts receivable belonged to period of $t - t_{del}$ matured in period t, minus the total amount of the accounts receivable pledged within period $t - t_{del}$ to $t - 1$belonged to periods $t - t_{del}$, plus the cash derived from pledging accounts receivable belonged to periods $t - t_{del}$ +1 to t matured in period t. A financing source is obtained from transferring accounts receivable from the previous creditor (assignor) to a new creditor (assignee), named pledging in the finance. Pledging is a very expensive way of financing that will only be applied when no more credit can be obtained from the bank. If the future accounts receivable is pledged, only a part of total receivables, usually 80%, is matured in the same period. Thus, Eq. (3) states that the total amount of accounts receivable belonged to periods t pledged within period t to t $t + t_{del} - 1$ cannot exceed the amount of accounts receivable in period t.
Here, it is assumed that all accounts receivable have equal period of maturing (t_{del}), although this assumption can be easily adjusted to new situations.

$$Crdline_t = Crdline_{t-1} + Loan_t - Repay_t + ir.Crdline_{t-1} \quad \forall t, \quad (4)$$

$$CrdCash_t = Loan_t - Repay_t \quad \forall t, \quad (5)$$

Eq. (4) states that the total debt in each period is a function of the debt in the previous period, the cash borrowed to credit line, the cash repaid to credit line, and the interest costs, where Net cash obtained by money borrowed or repaid to the credit line ($CrdCash_t$) is defined as Eq. (5).

$$Crdline_t \le MaxCrd, \quad \forall t, \quad (6)$$

$$Cash_t \ge MinCash, \quad \forall t, \quad (7)$$

In addition to pledging, the loan borrowed from bank is another financing source, obtained at the beginning of period with annual interest rate (ir) under an agreement with the bank. In this case, the bank imposes firm to have a minimum cash ($MinCash$), usually as percentage of the amount borrowed, and also restricts firm to an open line of credit ($MaxCrd$). The Eq. (6) and Eq. (7) show the minimum cash and the maximum credit agreed with the bank.

$$ScuCash_t = Scu_t - \sum_{t > t} IScu_{tt} + \sum_{t > t} CScu_{tt} + \sum_{t < t} IScu_{tt} . (1 + \mu_{tt}) - \sum_{t < t} CScu_{tt} . (1 + \lambda_{tt}), \quad \forall t, \quad (8)$$

$$\sum_{t < t} CScu_{tt} . (1 + \lambda_{tt}) \le Scu_t + \sum_{t < t} IScu_{tt} . (1 + \mu_{tt}), \quad \forall t, \quad (9)$$

Eq. (8) shows that, in each period, the cash relevant to the securities transactions is computed as sum of the cash derived from the marketable securities of initial portfolio, minus the cash invested as the marketable securities in the current period, plus the cash resulted from the sale of the marketable securities in the current period, plus total cash obtained in the current period by the marketable securities invested in previous periods with regard to the technical coefficient of investment (μ_{tt}), and minus the total marketable securities sold in previous periods maturing in the current period with regard to the technical coefficient of sale (λ_{tt}). Eq. (9) states that, in each period, the total marketable securities sold in previous periods maturing in the current period cannot exceed sum of the cash derived in the current period from the marketable securities of initial portfolio and the total cash obtained in the current period by the marketable securities invested in the previous periods.

$$\sum_{\acute{t} \geq t} \alpha_{\acute{t}t} \, . MPay_{\acute{t}t} \leq MExpns_t, \qquad \forall t, \qquad (10)$$

$$\sum_{\acute{t} \geq t} \beta_{\acute{t}t} \, . PPay_{\acute{t}t} \leq PExpns_t, \qquad \forall t, \qquad (11)$$

$$\sum_{\acute{t} \geq t} \gamma_{\acute{t}t} \, . HPay_{\acute{t}t} \leq HExpns_t, \qquad \forall t, \qquad (12)$$

$$\sum_{\acute{t} \geq t} \rho_{\acute{t}t} \, . TPay_{\acute{t}t} \leq TExpns_t, \qquad \forall t, \qquad (13)$$

Eqs. (10)–(13) show the payments associated with raw material, production, handling, and transportation with regard to the relevant expenses. Since, it is possible that the accounts payable are delayed or paid in same time, the model try to excite payers through the terms of $2\% - 1$ time period, net-3 time periods, where technical coefficients ($\alpha_{\acute{t}t}, \beta_{\acute{t}t}, \gamma_{\acute{t}t}$ and $\rho_{\acute{t}t}$) are introduced in the formulation to verify the relevant term. Thus, it is assumed that the discount can be obtained if the payments are performed timely, otherwise the discount cannot be acquired to payers.

$$MExpns_t = \sum_s \sum_p SPQ_{spt} \, . Mat_{st}, \qquad \forall t, \qquad (14)$$

$$PExpns_t = \sum_p \sum_d PDQ_{pdt} \, . Pro_{pt} + \sum_p PPQ_{pt} \, . Pro_{pt} + \sum_e \sum_p EPQ_{ept} \, . Rem_{pt}, \qquad \forall t, \qquad (15)$$

$$HExpns_t = \sum_d \sum_c DCQ_{dct} \, . Ope_{dt} + \sum_c \sum_e CEQ_{cet} \, . Ins_{et} + \sum_r \sum_d RDQ_{rdt} \, . Rep_{rt} + \sum_e \sum_l ELQ_{elt} \, . Dis_{lt}, \qquad \forall t, \qquad (16)$$

$$TExpns_t = \sum_s \sum_p SPQ_{spt} \, . SPC_{spt} + \sum_p \sum_d (PDQ_{pdt} \, . IPQ_{pdt}) . PDC_{pdt} + \sum_d \sum_c DCQ_{dct} \, . DCC_{dct} + \sum_c \sum_e CEQ_{cet} \, . CEC_{cet} + \sum_e \sum_r ERQ_{ert} \, . ERC_{ert} + \sum_e \sum_p EPQ_{ept} \, . EPC_{ept} + \sum_e \sum_l ELQ_{elt} \, . ELC_{elt} + \sum_r \sum_d RDQ_{rdt} \, . RDC_{rdt}, \quad \forall t, \qquad (17)$$

$$FExpns_t = \sum_p (W_{pt} - W_{p(t-1)}) . EP_{pt} + \sum_d (Y_{dt} - Y_{d(t-1)}) . ED_{dt} + \sum_e (Z_{et} - Z_{e(t-1)}) . EC_{et} + \sum_r (V_{rt} - V_{r(t-1)}) . ER_{rt}, \quad \forall t, \qquad (18)$$

$$IExpns_t = \sum_p RIP_{pt} \, . Hop_{pt}, \qquad \forall t, \qquad (19)$$

To determine the outflows of the cash required to compute the profit and the equity, the expense of material, production/reproduction, handling, transportation, establishing facilities, and holding inventory are defined as Eqs. (14)–(19), respectively. These expenses relate to the accounts payable through Eqs. (10)–(13).

$$Rec_t = \sum_p Demand_{ct} \, . Price_{ct}, \qquad \forall t, \qquad (20)$$

Eq. (20) shows that, in each period, the accounts receivable is defined as the sale of final products to the customers in the same period.

$$Profit = \sum_{c}\sum_{t} Demand_{ct} . Price_{ct} - \sum_{t} MExpns_t - \sum_{t} PExpns_t - \sum_{t} HExpns_t - \sum_{t} TExpns_t - \sum_{t} FExpns_t - \sum_{t} IExpns_t \qquad (21)$$

Moreover Eq. (21) states that the resulted profit is equal to the total revenue from the sale of products minus the total costs including material, production/reproduction, handling, transportation, establishment, and inventory holding.

$$\Delta E = \Delta SA + \Delta LA - \Delta SL - \Delta LL, \qquad (22)$$

$$\Delta SA = Cash_T + \sum_{T-t<t_{del}} Rec_t - \sum_{T-t\leq t_{del} \wedge t>T-t_{del}} Plg_{tt} + \sum_{p} RIP_{pT} . Pro_{pT} - Cash_{t_0} - Rec_{t_0} - \sum_{p} RIP_{pt_0} . Pro_{pt_0} \qquad (23)$$

$$\Delta LA = FExpns_T - FExpns_{t_0} \qquad (24)$$

$$\Delta SL = Crdline_T + \sum_{t} MExpns_t + \sum_{t} PExpns_t + \sum_{t} HExpns_t + \sum_{t} TExpns_t - \sum_{tt} \alpha_{tt} . MPay_{tt} - \sum_{tt} \beta_{tt} . PPay_{tt} - \sum_{tt} \gamma_{tt} . HPay_{tt} - \sum_{tt} \rho_{tt} . TPay_{tt} - Crdline_{t_0} \qquad (25)$$

$$\Delta LL = Loan_T - Loan_{t_0} \qquad (26)$$

Eq. (22) states that the change in equity is equal to the total change in short-term assets and the change in long-term assets minus the total change in short-term liabilities and the change in long-term liabilities. The change in short-term assets is equal to the difference between the short-term assets (including the cash available, the accounts receivable, and the inventory) at the end of first period and last period as Eq. (23). In this equation, the inventory value is computed based on the generally accepted accounting principles (GAAP) of historic cost, i.e. the lowest price that is production price. Eq. (24) shows the change in long-term assets as the sum of expenses of establishment at the end of last period minus the expenses of establishment at the end of the first period. The Eq. (25) states that the change in short-term liabilities is equal to the difference between the short-term liabilities including the debts and the accounts payable related to the material, production/reproduction, handling, and transportation at the end of the first period and the last period. The Eq. (26) shows change in long-term liabilities of enterprise is equal to the sum of cash borrowed to credit line at the end of last period minus the cash borrowed to credit line at the end of the first period.

IV. FINANCIAL SUPPLY CHAIN MANAGEMENT (FSCM) APPROACHES

In this article approaches for FSCM included Traditional approach and New approach.

- **Traditional approach:** Traditional financial approach integrates physical goods flows and financial flows. The more common objectives traditionally used in the literature is maximization of the profit or minimization of the cost. Traditional approach in supply chain measures performance improvement through measurement of profit or cost. Hence in this paper traditional approach considers the maximization of the profit as its objective that could be formulated as follows:
Maximize Profit
Subject to Eqs. (14)-(21)

- **New approach :** New financial approach considers in making decisions taking into account other financial indicators such as market to book value, liquidity ratios, capital structure ratios, and return on equity, sales margin, turnover ratios and stock security ratios, among others. Nevertheless, the direct enhancement of the shareholder's value (SHV) in the firm seems to be today's priority. This can be improved by maximizing the change in equity of the company (ΔE). Hence in this paper new approach considers the maximization of change in equity of the company (ΔE) as its objective that could be formulated as follows:

Maximize change in equity
Subject to Eqs. (1)-(20), (22)-(26)
These financial approaches apply integrated model with mixed-integer-linear programming (MILP) formulation, which financial planning in addition to design and operation planning is decided in it.

V. RESULTS AND DISCUSSIONS

To show the applicability of the proposed model, a case study is presented as reported in the recent literature. Both the traditional approach and new approach are tested, and their results are reported. The scale of the numerical experiment is as follows: the number of suppliers is 3; the number of potential locations to establish the plants is 4; the number of potential locations for establishment of the distribution centers is 5; the number of customer zones is 8; the number of potential locations for foundation of collection and repair centers is 4 and 3, respectively; the number of disposal centers is 3; and the number of time periods is 10. Table 3 provides the customer demands in each period, while the price of products is given in Table 4. It is assumed that the sale price in the different customer zones is the same. Table 5 presents the parameters associated with suppliers, where material costs and supplier capacities are given. Table 6 also illustrates the parameters related to the plants, where production costs, fixed costs, plant capacities, and store capacities are reported. Similarly, Tables 7–10 show the parameters associated with distribution centers, collection centers, repair centers, and disposal centers, respectively. Concerning the costs for the rest of the periods, it is assumed that the cost will experience a growth of 5% at each period.

Table 3: Demand of customers

Customers	Time periods									
	t1	*t2*	*t3*	*t4*	*t5*	*t6*	*t7*	*t8*	*t9*	*t10*
c1	263	329	345	382	432	598	693	636	557	443
c2	183	240	243	278	342	475	499	432	375	294
c3	157	211	212	241	375	394	439	372	313	241
c4	205	266	274	311	348	419	553	508	455	340
c5	168	222	229	255	296	350	466	390	318	233
c6	250	269	304	348	357	498	599	562	473	343
c7	312	336	372	424	479	608	758	659	581	410
c8	176	192	215	239	277	341	415	357	296	218

Table 4: Price of products

Customers	Time periods									
	t1	*t2*	*t3*	*t4*	*t5*	*t6*	*t7*	*t8*	*t9*	*t10*
c1-c8	207	226	258	284	330	403	490	449	380	310

Table 5: Parameters relevant to suppliers

	Suppliers		
	s1	*s2*	*s3*
Material cost	14	13	14
Capacity of supplier	1326	1332	1233

Table 6: Demand of customers

	Plants			
	p1	*p2*	*p3*	*p4*
Production cost	26	28	29	26
Holding inventory cost	6	5	6	6
Remanufacturing cost	13	12	14	14
Fixed cost of establishment	81632	98830	75452	61328
Capacity of production	810	920	780	720
Capacity of Remanufacturing	340	346	322	355
Capacity of store	355	413	335	299

Table 7: Parameters relevant to distribution centers

	Distribution centers				
	d1	***d2***	***d3***	***d4***	***d5***
Operating cost	6	6	5	5	5
Fixed cost of establishment	10580	11360	12453	10048	14854
Capacity of distribution center	903	879	912	896	844

Table 8: Parameters relevant to collection centers

	Collection centers			
	e1	***e2***	***e3***	***e4***
Collection cost	5	4	6	5
Fixed cost of establishment	5127	6818	7419	5448
Capacity of collection center	536	584	554	551

Table 9: Parameters relevant to repair centers

	Repair centers		
	r1	***r2***	***r3***
Repair cost	8	10	9
Fixed cost of establishment	15432	13079	13597
Capacity of repair center	389	369	357

Table 10: Parameters relevant to disposal centers

	Disposal center		
	l1	***l2***	***l3***
Disposal cost	4	3	4
Capacity of disposal center	148	160	156

In addition, the parameters related to the return rate of products are given in Table 11. The transportation costs are defined corresponding to the distance between the nodes on each layer of the supply chain network. The behavior of the proposed model has been studied in the case when the financial aspects are considered along with goods flows.

Table 11: Parameters relevant to return of product

	Time periods									
	t1	***t2***	***t3***	***t4***	***t5***	***t6***	***t7***	***t8***	***t9***	***t10***
Return ratio	0.6	0.7	0.6	0.5	0.4	0.5	0.4	0.5	0.4	0.4
Repair ratio	0.2	0.4	0.3	0.3	0.5	0.6	0.3	0.3	0.4	0.5
Remanufacturing ratio	0.5	0.4	0.6	0.5	0.4	0.3	0.6	0.5	0.4	0.4
Disposal ratio	0.3	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.2	0.1

Associated with financial parameters, Table XII presents the initial portfolio of marketable securities investments at the beginning of the time period. Besides, the initial cash is equal to 300,000, while the minimum cash is 120,000. Under an agreement with a bank, the firm has an open line of credit at a 10% annual interest with a maximum debt allowed of 100,000. The initial debt is equal to 70,000 and the prices of the inventories at the end of the time period are based on the lowest price, i.e. the production price. Sales executed in any period are paid with a delay equal to 2 time periods and the account receivables on sales are pledged at 80% of their face value. Moreover, liabilities borrowed due to the costs of raw materials, production, processing in facilities have to be repaid within 3 time periods according to the terms of the credit negotiated as $2\% - 1$ time period, net-3 time periods. The payments associated with the transport services cannot be stretched, and must be satisfied within the same period of time in which the transport task takes place.

Concerning the technical coefficients associated with transactions of marketable securities, we assume a 2.8% annual interest for purchases and a 3.5% one for sales. It is also supposed that at the end of the time horizon (period 10), 1,000,000 are withdrawn from the company as dividends. There are also outflows of cash equal to 100,000, 150,000, 75,000, and 150,000 in periods 3, 5, 8 and 10 due to payrolls, wages, rents, changes in fixed assets, and the repayment of the long-term debt, which remains constant during the whole time horizon. Here, we analyze both the traditional approach and new approach, and discuss the results. The problem is solved by the both approaches on a computer with an Intel core2 Duo 2.00 GHz processor and 2.00 GB of RAM using the GAMS and CPLEX solver with a 0% integrality gap. Table XIII reports the results associated with tradeoff of profit and change in equity. It is pointed out that the new financial approach improves the change in equity as much as 6.8% (6125830 for the traditional approach and 6542853 for the new approach), whereas the profit of the company is only decreased by 0.54% (8157491 for the traditional approach and 8113572 for the new approach). This tradeoff is a good result which convinces many decision makers to employ new financial approach. Since in the traditional approach, the holding inventory cost is considered in each period, the model is forced to hold the minimum possible inventory. Hence, the quantities of inventory in the traditional approach are less than the new approach, where the inventory at the end of the first period and the last period is only considered in the new approach.

Table 12: Marketable securities of initial portfolio

	Time periods									
	t1	***t2***	***t3***	***t4***	***t5***	***t6***	***t7***	***t8***	***t9***	***t10***
Initial portfolio	40000	30000	21000	15000	12000	25000	20000	35000	8000	27000

Table 13: Results of approaches

	ΔSA	**ΔLA**	**ΔSL**	**ΔLL**	**ΔE**	**Profit**
Traditional approach	5948007	207823	30000	0	6125830	8157491
New approach	6293704	279149	30000	0	6542853	8113572

The results clearly suggest the benefit of using the new approach over the traditional approach. These results are a good improvement, which convinces the majority of decision makers to employ the new approach, and helps them to come by a proper managerial insight.

VI. CONCLUSIONS

This paper has addressed the design of a financial supply chain model integrating the strategic and tactical decisions as well as the physical product and financial flows. To the best of our knowledge, this is the first study considering financial flows and cash management in the supply chain design. Moreover, the study has considered the change in equity, which is associated with the shareholders' value (SHV) of the firm, as the performance measure in the chain. To show the merits associated with the presented approaches, the results of the new approach and the traditional approach were compared through a case study, where the traditional approach firstly decided operations and fitted finances afterwards. The results indicated that the traditional approach leads to lower change in equity compared to the new approach. This fact illustrates the inadequacy of treating process operations and finances in isolated environments and pursuing as objective myopic performance indicators such as profit or cost. The results clearly show the benefit of using the new approach over the traditional approach, and convince the majority of decision makers to make use of the new approach. A decision making process which does not encompass such a procedure could results in a plan that responds well only at one of the indicators, while it performs poorly for another indicator. Hence, the new approach also helps decision makers to obtain a proper managerial insight.

In summary, it should be pointed out that our model can be generalized to other demand patterns, cost functions as well as prices, under consideration of the facility's capacity constraint. The proposed framework is not only a tool for researchers to investigate interesting research issues, but also an excellent tool for practitioners with broad applicability. This research framework can also be easily extended to study supply chains with various uncertainties such as demand, return rate and random yield. More possible future studies include extending it to multi-product environment and incorporating risk issues.

REFERENCES

1. Mentzer JT, DeWitt W, Keebler JS, et al: Defining supply chain management. Journal of Business logistics 22:1-25, 2001.
2. Jafarzadeh H, Moradinasab N, Gerami A: Solving no-wait two-stage flexible flow shop scheduling problem with unrelated parallel machines and rework time by the adjusted discrete Multi Objective Invasive Weed Optimization and fuzzy dominance approach. Journal of Industrial Engineering and Management 10:887-918, 2017.
3. Margolis JT, Sullivan KM, Mason SJ, et al: A multi-objective optimization model for designing resilient supply chain networks. International Journal of Production Economics, 2018.
4. Wuttke DA, Blome C, Henke M: Focusing the financial flow of supply chains: An empirical investigation of financial supply chain management. International journal of production economics 145:773-789, 2013.
5. Laínez JM, Puigjaner L, Reklaitis GV: Financial and financial engineering considerations in supply chain and product development pipeline management. Computers & Chemical Engineering 33:1999-2011, 2009.
6. Shapiro JF: Challenges of strategic supply chain planning and modeling. Computers & Chemical Engineering 28:855-861, 2004.
7. Shen Z: Integrated supply chain design models: a survey and future research directions. Journal of Industrial and Management Optimization 3:1, 2007.
8. Wang Q, Batta R, Bhadury J, et al: Budget constrained location problem with opening and closing of facilities. Computers & Operations Research 30:2047-2069, 2003.
9. Badell M, Romero J, Huertas R, et al: Planning, scheduling and budgeting value-added chains. Computers & chemical engineering 28:45-61, 2004.
10. Guillen G, Badell M, Puigjaner L: A holistic framework for short-term supply chain management integrating production and corporate financial planning. International Journal of Production Economics 106:288-306, 2007. 11. Puigjaner L, Guillén-Gosálbez G: Towards an integrated framework for supply chain management in the batch chemical process industry. Computers & Chemical Engineering 32:650-670, 2008.
12. Hammami R, Frein Y, Hadj-Alouane AB: A strategic-tactical model for the supply chain design in the delocalization context: Mathematical formulation and a case study. International Journal of Production Economics 122:351-365, 2009.
13. Sodhi MS, Tang CS: Modeling supply-chain planning under demand uncertainty using stochastic programming: A survey motivated by asset–liability management. International Journal of Production Economics 121:728-738, 2009.
14. Longinidis P, Georgiadis MC: Integration of financial statement analysis in the optimal design of supply chain networks under demand uncertainty. International journal of production economics 129:262-276, 2011.
15. Moussawi-Haidar L, Jaber MY: A joint model for cash and inventory management for a retailer under delay in payments. Computers & Industrial Engineering 66:758-767, 2013.
16. Protopappa-Sieke M, Seifert RW: Interrelating operational and financial performance measurements in inventory control. European Journal of Operational Research 204:439-448, 2010.
17. Ramezani M, Kimiagari AM, Karimi B: Closed-loop supply chain network design: A financial approach. Applied Mathematical Modelling 38:4099-4119, 2014.

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