A System Dynamics approach to a Chemist's Inventory and Finance Management.

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Abstract

A Chemist's shop can be considered in many countries as a Small Enterprise (and so part of the SME class) and, as such, it constitutes a complex business environment where several different and mutually dependent issues, both technical, economic and financial, may be identified. The growing complexity of an SME environment and the use of traditional analysis techniques, as known, do not allow for an effective forecast of a behavioural dynamics of the entire system. The need for coordination among the many management issues (and the awareness that risks may be contained and enterprise skills developed only by analyzing and controlling the behaviour of the overall business dynamics) give enormous evidence to the important need of correctly planning, in the light of collegial decision making, all of the enterprise's activities, as well as understanding the underlying dynamics due to the firm's internal structure.

Thanks to the new IT Technologies which allow the connection of simulation models to the Chemist's DBMS or ERP systems (in turn allowing models to work with real and dynamic data), the Chemist, has the great opportunity to use such data in order to optimally drive his strategic and operational management decisions. Towards this end, the implementation of specific management control/decision support systems, based on System Dynamics models, allow first for a better learning of the environmental dynamics which influence the economic behaviour of the firm, and second, for a deep understanding of the results of the decisional policies which the Chemist himself, together with his collaborating staff, may choose among a plethora of strategic choices. By ignoring that "structure influences behaviour", all the actions, even the ones deemed most *brilliant*, may have a very different result if the very nature of the environment is not clear.

A system dynamics approach has helped identifying those modelling and conflict resolution policies which may help in conducting a group model building session, towards the sharing of a common mental model and the collegiality of decisions which, in the long run, may bring economic success to the Chemist's business.

Introduction

This work sets out to reinforce the use of a systemic and coordinated approach inside a corporate organization context, such as the chemist's companies. Nowadays, it is in fact required not only to define the most appropriate managerial strategies but also to monitor and guide the decision making development so as to apply corporate decisions consistently to the long term objectives. In particular, as the financial management is increasingly difficult, many chemist's organizations are needed to re-plan both the supply and sales management.

In general, chemist's organizations are small businesses, thus in many cases they do not possess enough logistic and financial resources to manage the single areas in a joint and coordinated way. This generates not only numerous conflicts among the different area managers, but also exposes the organization to hexogen factors, as it happens to Italian Chemists as long as the relationship with the NHS is concerned. As a matter of fact, in many cases, the organizations experience delay problems in the invoice payment by the National Health Service and consequently are subject to a further resource limitation, thus incurring the risk of credit restraint by banks.

The numerous factors involved and their relative interactions are difficult to be managed and foreseen and are not efficiently undertaken by the present managerial systems, which are based on the traditional divisions of roles and competences. Therefore, it is common to follow routine systems, which are shaped to facilitate the chemist's lone entrepreneur inside the chemist's shop, but are at the moment unable to take on the actual managerial changes. In order to overcome these problems, more flexible managerial criteria have been created, that are capable of detecting and evaluating the present dynamics in a way to getting tailored to changing contexts, thanks to a systemic and coordinated approach both in measuring the activities and in decision making.

In general, if one organization wants to deal with evolving customer expectations and new competitive trends, it has to carefully monitor the business environment in a flexible and creative way. Such a dynamic context may be applied to the pharmaceutical retailing industry as well. The chemist should always adjust his/her actions to the organization's objectives and so assess potential threats arising from different corporate functions, such as medicine supplying and stock management. He/she also needs to continuously pursue superior financial and economic performances.

In this paper, we will show how collegial decisions based on a systemic view of the firm may help in pursuing good management results or at least avoiding failures, as well as explore one case study in which the main business dynamics for one chemist's organization are investigated. In particular, we will look at three main corporate functions (supply, finance, marketing) and we will define a unique simulated model in which joint choices should lead to benefits for the overall organization.

The model will support a managerial decisions support system (DSS) in order to continuously assess the decisions' results. Moreover, the model will include the interrelationships between all the business areas. Thus, thanks to a "systemic approach", every head of department will have the opportunity to implement consistent plans for the system optimisation, thus abandoning conflicting objectives.

The application of the model will lead to the following advantages:
- Conflicting situations will be minimised
- The information available for the decision making process is more accurate and broad
- The synergy between the different business areas will be maximised

The main managerial areas for a chemist's shop

One of the major threats in a chemist's organization is that both the shop manager and assistants are essentially focused in the sales activities. Chemist's organizations also show an apparent lack both in the fields of area coordination and supply management. However, nowadays, thanks to the Information Technology, the chemist may readily get broad and relevant managerial data which may be effectively used in order to improve the business management and procedures.

Here it follows an analysis of the different corporate areas:

- **Supply management:** the head of the supply area is required to thoroughly manage the product re-supplying. He/she should also comply with the numerous norms which regulate both the stocking and the preservation for some specific products. Indeed, the Chemist's also provides a high-valuable social service, therefore even limited product missing may be detrimental for the overall business image. Our hypothesis is that the head of this area should reach a specific service level whilst minimizing the stocking-out, so he/she needs to quantify methodically the orders according to the expected demand for any single product.
- **Finance:** generally, for a Chemist's shop, a high product value and a high cost for stocking are associated to a limited financial capacity. This is due to the fact that most chemist's organizations are family businesses and that the start-up costs are usually quite high. Therefore, it is necessary to pay attention to the financial repercussions of the stock management – particularly to the floating capital. As the repayment period for the Italian National Health System (NHS) is generally longer than the suppliers' one, important corporate resources need to be deployed and so the organization has to take over a bank loan. Undoubtedly, the financial management is crucial for the business success, since cash flow problems most of the times cause the organization to stop its business activities. Furthermore, if the suppliers do not trust the organization anymore, they may stop offering advantageous payment conditions and even break off product supplying and this may have detrimental effects on the overall business. Insufficient liquidity could also compromise the supplying operations – for example, advantageous supplying conditions are often approved for larger orders. In conclusion, banks may not renew the loan or may impose more expensive procedures for acquiring the necessary capital.
- **Marketing:** also in the Chemist's context, the marketing mix (Product, Price, Promotion, Place) is quite effective in influencing the consumer's choices and the overall sales level. The head of the marketing area endeavours to maximise the organization income and so he/she is focused on increasing the sales, in particular for the most profitable products. Moreover, for particularly valuable products, it may be possible to implement a promotion strategy that may positively contribute to the financial stability, as they are directly related to the corporate cash flow. It is thus necessary to focus the marketing efforts on products that are capable of creating financial resources, in order to minimise the overall indebtedness ratio. This will also be one of our hypothesis.

Different objectives: who decides then?

It is clear that, as in a still too common management practice, if the different area officers pursue their own objectives, it is not possible to have a stable organization under a financial and structural point of view. This would also restrain the organization synergies which may be achieved through a clear business vision. The need for coordination among the many management issues (and the awareness that risks may be contained, and enterprise skills developed, only by analyzing and controlling the behaviour of the overall business dynamics) give enormous evidence to the important need of correctly planning, in the light of collegial decision making, all of the enterprise's activities, as well as understanding the underlying dynamics due to the firm's internal structure.

We have analyzed the three main corporate functions described in the previous paragraph (supply, finance, marketing), which can be also located at the SME level, and have defined a coordination model, including the interrelationships between all the business areas, in which joint choices should lead to benefits for the overall organization. Thus, thanks to a "systemic approach", every head of department will have the opportunity to implement consistent plans for the system optimisation, thus abandoning conflicting objectives.

Here it follows a synthesis of the overall hypothesized objectives for the three departmental areas, first following the traditional approach and then the joint approach.

Management Area	Implicit Open-Loop Objective Hypothesis
Procurement & Inventory	Guarantee desired/required minimum stock levels
Marketing & Sales	Increase income and generate profits
Finance	Guarantee financial equilibrium

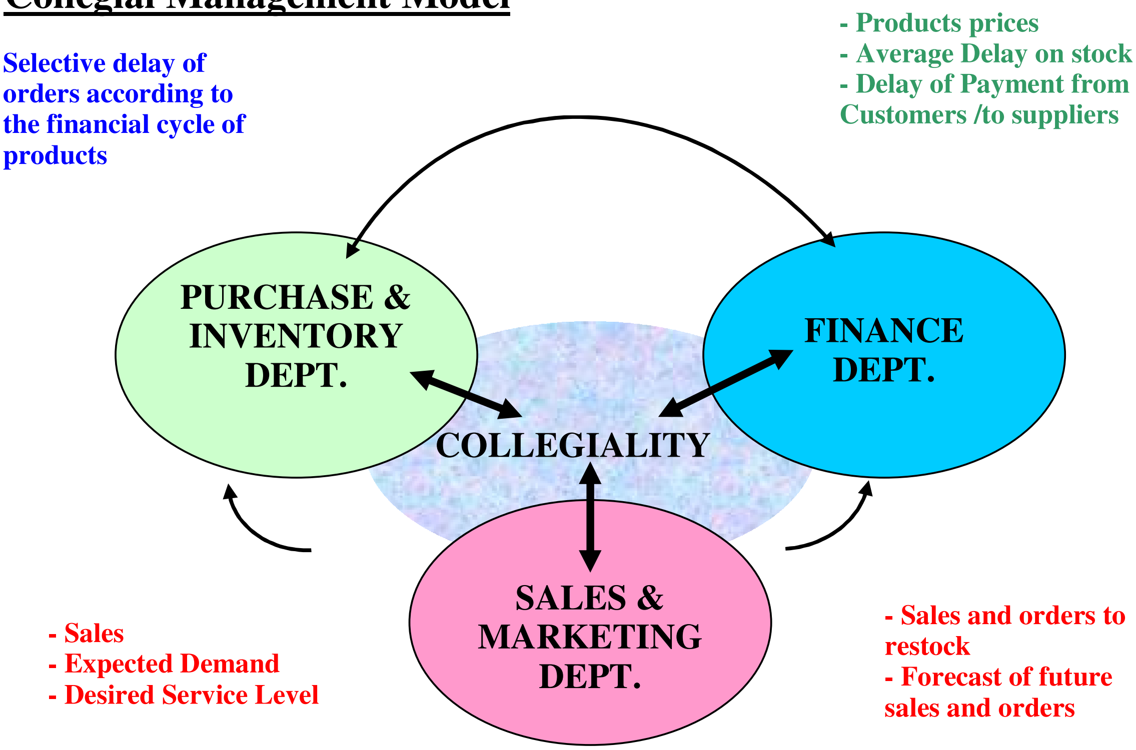
Table 1: implicit objectives of each area manager

In our research, we have developed a model which assists the chemist in some of these critical issues, which, as said, are strongly interconnected because of their very multidisciplinary nature.
By means of a systemic approach (i.e. by using group model building sessions and system dynamics modelling techniques), it is then possible to let the heads of the various departments or areas abandon their own monotheistic view of the organization's reality (just think that, most of the times, they feel as the problems of the area they rule is the most important and serious problem of the entire firm!) in order to build a shared model of the business environments they're in.

That is, by thinking systemically, the management staff is able to analyze in a clearer way the interrelations between the various areas and understand how a possible solution to a problem inside an area may effectively bring real advantages to the overall organization or merely create even worse problems in the long run. By avoiding "false" solutions and sharing a common solution, underlying a shared mental model of the system, the various head managers are then able to build a strong collegiality towards decision making procedures.

Such a situation may also arise in the context of a small Chemist's shop, where all the main managerial functions are usually synthesized in the Chemist himself, most of the times also the owner of the shop. Well, common managerial practice still too often push single decision makers towards separating the moments for different decisions. That is, the Chemist may decide first to take into account Financial issues and then solve Inventory Management problems, without considering that they just represent different faces of the same aspect. By thinking systemically and by resorting to system dynamics simulation tools, the Chemist may now be able to get the right decisions.

Collegial Management Model



Decisions regarding orders to restock, traditionally of the Purchase & Inventory Dept. competence, now are taken, according to a collegial decision model, in accordance with the Sales & Marketing Area and with the Finance Dept.

In a collegial decision system becomes crucial the presence of a shared information system and of a shared mental model of reality.

Figure 1: A collegial decision framework

Our starting Point: The Management of a Chemist's Inventory

In System Dynamics terms, we can usually think of the inventory management dynamics as a bathtub dynamics situation. The inventory corresponds to the bathtub (a level) whereas orders correspond to an inflow and sales to an outflow. The desired inventory level is then the desired quantity of goods/products to be held on stock and which the organization assesses as the most consistent to its contingent needs. Whilst in first approximation the exit flow, i.e. product sales, is usually out of direct control because of variability in demand, the entry flow (orders) may be perfectly controlled by the organization, which may decide how much and when to acquire new products to be put on stock. So the inventory management is usually restrained to the re-supplying management. This policy is sometimes in system dynamics referred to as an open-loop mental model. It happens in fact that the head of the Marketing and Sales area is capable of foreseeing (in a more or less precise way) the future demand by collecting and elaborating the historical data of demand, thus statistically trying to infer future data on sales. Demand forecasts should then be included in the supply and inventory management practices (the inventory then being the decoupling buffer between instants concerning to sales and orders) in order to:

- offer a certain service level to customers
- absorb possible sales variations with minimum safety stock levels
- eliminate or minimize any waiting time for customers

Such a systemic approach concerning supply chain management has been extensively discussed in literature (see [10], [22]). It is interesting to note, in the following causal map depicting the Supply Chain Area relations, how the stock-out variable may influence, by means of the Service Level, the expected demand, thus also affecting future sales and giving feedback to the purchase department on the expected quantities to be sold, which in turn provides the orders to issue.

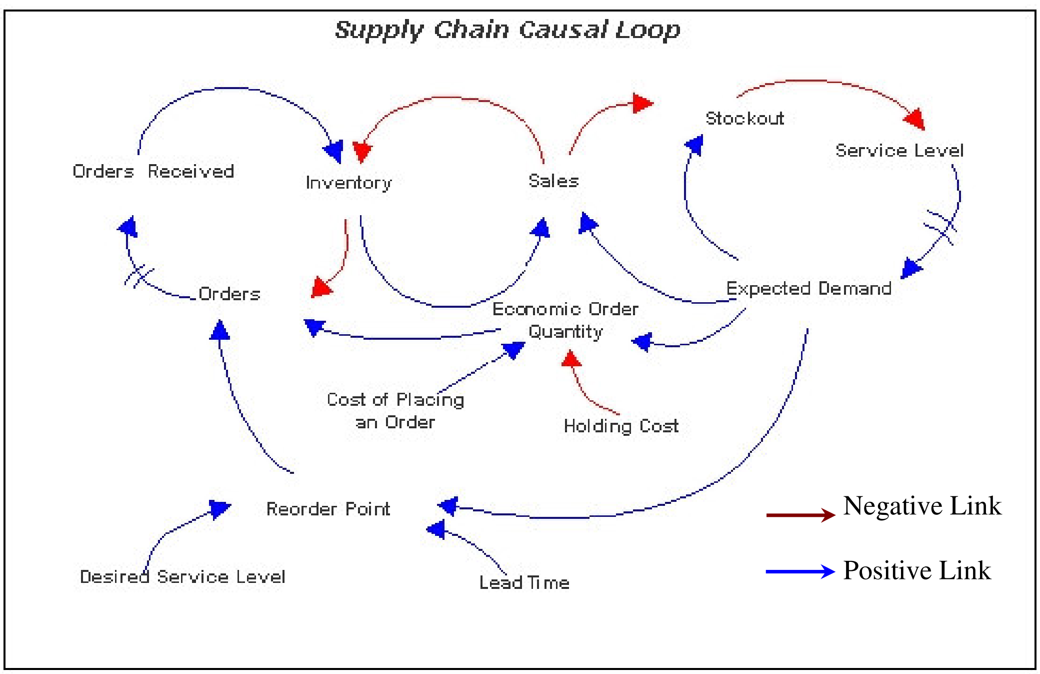


Figure 2: Purchase & Inventory Management Area - Causal Loop Diagram

It is nowadays ascertained that, in order to properly manage an organization's inventory, it is almost always necessary to implement a proper information system (today also referred to as ERP systems) for the Procurement & Inventory area. This may in fact help collecting data on all the supplying sources, i.e. all the possible suppliers for a specific product, their delivery average time, their price list, their mode of payment, and their quantity limitations.

As far as the sales are concerned, another important source of information (also requiring an information system) comes from the Marketing area: demand forecasts per product, consumer segments, purchasing behaviour and characteristics (e.g. propensity for the costumers who do not find a specific product to wait for it - see [8], [7]). Furthermore, it may be useful to assess some potential managerial constraints, in particular on the finance side (e.g. how to manage the stock and how to manage the product line according to the generated cash flow and its relative financial cycle) as we will see in the following sections.

Cost Items and the ABC Analysis

In the inventory management area, different typologies of cost may be identified: stores management expenses, potential obsolescence and perishing risks, all the maintenance costs (conditioning, heating, freezing and cooling), and opportunity costs for the invested capital. What we call as “ABC analysis” may be quite useful in this context, as in a Chemist's there are many different product typologies and it would be necessary to decide how sophisticated is the supply management policy for each of them. The ABC analysis offers useful criteria for selecting articles according to their relative importance and quantity and for clustering them in classes according to such criteria. Also, as the ABC classification varies, it may be applied a different supplying policy.

The main rationale which allows for product clustering is based on an “importance” ranking. First, the articles are arranged according to a value defined by the article's price multiplied by its relative yearly selling volume: this means that each product, during a financial period (usually, one year), provides the organization certain sales proceeds (a revenue). According to such an arrangement principle, article entries are listed decreasingly on the X-axis of a diagram, while the percentage of articles over the total on stock, aggregated for each class, is listed on the Y-axis. The resulting concentration diagram of the following figure describes the inventory situation, allowing managers to quickly understand where the main value of products lies. A Pareto chart would have also been suitable towards such a classification.

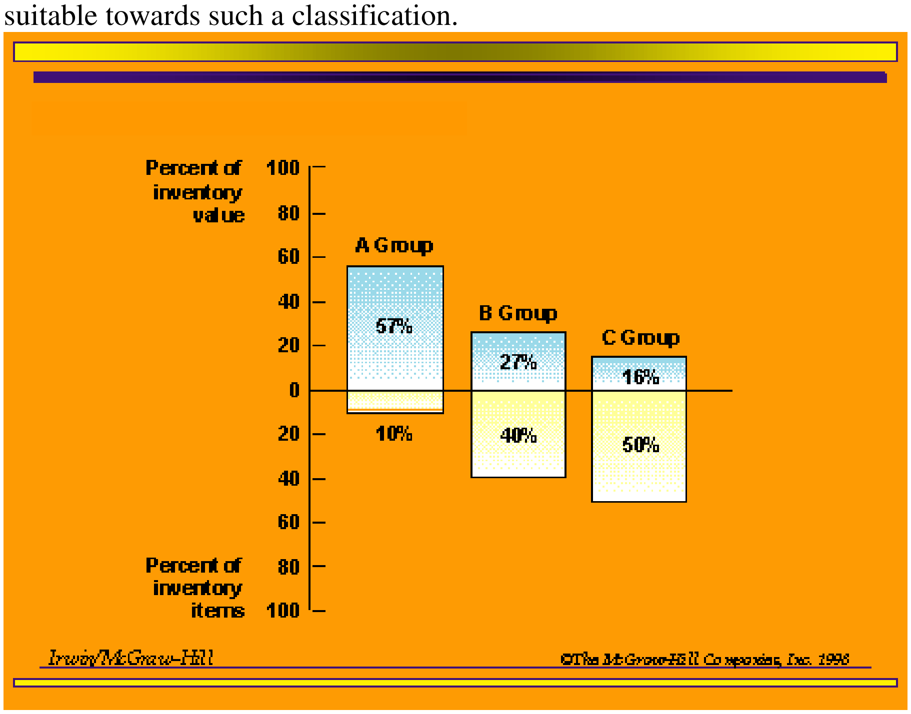


Figure 3: ABC Inventory Analysis

We have seen so far how it is possible to quickly classify products according to monetary terms. One could object that this method is someway reductive if we think of all the parameters that could be taken into account in order to describe the many inventory critical aspects.

If for example we took into account the warehouse dimensions (that is, the stock/inventory physical dimensions) as a critical issue, then each product's packaging volume (in terms of required stocking space) would be another indicator suitable for classification purposes. However, since it wouldn't be correct to decide which products to stock only on the basis of a dimensional aspect, in order to let all the articles be comparable, the "monetary value" indicator is mostly used.

Moreover, there are some more constraints also imposed by Government Laws. That is, the National Health Care System (NHS) provides the population with a State Benefit (called "Ticket" in Italy) on some predetermined classes of products, which in turn comes as a consistent discount on such prescribed medicines (the customer effectively pays only a sort of NHS "fee" in order to have that medicine, while the difference is charged on the NHS expenditures). This usually happens especially to protect those population classes which cannot allow themselves to pay for expensive medicines.

Since by means of the ABC classifications some of these medicines may be erroneously classified as in the C class, it becomes very important for the Inventory manager not to incur in a stock-out for them, mostly because they constitute a relevant element both ethically and under the mission/vision point of view of the firm. Running out of stock for a long period would probably cause an erosion of the business image of the firm (i.e.: people going to another Chemist's).

Service Level and inventory management policies

The ability of satisfying customer requests may be measured according to the so called "offered service level". It represents the number of the articles available on stock with regards to the overall same products requests.
For example, a Service Level (SL) of 90% means that at least 90 times out of 100, the organization was able to meet customers needs (on 100 requests of a certain medicine, 90 were on stock). For high SL, the organization must confront itself with the critical issue of correctly dimensioning the inventory's safety stock (a minimum stock level allowing the organization to withstand long delivery times from suppliers). In fact, a 90% SL would probably also mean that a certain article/medicine has a very high social impact and that the Chemist Management wouldn't run the risk of running out of stock for them in order to maintain a good public image (this is especially true for ethic articles or medicines for which the poorest classes in the population get a NHS support – the "ticket"). Instead, a 50% SL would mean that the product is not critical (customers would probably wait some time in order to receive it) and a stock-out would not heavily and detrimentally impact on the whole organization's business image. Thus, Service Level is not a sales-volume dependent variable.

Setting a proper service level for each product is then function of the product type, of its relative importance, and of the company's strategy. The Sales & Marketing Head Manager has the task to define proper service levels for each product or class of products, according to customers' preferences, and the impact that it may have on the company's image.

By making use of such policies, of desired Service Levels and of demand forecasts, the Procurement & Inventory Head will then have to determine proper supply policies. Among the available choices, we chose the following ones, which are the most known in literature and also most used in practice:

- **<u>FIXED-ORDER QUANTITY (FOQ)</u>**: a constant stock monitoring is performed so that as the inventory level reaches a certain fixed value, a new order is issued. The quantity of articles to order is equal to the well known **Economic Order Quantity** (EOQ, see [4], [5]) and the **reorder point** is set at a level that may allow to cover the expected demand during the order *lead time* (the waiting time for new ordered products before entering inventory) plus a *safety stock* quantity which is determined by the desired Service Level for that product.

The total annual cost function (TC) can be calculated by summing the annual purchase cost, the annual ordering cost and the annual holding cost:

$$TC = DC + \frac{D}{Q}S + \frac{Q}{2}H$$

where:

TC = Total annual cost;
D = Demand;
C = Cost per unit;
Q = Order quantity;
S = Cost of placing an order;
R = Reorder point;
L = Lead time;
H = Annual holding and storage cost per unit of inventory

Then, taking the first derivative of the total cost function with respect to Q, and setting it equal to zero, we obtain the optimized value (at minimum cost) of order quantity (EOQ):

$$EOQ = \sqrt{\frac{2DS}{H}}$$

The reorder point calculus also takes into consideration the average daily demand (d) and lead time (L), as well as the Safety Stock:

$$\textit{Safety Stock} = Z^* \sigma_L$$

$$R = d^* L + \textit{Safety Stock}$$

where:

Z = The number of standard deviations for a specified service level
σ_L = standard deviation of demand over the lead time

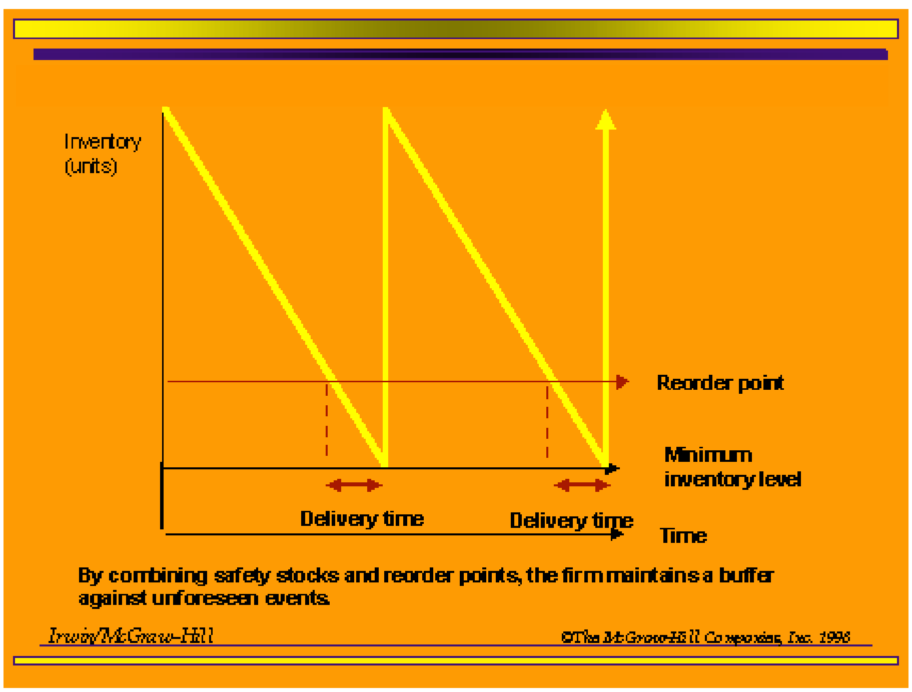


Figure 4: Reorder Point and safety stock

– **<u>FIXED-TIME PERIOD (FTP)</u>**: inventory is monitored only at fixed time intervals (weekly, monthly, ...). The product quantities to order are then variable from period to period and highly

dependent on the previous time window selling rate. The firm could then run the risk of a stock-out because of a sudden increase in sales.
Given a fixed time between reviews (T) and the current inventory level (I), and known the lead time (L) and the forecast average daily demand (d), the order quantity (q) is:

$$q = d \cdot (T + L) + Z\sigma_{T+L} - I$$

where:

Z = The number of standard deviations for a specified service level;

σ_{T+L} = standard deviation of demand over the review and lead time.

- **TWO-BINS MODEL**: in this model the inventory (of capacity C) is seen as split in two parallel ones, each with capacity C/2. As soon as one of them gets empty, an order of C/2 products is performed. This policy can be seen as a variation of the FOQ one, even if no data on the reorder point or on EOQ is required.

A multi-product model

In order to select the best procurement strategy in a Chemist's environment, it is first necessary to set a desired service level for each product or product class and decide which of them should be controlled more frequently. Let's assume that we have a three product model, say our Chemist's only sells three kind of products (for example, namely, "Aspirins ABC", "Antibiotic XYZ", "Antiviral JFK"). On the basis of the ABC analysis, the inventory levels of products belonging to classes A and B should then be controlled more frequently. As already pointed out, the reason for this is mostly because articles in these two classes generate most of the organization's yearly income. Class C, instead, according to the same rationale, requires less rigorous inventory control measures. It's then possible to associate one of the inventory policies previously analysed to each class, thus effectively responding to their different monitoring needs:

Class	Policy	Notes
A	Fixed Order Quantity	Products providing a high inventory value should belong to a class deserving a continuous monitoring policy of the stock levels
B	Fixed Time Period	Products providing an average inventory value should belong to a class deserving a periodical monitoring policy
C	Two Bins	Products providing a low inventory value should be deserved a less rigorous monitoring policy

Table 2: associations between Product Classes and Inventory Management Policies

The associated procurement policy will always be the most adequate, since the inventory levels will always result equal to minimum stocking levels according to the desired requirements, thus avoiding an unprofitable situation in which lots of unclaimed products lay unsold. In fact, by comparing the examined procurement policies, the Fixed Time Period will always require stocking levels greater than those associated to the Fixed Order Quantity. In order to guarantee a desired Service Level, as said, it is necessary to set a proper safety stock, which anyway varies according to the chosen inventory management policy. A more rigorous and careful policy allow to limit the safety stock value since the expected demand provides useful data on right quantities to be ordered. Safety-stock is defined as the stock that is needed in addition to the Expected-Demand in order to provide some level of protection against stock-out. The amount of Safety Stock depends on the desired service level. This is mostly due to the fact that the FOQ policy assumes a continuous monitoring of inventory levels, with an order immediately placed as the reorder point is reached. In contrast FTP models assume that inventory is monitored only at specified revision moments. For example, by considering the difference in having 5 products worth 10€ each laying unsold in stock rather than having 5 products worth 100€ each, one may easily understand the reason for which the procurement policies depend on the overall value of products on stock.

A product undergoing an increase in price, may skip category (i.e.: pass from class C to class A) and then be subject to a more strict control according to its relative inventory level. Since the monitoring policy would be then more rigorous, this would also require a lower safety-stock level, which in turn would bring to a considerable decrease in holding costs, as reported in the following table:

Class	*Safety Stock (SS)*	*Quantity on stock*	*Product Value*	*Safety Stock Value*	*Holding Cost*
C	35	Q(C) + SS	4€	140€	3,5€
B	3	Q(B) + SS	8€	24€	0,6€
A	-4	Q(A) + SS	12€	-48€	-1,2€

Table 3: an example of the decrease of the Holding Costs

Where:

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Holding Cost = Stock Value * Interest_Rate
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with an interest_rate of 5% over a period of 6 months (that is, for example, for Class C: Holding_Cost = 140*(0,05*6/12) = 3,5).

As the safety-stock variation becomes negative, this means that the actual service level would be higher than the desired SL. It is then possible to reduce the reorder point.

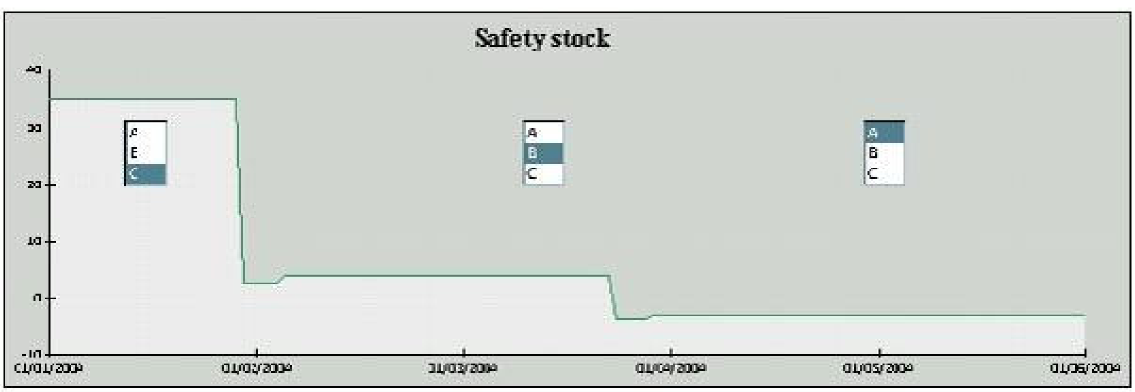


Figure 5: The safety stock dynamically varies according to the actual inventory management policy.

By dynamically updating the situation (in a simulation or in a DSS, both based on real data from the firm) and the overall "value" of products on stock, policy-class associations may also change with time.

The advantages of this model were found to be more evident especially in presence of high and unexpected customer demand or price variations.

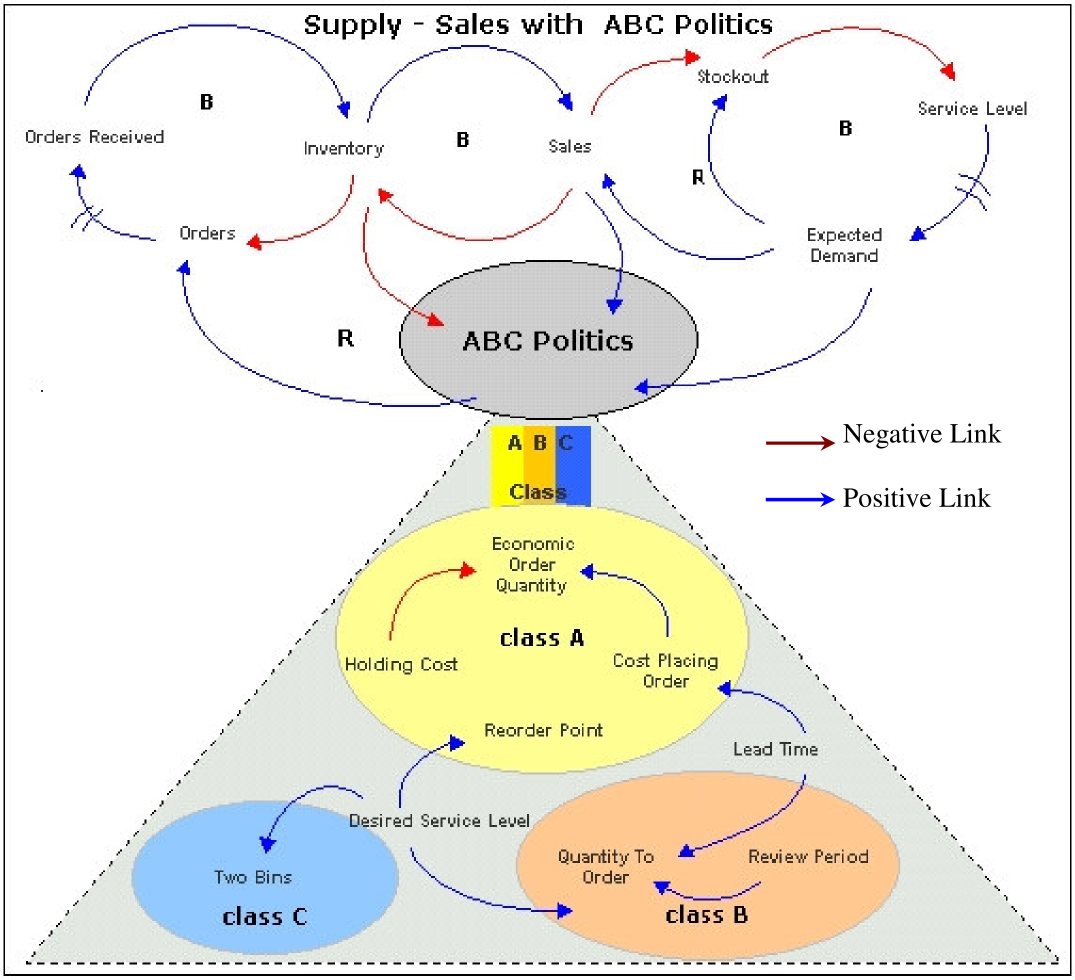


Figure 6: Causal loop diagram depicting the dynamics underlying the association of classes to inventory management policies

By taking into account different inventory management policies (a supply chain aspect) according to service level indications (a marketing aspect), we have thus seen how our beginning model may effectively allow for a shared decision policy between the two management areas considered so far.

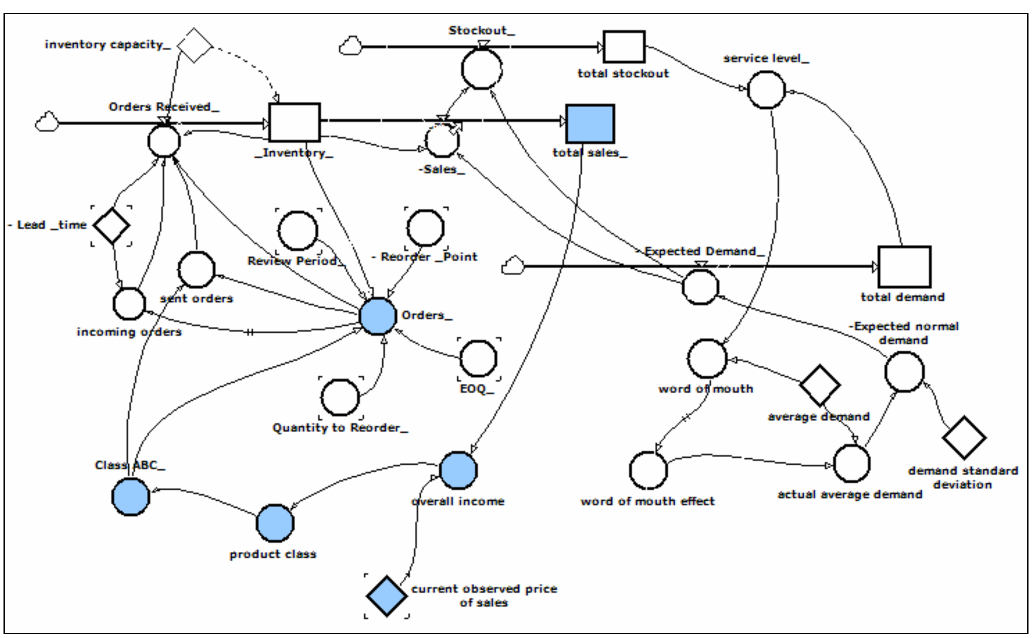


Figure7: The Inventory Stock & Flow Diagram

If we consider the rationale behind the causal relationships depicted in the Causal Loop Diagrams above, we now show how a simulation model has been designed in order to represent the dynamics explained in the previous sections.

As standard System Dynamics modelling suggests, *Inventory* is a stock while *Orders* and *Sales* are the inflow and outflow affecting it. We have modelled sales as determined each moment by an *Expected_Demand* flow as well as by the total amount of products currently on stock (*Inventory*):

```
Sales = MIN(Inventory, Expected_Demand)
```

where the Expected Demand has been modelled with a Normal. It is interesting to notice how a good Service Level (modelled as depending on a stock-out situation) may positively impact sales by means of a word of mouth effect on the average expected demand (see also the paragraph "Adding up Marketing Issues").

According to the Orders rate, we have modelled it as dependent both on a previous ABC Inventory analysis (*ABC Class*), in order to determine to which class each product belongs to, and on information concerning *when* and *how much* to order, that is the inventory management policy.

Such information is:

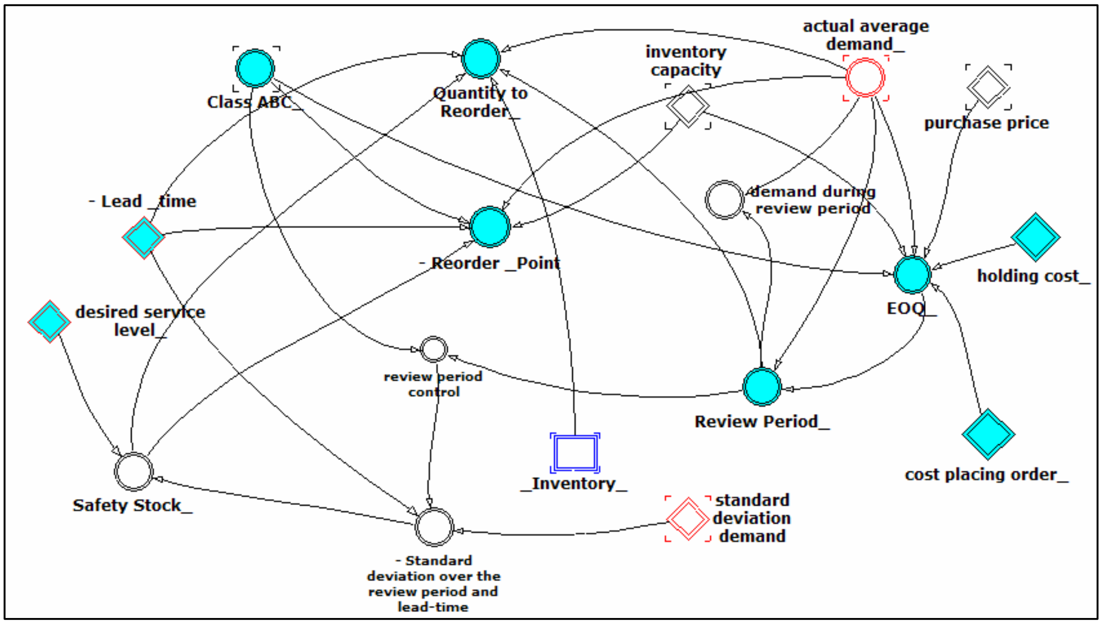
1. Fixed Time Period (FTP): *Quantity to Reorder* and *Review Period*
2. Fixed Order Quantity (FOQ) and Two Bins (2B): *Reorder Point* and *EOQ*
3. ABC Class: *Product Class* calculates the percentage of the Overall Inventory Economic Value (OIEV) for each array element (that is for each actual product in our model). According to threshold percentages that we defined in order to establish to which class each product type belongs to, we have for each product type j in the array of available products types the following situation:

   Given M product typologies $P_1 \dots P_M$, each of them possessing a certain amount on stock (that is, for each typology, say "Aspirins XYZ" we have 20 boxes on stock while for "Antibiotic WXZ" we have 30, and so on…), we suppose to order them according to the "Inventory Value" rationale described in previous sections. Note that Inventory Value is calculated according to the following rule:

$$\mathrm{INV\_VAL}(i) = P_i\,(\mathrm{value}) * P_i\,(\mathrm{volume})$$

We define a procedure, **CLASS**, which will sort out product categories $P_1 \dots P_M$ into the three desired classes A, B and C (see appendix for details).

So we have (also according to the associations described in Table 1 and mathematical rules already defined in paragraph "Service Level and inventory management policies"):



Figur 8: SFD calculations of EOQ and other parameters

Which brings us to have:

Class Type	Inventory Management Policy	Order Function
A	FOQ	`Orders = f (Reorder Point, EOQ)`
B	FTP	`Orders = f (Review Period, Quantity to Reorder)`
C	2BINS	`Orders = f (Inventory Capacity, Bin Capacity)`

Table 4: The order rate depends on the policy which in turn depends on the Class of the product to be ordered

Expanding the boundary of the model: economic and financial issues

Managing an organization, independently from its dimensions, essentially means taking actions which tend to generate both costs and revenues, as well as investing money which translates in other assets (real estates, share investments, etc...) and floating capital.

Thus, we can underline two different aspects:

1) an **economic** aspect, mostly consisting in the need for each CEO/Enterpreneur/Chief Manager to reach the break even point for its organization (that is, a positive balance between revenues and costs);
2) a **financial** aspect, mainly consisting in determining the best investments to do and which resources to use towards this end, eventually determining whether to resort or not to the bank credit system.

It is easy to understand how any management decision regarding procurement, marketing, trading, administration, human resources, etc... may have side effects or reflections both in economic and financial terms. This brings us back again to the need of a systemic view of the firm.

When thinking of a strategy tending to increase incomes by raising prices or by selling more products, we could find out that the expected income would be, as described in the previous sections, delayed in time. In fact it happens in some situations that customers are allowed a certain delay in payments (see Hospitals, or Local NHS Services as Primary Care Trusts or Walk-in Centres). Under these conditions, there would of course be an increase in credits (to be collected in the future) but also a generation of the need of ensuring a certain level of inventory by reordering.

We then see that such a strategy, even if produced a long term income, has instead created at the same time the need for cash; that is a need for an increase in the floating capital. This, because of a negative financial cycle, would be then achieved with new capital investments. Selling more products could at the same time generate, because of the success of the firm in its market, a process which could bring to an increase in demand and in the overall yearly sales of the company. This means growth. And such a situation would ask for even more investments, such as for example new warehouses or widening existing storehouses. The organization has then the need to operate also at a financial level.

Economic and financial decisions then appear to be strongly connected by causal relationships, as in the following figure, and every management decision should then be carefully calculated in order to take into account possible effects or consequences.

The Floating Capital and the Financial Cycle

As we have already seen, an increase in sales not always corresponds to an immediate increase in income: there exists a certain delay. In a similar way, the procurement of products out of stock not always underlines an immediate outcome (costs) for the firm, since suppliers often allow for a certain delay in payments. Whatever these delays are, we want to point out the concept of the rare coincidence between costs/revenues (economic aspect) and incomes/outcomes (monetary aspect, that is when the money effectively becomes into - or goes out of - possession of the company, see[8]).

Given that:

DPC **=** *average Delay of Payment from Customers*

DPS = *average Delay of Payment to Suppliers*

an organization can face one of the possible following situations:

Situation	Cash availability	Actions
DPC < DPS	Immediate cash if DPC = 0 Positive Circulating Capital (CC)	Short term Financial Investments, deposit on bank balance, internal investments
DPC > DPS	Lack of resources Negative CC	Invest using own resources/capitals or resort to the credit system in order to compensate the delay between expenses and revenues.

Table 5: Financial Cycle possible situations

In light of what just analyzed, when speaking of the financial cycle (roughly, the delay between debts and credits) we can thus accept the following equation:

`Financial Cycle = DPC + Average Time on Stock – DPS`

A simplified causal loop describing this situation can be examined in the following figure:

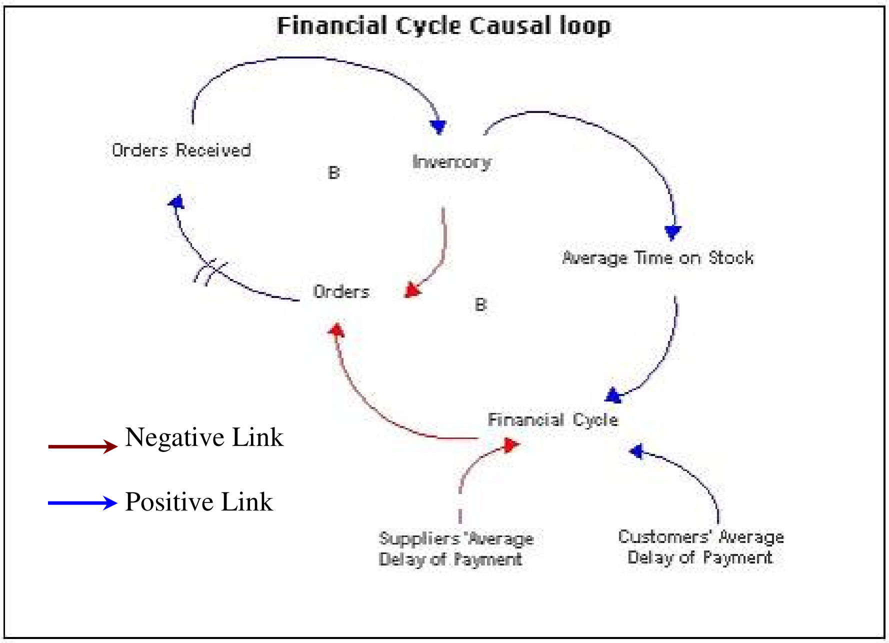


Figure 9: Financial Cycle Causal loop (simplified)

Orders do not only depend on products' Inventory levels but also on the influence that the latter have on the floating capital, in turn measured by means of the financial/monetary cycle.

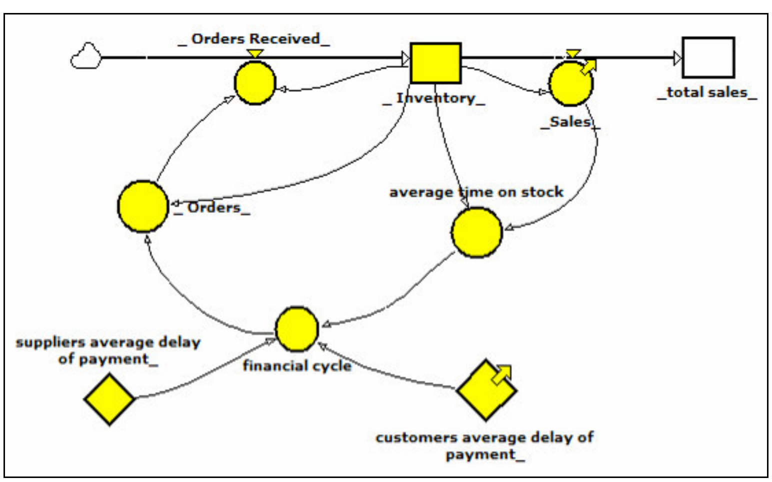


Figure 10: Financial Cycle Stock & Flow Diagram

Financial Forecasting and Cash-flow dynamics

Forecasting is a fundamental tool that supports a Chemist's planning and control. Cash Flow reports essentially the movement of money into and out of the enterprise during a fixed period. So it is determined by the amount of orders and sales, taking into account the delays in customers' and suppliers' payments (see[2],[6]).

Cash flow forecasts try to predict the cash inflows and outflows in the future, considering the credits own and the debts due in a certain period, in order to evaluate any possible increase or decrease of liquidity on the firm's bank balance.

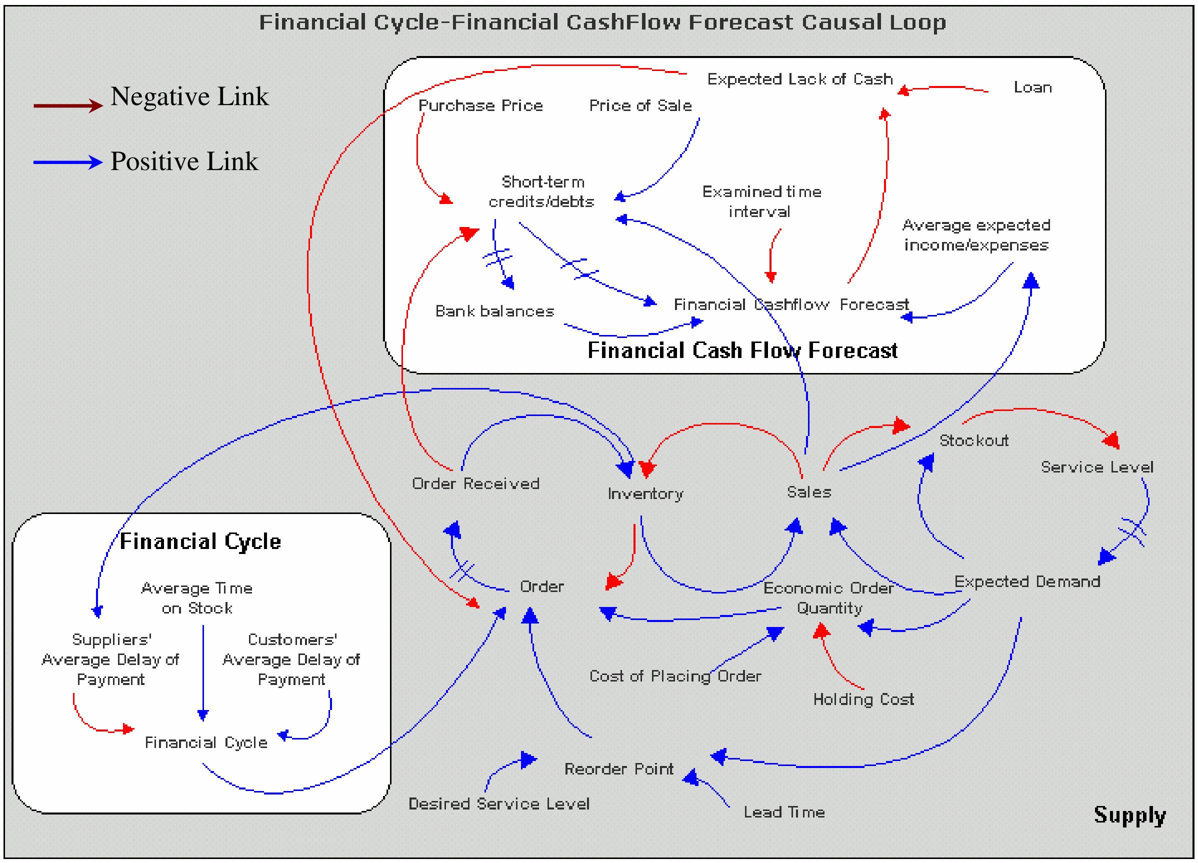


Figure 11: Causal relationships between the Procurement Area and the Finacial Area

The main aspect we tried to focus on, lies then in the following equation (all the arguments are to be considered with values inside a specific time interval):

Financial CashFlow Forecast = Bank Balance + Expected Incomes + Short Term Credits - Expected Expenses – Short Term Debts – Overall Management Expenses

If the Financial CashFlow Forecast should point out an Expected Lack of Cash, orders of products with a Financial Cycle showing an absorption of resources will then be limited. This will in the long run bring the financial situation back to equilibrium (Financial Cycle > 0) as well as create a positive cashflow which will enable the firm to start back ordering those products whose orders had been suspended or at least slowed down. In particular, financial cash flow forecasting allows considerations about the impact of sales, the expenses, the cost of sales, the payroll.

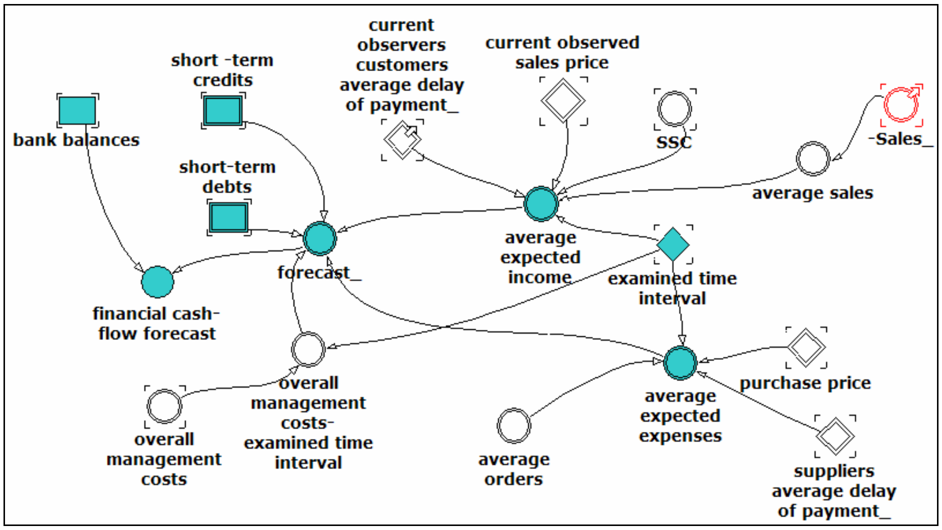


Figure 12: The Financial Cash-Flow Forecast SFD

The interaction between the cash flow forecast and the financial cycle is pointed out in the following figure, where the Expected Lack of Cash, deduced from the Cash-Flow Forecast, influences the Order quantity, which belong to a loop the influences and is influenced by the Financial Cycle.

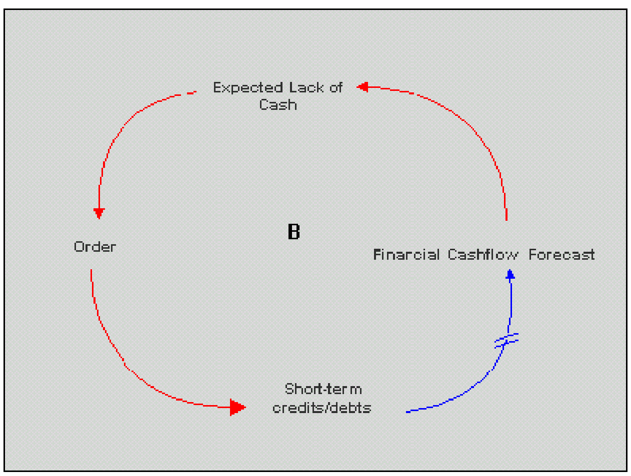


Figure 13: Cash equilibrium dynamics

In particular, financial cash flow forecasting allows considerations about the impact of sales, the expenses, the cost of sales, the payroll. The interaction between the cash flow forecast and the financial cycle is pointed out in the following figure, where the Expected Lack of Cash, deduced from the Cash-Flow Forecast, influences the Order quantity, which belong to a loop the influences and is influenced by the Financial Cycle.

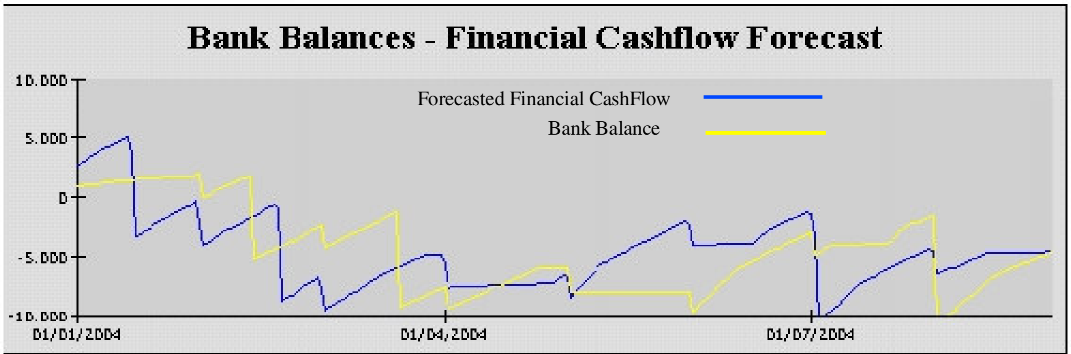


Figure 14: The behaviour of the bank balance reproduces quite well (with a certain delay) the behaviour of the forecasted financial cashflow

Adding up Marketing issues

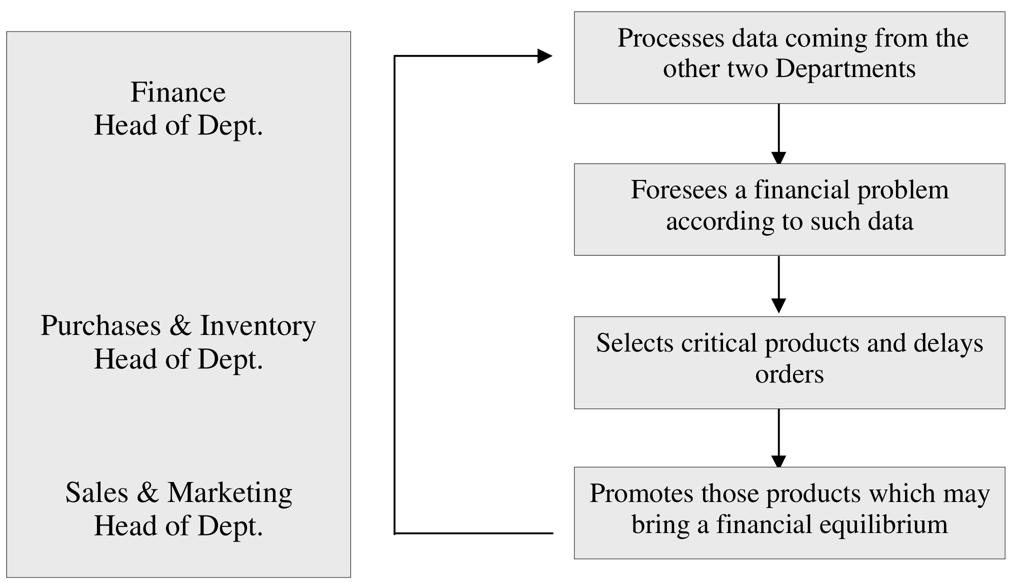
Marketing is the set of tools and strategic decisions by which the chemist's management can improve the relationship with its suppliers and customers. For an efficient use of such tools a real understanding of the dynamics of the goods demand and requirements is needed. So the objective of the marketing managers is understanding clients' needs, ordering products and organizing services that meet those needs, then pricing and promoting those products and services. A marketing analysis is a structured approach to evaluating clients' environment, revealing lucrative market opportunities and mapping out an effective strategic path.

The planning process involves: a situation analysis, in order to evaluate clients strengths and weaknesses, and external opportunities and threats; a market definition, in order to segment market, profile targeted consumer groups and forecast potential sales; a strategic development, to establish, validate and align competitive positioning, promotion and sales strategies. Starting from the plans, continuous marketing actions are needed, using fundamental tools such as price and promotion policies.

As long as the marketing issue is concerned, products on sale usually already have very well-defined characteristics because of an original effort made by the big production companies of medicines. It seems then necessary that the Chemist be informed on how these producing companies conduct their marketing and advertisement campaigns as well as try to evaluate how such campaigns may produce good or bad effects for the sales.

Marketing as an aid to the Financial Management Area

Marketing actions can help the financial management area with prices and promotions policies in order to increase the sales of those products that generate financial resources, thus encouraging the financial equilibrium (see [7]).



The action of a marketing campaign influences the Expected Demand. If this action is further stimulated by a Financial Cycle showing resource absorption, then it will act in order to stimulate demand, both by means of word of mouth and a price/promotion effects. This means that the Marketing Dept. Head will be addressed to act on the price and promotion handles in order to increase sales of those product which generate resources at a floating capital level.

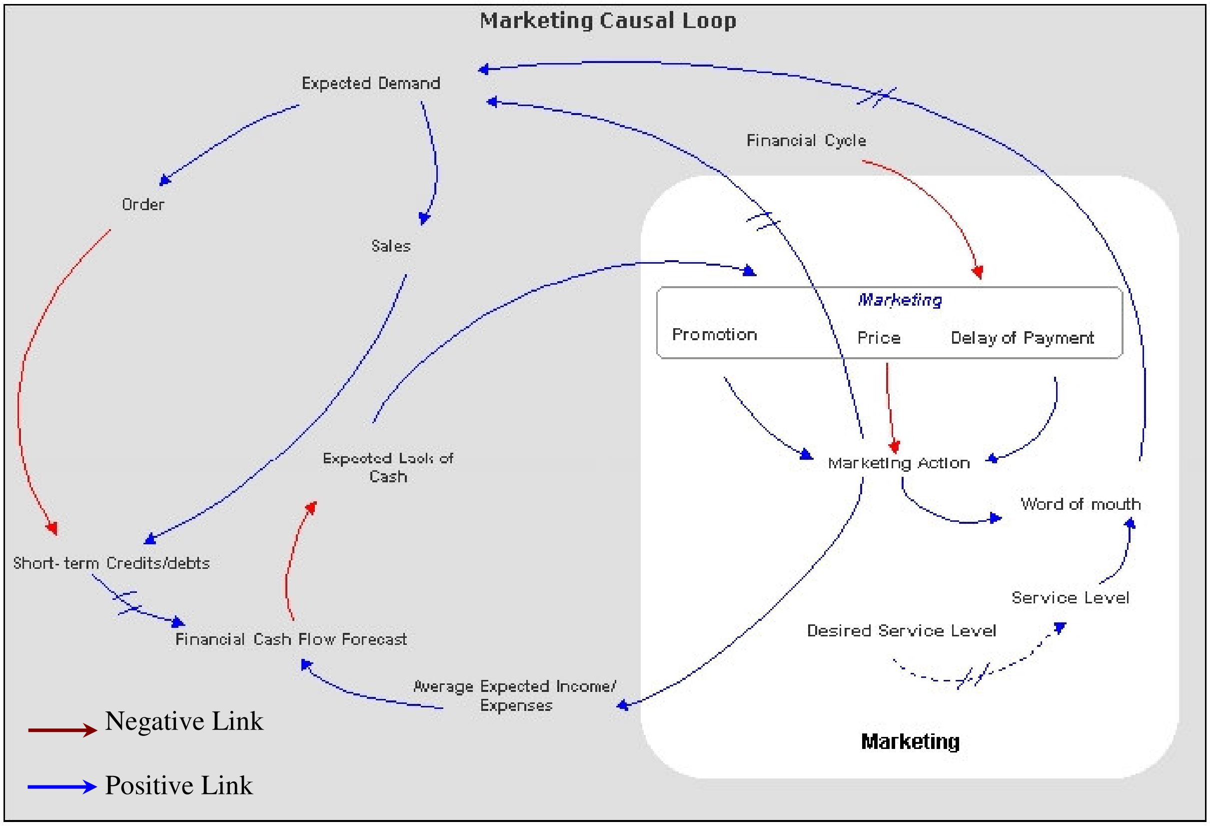


Figure 15: Marketing and financial causal loop diagram

As we see from the following picture, average sales increased as soon as a marketing action based on a simple strategy of price/promotion mix was implemented in our model.

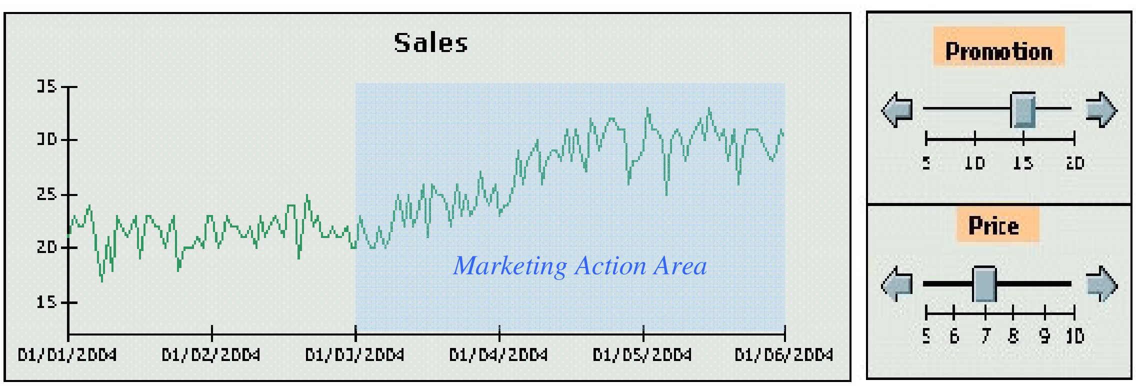


Figure 16: Average sales increase as the marketing action comes into play

As we see from the Marketing CLD, we modelled the marketing action as dependant on three main variables: price, promotion and delay of payment. We used the *Weber-Fechner Model* in order to evaluate the influence that such a conceived marketing action may have on demand:

```
mkt  action = a + b*ln(current observed price-current reference price)/current
                reference price + c*F[promotion, payment conditions, ecc…]
```

where:

- **a**: weight of the average demand *without* the Marketing Action
- **b**: measures the sensibility of demand to price variations
- **c**: measures the sensibility of demand to promotions

Moreover, we see that the *actual_average_demand* depends both on a word of mouth effect as well as on the MKT_action_effect by means of the aggregate variable *MKT_action_word_of_mouth*, so that:

```
actual average demand = average demand + MKT action_ word of mouth
```

where:

```
mkt action_word of mouth = DELAYPPLMTR((MKT action * average demand) + Word of
                                mouth; customer visit frequency)
```

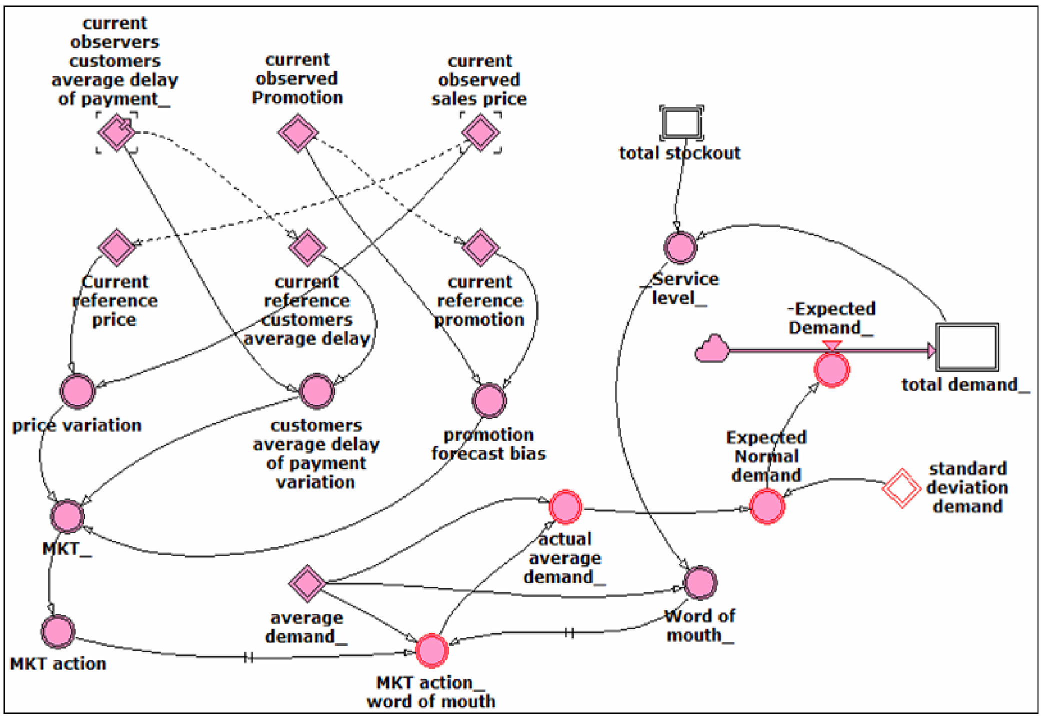


Figure 17: The marketing stock and flow diagram

Overall Causal Loop Diagram

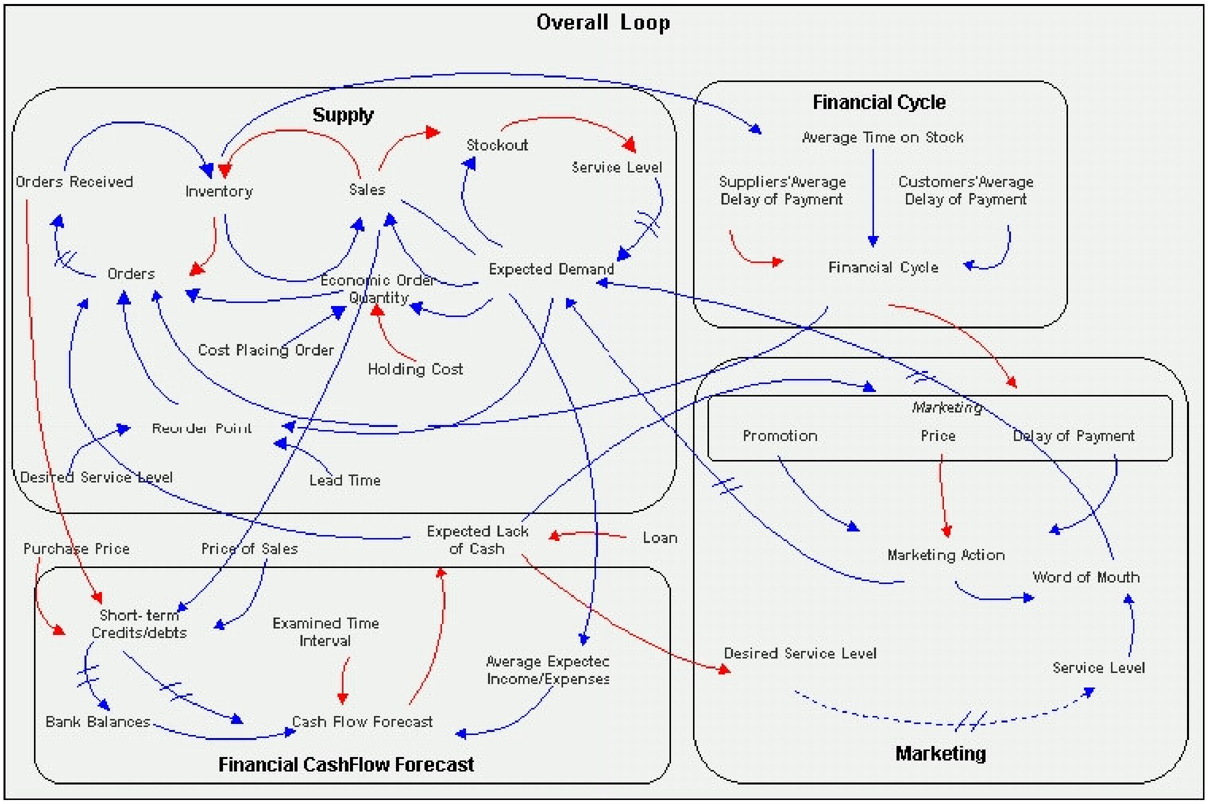


Figure 18: Overall causal loop diagram describing the interdependencies between the three identified management areas

The overall causal loop diagram above reports all the main interactions included in our model. We implemented the model in a Powersim Studio 2001 Demo Edition and realized an interesting Flight Simulator which also allowed us to draw some analysis results, as will be seen from the following case study.

Case Study: Public Health Service on the hem of the crisis.

The problem of delays in suppliers' payments seriously compromises the Italian National Public Health Care service level. The average delay with which NHS local units and hospitals usually pay their own suppliers (e.g. the Chemist's), ranges from three months to one year, well beyond the 90 days by law and the national average of 150 days. A vicious circle is then originated and the enterprises offering those goods/services are forced to resort to the credit system and get indebted in order to comply with VAT payments, then also to face with the problem of limited resources for technological innovation, and to invest in human knowledge.

In order to avoid such financial burdens, one would expect an increase in the costs of the supplies of goods and services, which would then further weight down the National Health Care System budgets. The effects of this critical situation are twofold: the NHS structures are alarmed (already conditioned from the budget limits) by the impossibility to maintain the quality of certain services, or even get incapacitated to run the demanded services, while the suppliers run the risk of getting a deny in credits by the banks (with repercussions inside the enterprise, which sooner or later would then no longer be able to manage its multiple engagements) [9].

That is the case, for what concerns the sale of medicines to certain type of customers, in which often the Chemist's finds itself: the Chemist must wait a long period of time for the reimbursements from the National Health System, which is greater than the payment delays obtainable from his own suppliers. Therefore, while in the case of many enterprises the Finance Head is able to create resources, in the Chemist's these are absorbed: it becomes then necessary to resort to additional financing. An example that illustrates the determination of the financial cycle of two different situations is reported below: one class of products is mainly sold to NHS Local Units or hospitals, while the other is for public sale in the shops (see [8]).

Delays	Sales to Hospitals and Public Sanitary Bureaus	Sales to the public
Average product time on stock (days)	0	15
Average Suppliers quittance delay (days)	60	30
Average Customers Payment delay (days)	150	0
Financial Cycle (under monetary terms)	150 + 0 - 60 = **90**	0 – 30 + 15 = **-15**
Managing the floating capital	Draws resources	Generates new resources
The company may balance drawn resources with those generated		

Let's examine a situation in which we are allowed to manage for 6 months a Chemist's Shop in which we sell only three categories of products, the first two of them undergoing reimbursement from the NHS, while the third is able to bring immediate cash to the Chemist's. Here are the initial conditions of the parameters/variables of interest:

Product category	1 (NHS)	2 (NHS)	3 (cash)	
Bank balances (€)				**1000**
Loan (€)				4000
NHS Payment delay (days)	150	120	0,0	
Suppliers quittance delay (days)	45	30	30	
Price of sale (€)	7,0	8,5	5,5	
Purchase Cost (€)	5,5	6,5	3,0	
Expected Demand	22	20	24	
Desired Service level	**99%**	**98%**	**90%**	

Non collegial policy management: a typical open-loop approach

The marketing director, without considering the aforementioned financial problems, will concentrate in trying to increase the sales inducing the head of the buyers to carry out greater orders. This will increase the indebtedness degree and will consequently reduce the cash. In such a situation the banks could deny further credit to the Chemist's that will be soon insolvent again towards suppliers. These difficulties will have impacts on the sales and will further bring down the financial situation.

Here are the implicit counteracting objectives of the three Department Heads (see also Table 1):

Management Area	Implicit Open-Loop Objective
Procurement & Inventory	- Guarantee desired/required minimum stock levels - No stock-out
Marketing & Sales	- Increase income and generate profits - Increase/Mantain demand/market share levels as well as Service Level
Finance	- Guarantee financial equilibrium - Mantain a positive cash situation possibly without exausting the loan amount and thus not incurring in problems with the bank)

Here are the results of the simulation:

Non-collegial Policy results:

Product Type	1	2	3	
Bank balance (after 6 months)				**-7740 €**
Credits (€)	13760	20151	121	
Debts (€)	3443	3250	2277	
Average Sales	13,2	19,0	21,3	
Service level (pct)	**66%**	**95%**	**88%**	

In a time graph we can also better appreciate the scarce results of such an open loop non-collegial policy.

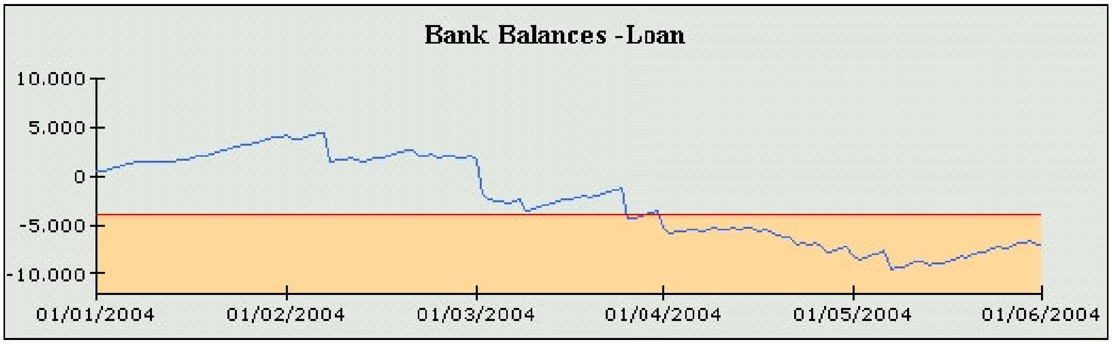


Figure 19: The result of an open-loop non-collegial policy would soon bring to financial problems.

Collegial policy management: a systemic approach.

The Procurement & Inventory Area Head Dept. and its staff must adapt the supplying policy so as to favor the strategic choices of the marketing director and its staff, instead of building, as often happens, a capacity constraints that sometimes makes useless the company efforts. Moreover, taking into account financial aspects, it appears necessary to orient activities as much as possible towards those fields which are able to create resources from the management of the floating capital. For the marketing director, the resources absorbed by a negative management of such a capital (the sale to NHS Local Units and hospitals) can be for example compensated through an proper diversification of its own offer, that involves also the sale of certain medicines to the public behind immediate payment.

In a Chemist's, this can be evaluated a-priori if the purchasing of a certain lot could be financially covered, and, if this is not the case, it is possible to increase the purchase of articles with a financial cycle which generates resources, and in the meantime limit the purchasing and the stock level of those which instead absorb resources. Thus, this procedure will help the Chemist's management, often unbalanced mostly towards selling activities, not to neglect the financial dynamics invoked by the sales-purchases and by the costs of the employees and the rent of the working places.

Collegial Policy results

Product Type	1	2	3	
Bank balance (after 6 months)				**60 €**
Loan (€)				4000
Credits (€)	16500	16200	330	
Debts (€)	5300	3500	3000	
Average sales	20	18	22	
Service level (pct)	**96%**	**95%**	**97%**	

Figure 20: A coordinated action coming from collegial decision making allow for a sustainable organization.

From a quick comparison between results we have:

Product category	1		2		3		Tot A	**Tot B**	**Delta**
Bank balances							-7740	**60**	***+7800***
Credit	13760	16500	20151	16200	121	330	34032	33030	-1002
Debts	3443	5300	3250	3500	2277	3000	8970	11800	+2830
Average sales	13,2	20	19,0	18	21,3	22	53,5	60	
Service level	**66%**	**96%**	**95%**	**95%**	**88%**	**97%**			

As we can see, we were able, by taking into considerations at the same time all of the (now explicit) objectives of the various Deparments, to have lesser credits, a little more debts and a general good situation in which our Loan hasn't been exhausted. By pushing a little more on the third product (which was the one allowing to have quick cash), it was possible to get to far a better economical situation. Even though the desired service levels for product 1 and 2 are not met, this is not a real problem since we're talking about sales to hospital or health care institutions where it is not necessary to have by law (as it happens instead while selling medicines to the public in Chemist's Shops) a certain Service Level for those product types undergoing reimbursement from the Italian NHS.

Conclusions and future work

In the end, our model brings into consideration, those many aspects which play important roles in managing a Chemist's. By observing the dynamics given by the interaction among the various structures, the Chemist himself, without outsourcing management to expensive Consulting Companies, will learn to interactively and promptly do the best choices, refining them from time to time. He will be able to develop the ability to take difficult management decisions as well as corrective actions in order to align enterprise performance objective and its mission at best.

Thanks to the collegiality of the decisions and the system dynamics approach it has been possible to:

- Continuously determine and monitor the quality of the offered services
- Guarantee the compatibility between the service level to be offered and the available economic and financial capacity
- Understand the dynamics of the firm's cash-flow by checking the variability in the payment conditions from suppliers and customers
- Limit the conflicts arising in the decision making process
- Provide a valid tool to management control in order to evaluate the company performance

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APPENDIX: Sorting of product categories in classes (ABC CLASS)

We first need to define:

ONEI: Overall Number of Elements on Inventory

OIEV: Overall Inventory Economic Value (that is the sum of all INV_VAL(i))

T_INV: N° of elements on Inventory Threshold

T_VAL: Economic Value of Inventory Threshold

LIST: auxiliary list where to put elements which are likely to belong to class X

INV_ACC: n° of elements accumulator

VAL_ACC: economic value accumulator

Thus we have:

PROCEDURE CLASS

```
|   start
|   while (INV_ACC <= ONEI * T_INV)
|      do   if (VAL_ACC <= OIEV * T_VAL) then
|              if (i<=M) then [
|                           add prod_type(i) to LIST X
|                              update accumulators with next element's values
|                              CLASS (i+1, LIST X, ACCs)
|                              ]
|              else return;
|           else [
|                 add product to LIST X and return LIST composition
|                 reset accumulators to zero
|                 CLASS (i+1, LIST X, 0) -> (check if next elements may also
|                                                  belong to LIST X)
|                 ]
|   return;
|   end;
```

We will then execute the procedure with the following instances:

CLASS (i, A, 0)

CLASS (i, B, 0)

CLASS (i, C, 0)

where the counter "i" gets updated during each procedure's execution (we didn't show this for simplicity in the procedure above)

Example:

Suppose we have 12 categories of product with the following situation:

Product Category ID	1	2	3	4	5	6	7	8	9	10	11	12
Quantity	10	10	10	10	10	10	10	10	10	10	10	10
Value	20	15	10	8	6	4	3	2	2	1	1	1

If we further decline the table with cumulative values in terms of Overall Economic Inventory Value (OIEV) and Overall Number of Elements on Inventory (ONEI) we have the following table:

	T_INV	T_VAL					
RATIONALE CLASS A	0,25	0,5					
RATIONALE CLASS B	0,4	0,2					
PRODUCT CATEGORIES	Quantity	Value	Slope	Cum. Q.ty	Cum. Value	% Q.ty	% Val
1	10	20	2	10	20	0,0833333	27,39726
2	10	15	1,5	20	35	0,1666667	47,94521
3	10	10	1	30	45	0,25	61,64384
4	10	8	0,8	40	53	0,3333333	72,60274
5	10	6	0,6	50	59	0,4166667	80,82192
6	10	4	0,4	60	63	0,5	86,30137
7	10	3	0,3	70	66	0,5833333	90,41096
8	10	2	0,2	80	68	0,6666667	93,15068
9	10	2	0,2	90	70	0,75	95,89041
10	10	1	0,1	100	71	0,8333333	97,26027
11	10	1	0,1	110	72	0,9166667	98,63014
12	10	1	0,1	120	73	1	100
total	120	73	0,608333		120		
CALCULUS RATIONALE A	30	36,5	1,216667				
CALCULUS RATIONALE B	48	14,6	0,304167				

By executing the procedure, we have the following situations:

Procedure: Class A	**Step 1**	**Step 2**	**Step 3**	**result**
Sequence in LIST creation	**1**	**1,2**	**1,2,3**	**1,2,3 -> CLASS A**
Cum. Q.ty	10	20	30	
%Cum Q.ty	**0,08**	**0,17**	**0,25**	
Cum. Value	20	35	45	
%Cum. Value	**0,27**	**0,48**	**0,62**	

We see that at step 3 we have found a percentage of Inventory composition satisfying the "Cum_Qty% <= T_INV(A)" condition (**c1**) as well as the "Cum_Val% >= T_VAL(A)" one (**c2**).

We will now check whether also the other following categories may belong to Class A.

Procedure: Class A	**Step 1**	**Step 2**	**Step 3**	**result**
Sequence in LIST creation	**4**	**4,5**	**4,5,6**	**4,5,6 -> NO CLASS A**
Cum. Q.ty	10	20	30	
%Cum Q.ty	**0,08**	**0,17**	**0,25**	
Cum. Value	8	14	18	
%Cum. Value	**0,11**	**0,19**	**0,25**	

In this situation, categories 4, 5 and 6 cannot be added to CLASS A since when **c1** is met, **c2** isn't satisfied. Then we have to carry on our calculations and see whether these categories may belong to CLASS B.

Procedure: Class B	Step 1	Step 2	Step 3	Step 4	result
Sequence in LIST creation	**4**	**4,5**	**4,5,6**	**4,5,6,7**	**4,5,6,7 -> CLASS B**
Cum. Q.ty	10	20	30	40	
%Cum Q.ty	**0,08**	**0,17**	**0,25**	**0,33**	
Cum. Value	8	14	18	21	
%Cum. Value	**0,11**	**0,19**	**0,25**	**0,29**	

In this case we see that at step 4 we have found a percentage of Inventory composition satisfying the "Cum_Qty% <= T_INV(B)" condition (**c3**) as well as the "Cum_Val% >= T_VAL(B)" one (**c4**). We will now check whether also the other following categories may belong to Class B.

Procedure: Class B	Step 1	Step 2	Step 3	Step 4	result
Sequence in LIST creation	**8**	**8,9**	**8,9,10**	**8,9,10,11**	**8,9,10,11 -> NO CLASS B**
Cum. Q.ty	10	20	30	40	
%Cum Q.ty	**0,08**	**0,17**	**0,25**	**0,33**	
Cum. Value	2	4	5	6	
%Cum. Value	**0,03**	**0,05**	**0,07**	**0,08**	

In this situation, categories 4, 5 and 6 cannot be added to CLASS A since when **c3** is met, **c4** isn't satisfied. Since these categories where the last ones to be considered, and since there are no more classes other than CLASS C, they will for sure belong to Class C.