

## Scheduling payments optimization to drive working capital performance within a supply chain

Fadéla El Miloudi<sup>1</sup>, Nicolai Tchernev<sup>2</sup>, Fouad Riane<sup>3</sup>

<sup>1</sup> Faculty of Science and Techniques, Hassan 1er University, settat Morocco

<sup>2</sup> LIMOS Laboratory, Blaise Pascal University, Clermont-Ferrand, France

<sup>3</sup> Ecole Centrale Casablanca, Morocco

fadela.elmiloudi@gmail.com, tchernev@isima.fr, rianefouad@gmail.com

**Abstract.** The financial supply chain involves the flow and use of cash thru the physical supply chain. There is an accompanying flow of cash in the transfer of products and services between supply chain players. The management of the flow of money is complex since the delivery or receipt of a product or service does not necessarily give rise to an immediate collection or disbursement of money. This impacts significantly the working capital and forces the companies to look for nearly the same visibility in their financial flows as in their physical ones. We address in this the paper the financial issues of supply chain management. We review the fundamentals of working capital and supply chain finances techniques. We consider the particular problem of scheduling invoice payments cash collection in order to improve working capital performances. We develop a mathematical program to model the problem and evaluate its performance.

**Keywords:** Supply chain finance, Collaborative supply chain, Working capital.

### 1 Introduction

The concept of supply chain refers to the flow of materials, information, payments, and services from raw materials suppliers, through manufacturers and warehouses, to the end consumers. It includes the organizations and processes that create value and deliver products, information, and services to customers. The management of such a supply chain consists on designing, organizing, planning and coordinating, within a network of players, the overall supply chain activities. These activities include purchasing, payment flow, materials handling, production planning and control, logistics and warehousing, inventory control, distribution and delivery. The cornerstone for remaining competitive for almost organizations relies on their ability to have a clear visibility on their product and information flows in order to deliver the right product, to the right customer, in the accurate quantity, in the requested quality, at the appropriate place, at the looked-for time in the efficient way that respects the competitiveness strategy of the company.

Companies are nowadays searching for nearly the same visibility in their financial supply chains as in their physical ones. The financial supply chain involves the flow and use of cash throughout the physical network. The management of these financial flows that include all transfers of money, payments, payment schedules etc is complex. The inflows and outflows of cash are continuous thru an organization's life span and are mostly unknown, because such inflows and outflows depend on movement of goods and thus on market demand. The structural non-synchronization of flows of cash with the transfer of products and services impacts the ability of a company to continue running operations. Maintaining and improving financial performance is challenging for almost all companies

We address in this the paper the financial issues of supply chain management. We review the fundamentals of working capital and supply chain finances techniques. We consider the particular problem of scheduling invoice payments cash collection in order to improve working capital performances. We develop a mathematical program to model the problem and evaluate its performance on fictitious instances.

### 1.1 Optimizing Working Capital

Working capital is one of the most important indicators of a company’s financial health and the best indicators to measure supply chain efficiency [8]. Every company must balance its outflows and inflows cash to ensure the optimal capital amount needed to operate. For managers, this is a continuous preoccupation that involves activities related to encashment and disbursement of the cash flow company [18], and whose objective is to ensure to the company the availability of sufficient resources for its optimal functioning. Maintaining and improving working capital performance is challenging for most companies. In order to survive, to fund their supply chain and to enable business continuity, companies need to find other sources of liquidity and evaluate alternative ways to satisfy their liquidity needs [16].

Thru a supply chain, flows of cash emerge with the transfer of products and services. However, delivery of products or services does not necessarily give rise to an immediate collection or disbursement, which impacts significantly the cash flow of the company.

The non synchronization between physical flows and monetary ones is structural in companies. It is the result of the conjunction to the time lag induced by the procurement cycle necessary to get raw material, the production cycle needed to convert raw material to finished products and finally the commercial cycle required to transform stocks to real sales. These offsets are also the result of payment terms granted to customers to pay their bills. This creates a lag between suppliers’ disbursements and cash collection from customers creating financial needs within the company. These needs must be optimized and / or funded to enable the continuity of running the business.

To better understand and interpret financial flows, we must analyze a cash flow management, settlements and receivables control, and the liquidity management in order to enable the company to meet its commitments [2].

Effective working capital management reflects effective management of its components: inventory, cash collection from customers and invoices’ payments to suppliers.

Managing working capital has two main objectives. The first one is to control working capital to improve cash flow. The second objective is to strengthen the internal financing capacity of the company to limit dependence on external funding and liquidity risks [4]. Working capital management aims to reduce the capital tied up in a company through reducing current assets (receivables + Inventory) and the extending current liabilities (debts) [15].

$$WC = \text{Current assets} - \text{Current liabilities}$$

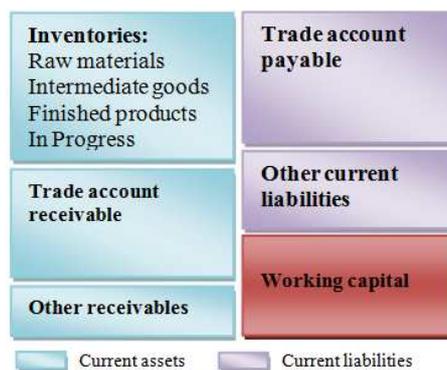


Fig. 1 Working capital components (based on the Hofmann’s model, 2011)[5]

Working capital (WC) is the algebraic difference between current assets and current liabilities, and reducing it reflects ability of the company to transform current assets (receivables) into liquidity to fulfill its short-term debts [10].

### 1.2 Cash to cash Cycle Time

Working capital management allows reducing immobilized amount of money. But the reduction of the amount must be accompanied by the release of cash in time. Hence, the introduction of the cash to cash

cycle indicator that measures how long time the money is immobilized as current assets, and evaluates the company's ability to meet its short-term obligations [9] & [11].

The cash to cash (C2C) cycle was introduced by Richards and Laughlin in 1980 [17]. It has been described as “the average days required to turn a dollar invested in raw material into a dollar collected from a customer” [19]. It includes elements allowing working capital deep analysis.

$$C2C = DSO + DIH - DPO$$

- Reducing the customer cycle can be made by reducing the time granted to customers or looking for prepaid solutions. This can increase receipts and reduce Days Sales Outstanding (DSO).
- Optimize operations management, production planning, and inventory management can reduce inventory at an effective level, without risking the continuity of the production or distribution cycle. This will reduce Days Inventory Held (DIH).
- Increase supplier cycle can be achieved through negotiations deadlines or payment of delay penalties. This will increase days payables outstanding (DPO).

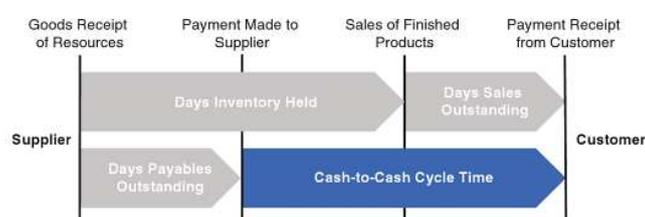


Fig. 2 Cash-to-Cash Cycle Time (Hofmann and al., 2011)[5]

Working capital management and cash to cash cycle involves improving cash through the optimization of solutions and customers/suppliers financing cycles. Three main supply chain strategies are commonly used by companies to improve their working capital. They can either manage inventories more efficiently or reduce the Days Sales Outstanding (DSO) and payment terms from customers or increase Days Payable Outstanding (DPO) by paying suppliers on later terms.

Financing working capital could take two forms: the optimal location of the external financing needs (supply chain finance) and building an efficient internal market for capital (finance collaborative). In the first case, the financial resources come from financial institutions external to the chain, in the second it is the members of the chain themselves that provide them.

### 1.3 Supply chain Finance

Supply chain finance can be defined as the use of financial instruments, practices and technologies for optimizing the management of the working capital and liquidity tied up in supply chain processes for collaborating business partners (EBA 2013). A lot of researches have focused on reverse factoring. Also called approved payables finance, reverse factoring allows a supplier to receive a discounted payment of an invoice due to be paid by a buyer.

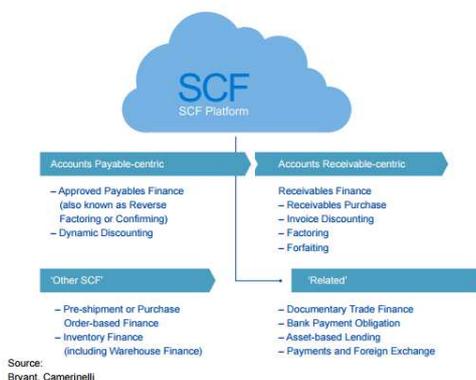


Fig. 3 The Complete Supply Chain Finance Portfolio (EBA 2014) [20]

The reverse factoring is an asset finance solution that requires the integration of a financial partner in the supply chain to allow a relationship between customer and supplier to fund payables. Both parties (customers and suppliers) are agreeing to participate in the financial solution building.

When a vendor who sells a product or service needs to collect money before maturity, he uses this financial partner who agrees to pay, immediately by applying commissions and interest rates, validated invoices not yet due, which will allow him to receive an advance payment without compromising his own working capital. Supplier by agreeing to give up part of his debt is then certain to collect his money faster which improves his cash flow. The client company can, in turn, continue to operate with the advantage of greater financial security and a stable flow of supply and expenditure [12].

The reverse factoring offers benefits to all supply chain partners. Through this solution, big customers allow their suppliers to have more flexibility in managing their cash flow and prevent them from compromising their supply chain. In other words, if customers consider very important to be delivered on time, they can fund their suppliers with the reverse factoring [6]. However, the reverse factoring remains a rather expensive solution to implement and requires highly developed information systems and high investment budgets which can harm the financial health of small participants. Also, it does not consider regulatory constraints (law on payment terms and IFRS requirements). In addition, using reverse factoring requires the introduction of a financial partner which increases the cost of the whole chain.

#### 1.4 Collaborative finance

The collaborative finance throughout the supply chain is a solution for the advanced funding of working capital without the intermediation of a traditional financial institution. It consists on reducing overall cost of supply chain financing, increasing profitability and avoiding the unnecessarily high cost for getting funds from third financial part. It aims to improve trade credits negotiated in the relationship between seller and buyer.

This strategy of securing and financing the supply chain is not new. Meltzer in 1960 showed that in periods of economic crisis and reduced liquidity in the market, companies with significant cash availability can substitute traditional external financing via commercial credits [13]. This collaboration can result in smarter trade credits and better invoices payments planning of suppliers and customers in order to guarantee further working capital optimization and financing cost reduction.

In a supply chain, customer and supplier are the main partners to achieve operational and financial goals. The weight and the circumstances of one impact the performance of the other. Therefore, poor collaboration in supply chain management will cause operational and financial difficulties of the whole.

On supply chain, the supplier is a customer in his turn. Therefore the overall scheme is as follows:

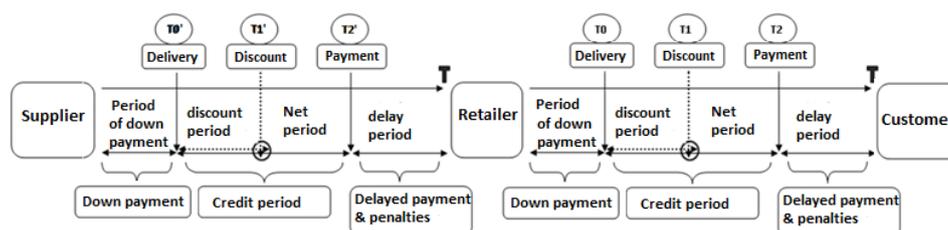


Fig. 4 Commercial credits in a supply chain [7]

If payment is made on delivery (T0), so there is no commercial credit. Otherwise several cases arise.

The buyer can make upfront money before the date of delivery. In this case, the seller gets a free credit between the prepayment date and the delivery T0. In the case of payment after delivery, the buyer is in a credit period. During this period, he can decide to pay at the time T2 and get a free credit between T0 and time T2; or decide to pay at T1 before the due date and receive a discount.

This decision affects the cost of credit for the buyer because in practice he can:

- Pay at maturity date T2: in this case he has free credit between delivery and payment
- Pay at the time T1 and benefits from discount.
- Pay in the net period between T1 and T2 but undergoes the shortfall related to the waiver of discount.
- If the buyer exceeds the time T2, he is in arrears. The seller begins to bear late payment penalties.

To ensure liquidity, the supplier agrees payment terms to his customers or offers them a discount for early payment. The client in his turn has the choice between paying bills at maturity or have a dynamic discount for early payment. But this operation may not be optimal and may create increased working capital, may increase costs of the chain or create a shortfall for the company.

Typically, conventional organizations choose internal financing resources to finance the supply chain and operational processes. This solution allows immediate funding, avoids constraints related to supply forecast and can be more expensive.

Choose the mode of funding is fundamental to create value through using or not available cash in the company and optimizing financing costs.

Any existing cash can be used in remunerated deposits; therefore, any shortfall caused by an unrealized deposit must be included in financial optimization decisions.

We aim in this paper to develop such an optimization model. The objective is to allow a company optimizing its cash and minimize its financing costs thru a smart schedule of its cash collections and invoices' payments.

## 1.5 Issue statement

We address a 3-level supply-chain company that receives goods from several suppliers, transforms them and sales the manufactured products to several wholesalers. We will focus on the money flow. The company collects cash from downstream partners (wholesalers) and issues payments to the up-stream partners (suppliers). These cash transactions are completed following specific payment terms. Typically, these terms specify the period allowed to a buyer to pay off the amount due. They also detail the discount and the penalty rates applied to encourage early payments or to avoid timely ones.

The company has an important number of invoices to be paid to suppliers at any time and almost the same important number of customers invoices to be collected. The objective is to derive an optimization model that helps scheduling payments in order to optimize the working capital [21].

We consider a discrete planning horizon H of T periods of equal length. We assume that the future cash in-flows and out-flows from downstream and upstream partners along with their terms (payment date, discounts rates and penalty rates) are known in advance over the planning horizon.

- $SK = \{k \text{ customer invoices}, 1 \leq k \leq K\}$  denotes the set of customer invoices to be perceived over the horizon H.
- $SJ = \{j \text{ customer invoices}, 1 \leq j \leq J\}$  denotes the set of supplier invoices to be paid over the horizon H.
- Let  $IR_k^{d_k}$  stands for the amount of the k<sup>th</sup> invoice to be received by the firm from its downstream partner at negotiated date  $d_k$ .
- Let  $IP_j^{r_j}$  denotes the amount of the j<sup>th</sup> invoice to be paid by the firm to its upstream partners at negotiated date  $r_j$ .

If a customer invoice k is paid before its due date  $d_k$ , the terms of payment of the invoice guarantees a discount rate  $c_k$  per period. Thus, if the invoice k is paid t periods before the due date, the collected amount is then  $IR_k(1 - c_k)^{d_k - t}$ . Such discounts are given to encourage early payment of invoices and to accelerate cash in-flows collection.

If a payable invoice  $j$  is paid after its due date  $r_j$ , the terms of payment of the invoice depicts a penalty rate of  $s_j$  per period.

Thus, if the invoice  $j$  is paid  $t$  periods after its due date, the payable amount is then  $IP_j(1 + s_j)^{t-r_j}$

Without less of generality we assume that the customer invoices cannot be paid after the due date and the supplier invoices cannot be paid before their due dates. We also assume that any accumulated money at any period of time can be invested by the company to earn interest  $\alpha$  and the bank financing rate is always higher than  $c_k$  and  $s_j$  ( $\alpha > (c_k, s_j)$ ).

The company's objective is to optimize cash flows, minimize cost of money and provide a payment schedule for all invoices. One wants to decide on the date of payment for suppliers' invoices and collection of customer payments during the planning horizon  $T$ . We develop hereafter a 0-1 linear program to maximize the present value of the cash in hand. We use then the following decision variables:

- $X_{k,t}$  : is a binary variable equals to 1 only if the  $k^{\text{th}}$  customer invoice is perceived by the firm at period  $t$ .
- $Y_{j,t}$  : is a binary variable equals to 1 only if the  $j^{\text{th}}$  supply invoice is paid by the firm at period  $t$ .
- $\delta_t$ : is the cash in hand at the end of period  $t$ .
- $\delta$  is the cash in hand at the beginning of the horizon  $H$ .
- $e_t$ : is the amount of money borrowed from the bank at period  $t$  if the cash in hand is not enough to execute scheduled payments. We assume that the reimbursement of this money should be done a period after.

We use also the following parameters:

- $\alpha$  : is and interest rate that must to be paid per period for loan money from the bank.
- $R_t$  : is the total money collected from downstream customers at period  $t$ .
- $P_t$  : is the total money paid to the upstream supplier at period  $t$ .

$$\text{Min } Z = \sum_{t=1}^T (1 + \alpha) * e_t + \Delta P + \Delta R \quad [1]$$

$$\sum_{t=1}^T X_{k,t} = 1; \forall k \in SK; \quad [2]$$

$$X_{k,t} = 0; \forall t, t > d_k, \forall k \in SK; \quad [3]$$

$$\sum_{t=1}^T Y_{j,t} = 1; \forall j \in SJ; \quad [4]$$

$$Y_{j,t} = 0; \forall t, t < r_j, \forall j \in SJ; \quad [5]$$

$$R_t = \sum_{k=1}^K IR_k^{d_k} * (1 - c_k)^{d_k-t} * X_{k,t}; \forall t \quad [6]$$

$$P_t = \sum_{j=1}^J IP_j^{r_j} * (1 + s_j)^{t-r_j} * Y_{j,t}; \forall t \quad [7]$$

$$e_t + \delta_{t-1} + R_t - P_t - \delta_t - (1 + \alpha) * e_{t-1} = 0; \forall t, t > 1 \quad [8]$$

$$e_1 + \delta + R_1 - P_1 - \delta_1 = 0 \quad [9]$$

$$\Delta P = \sum_{t=1}^T P_t - \sum_{j=1}^J IP_j^{r_j} \quad [10]$$

$$\Delta R = \sum_{k=1}^K IR_k^{d_k} - \sum_{t=1}^T R_t \quad [11]$$

Constraint [1] defines the objective function. It consists on the minimization of the total cost incurred by postponing supplier payments, advancing cash collection from customers and borrowing money from a bank. Constraints [2] and [3] guarantee that money collected from upstream customers should be done within the horizon  $T$ . Constraints [4] and [5] ensure that suppliers' invoices must be paid within the horizon  $T$ . [6] and [7] compute for each period  $t$  respectively the total money collected and the total money paid. [8] and [9] are the cash flow conservation constraints. Equations [10] and [11] computes the shortfall due to the use of discounts and penalties.

### 1.5 Experimentation

The 0-1 linear program was implemented under LINGO 15.0 and was validated on a real sample of customer and supplier invoices consisting of 20 invoices to be collected and 15 supplier invoices to be paid over a horizon of 10 periods as depicted in the following tables.

K	lrk [k\$]	dk [week]	K	lrk [k\$]	dk [week]
K1	8 000		4 K11	7 500	4
K2	15 000		5 K12	12 500	3
K3	13 000		6 K13	7 500	9
K4	6 500		9 K14	15 500	8
K5	12 000		10 K15	12 000	6
K6	13 000		4 K16	7 500	10
K7	14 500		9 K17	13 000	5
K8	6 500		8 K18	9 500	6
K9	5 500		1 K19	16 500	6
K10	13 000		8 K20	10 500	6

Table 1: The design experiment for customer invoices

J	IP [k\$]	rj [week]	J	IP [k\$]	rj [week]
J1	6 500		4 J9	12 500	1
J2	12 000		2 J10	17 500	5
J3	13 000		3 J11	25 500	4
J4	14 500		8 J12	12 000	9
J5	6 500		6 J13	7 500	8
J6	5 500		4 J14	13 000	1
J7	13 000		5 J15	19 500	7
J8	7 500		2		

Table 2: The design experiment for supplier invoices

We conduct different experiments to derive insights about the use the model with regard of different values of discount and penalty rates and interest rate.

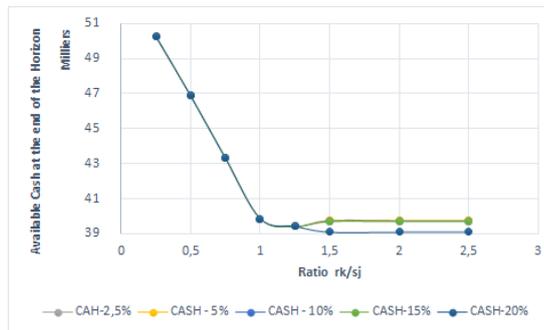


Fig. 5 Evolution of available cash at the end of the horizon

Fig. 1 summarizes the evolution of available cash at the end of the horizon versus the evolution of the ratio  $ck/sj$  for different value of interest rates. One can notice the S-shape of the curve. The cash decreases with the increase of the discount rates and stagnates at to certain limit. Fig 2 indicates the evolution of the gap of the money collected from downstream customers compared to the gap of the money paid to the upstream supplier. One can notice the existence of a breakpoint at a ratio  $ck = sj = 4\%$



Fig. 6 Evolution of available cash at the end of the horizon for an alpha = 1% and sj = 4%

## 2 Conclusion

In this paper we highlighted two main methods of funding and optimization working capital (supply chain finance and collaborative finance). We tried to propose a model allowing the application of supply chain finance reasoning on commercial credits for collaborative funding, while applying the principle of financing flexibility offered by the reverse factoring.

Our work aims to determine a payments planning model to generate cash and minimize costs before considering short-term borrowing. Our model ignores delayed customer payments and anticipated supplier payments. The perspective would be to propose in a future paper a second broader model incorporating these two cases.

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