

Mailing Decisions in the Catalog Industry

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### **ABSTRACT**

This paper is concerned with mailing decisions in the catalog industry. We present an overview of the catalog industry and its practices. Then, we describe a linear programming model to help catalog companies determine the most profitable mailing strategy over the planning horizon. The solution of the model specifies for each campaign how many names should be rented, how many catalogs should be mailed to the house list, and how many multiple mailings to do for each house segment to produce profitable buyers. This model can be used to test the performance of the company with respect to different operational, financial and market conditions. The model rely on data that is commonly available in catalog companies.

## 1 - OVERVIEW OF THE CATALOG INDUSTRY

The catalog industry is the most important part of the direct marketing industry. The term catalog industry is frequently mixed up with mail order and direct mail business. All of these lead to a direct sale without using an intermediary. For purposes of this study, we define catalog industry as a method of promoting business by mailing sales literature - **catalogs** - directly to prospective customers and encouraging them to purchase products and services via mail, fax or phone orders (Holtz 1990). For the product sector, this industry is dominated by companies that sell merchandise made by third-party vendors although there are several that sell their own products. The major activities of this industry are: offer selection, catalog production, mailing lists selection, inventory planning, catalog mailing, order processing and shipment of the merchandise. This paper focus on mailing lists selection.

Catalog companies can divide the calendar year in periods of equal length; examples are two periods of 6 months each, or four periods of 3 months each, and so on. The companies mail catalogs to their potential buyers during each period; these mailings are called "a campaign." During a campaign the companies can mail a one-time catalog (*single mailing*) to a prospect and/or mail multiple catalogs to the same customers (*multiple mailings*).

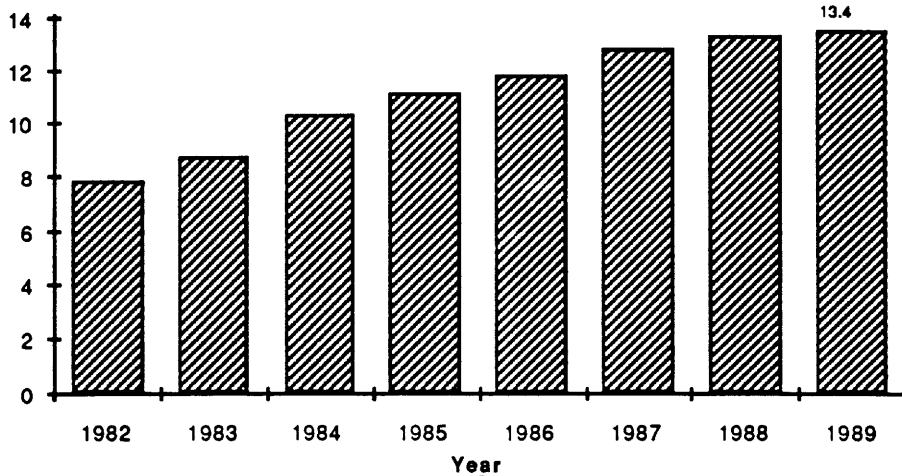
The catalog industry is often seasonal and generally a campaign coincides with a season of the year -- this explains why the words campaign and season are often used interchangeably.

The catalogers frequently test products, offerings, price, rental lists, and the like. They take advantage of a campaign to test under real marketplace conditions. The results of the tests are used for the next campaigns.

The catalog industry has come a long way since 1872 in the United States when Montgomery Ward published a one-page list of clothing items that could be purchased by mail. By 1927 two heavyweights in both catalog and retail store operations, Montgomery Ward and Sears Roebuck, were mailing 75 million letters and catalogs. In the first part of the 1980's, catalog sales experienced rapid growth. By 1989 100,000 companies were distributing more than 13 billion catalogs, see Figure 1, with more than 30 million catalogs in the mail every day.

While retail sales are growing at around 6 percent annually, catalog/direct mail sales are growing at around 10 percent. One of the most important factors driving that growth is increased computer power. It has allowed companies to build enhanced customer databases, capture and process information regarding customers' income, demographics, family composition and buying trends. With that, catalogers are targeting their mailing to customers most likely to buy.

**billions of catalogs**



**Fig. 1 - Estimated Number of Catalogs mailed**

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Source: DMA/USPS Revenue, Pieces and Weight by Classes of Mail Report, 1990

Buying by mail has advantages and disadvantages, as perceived by the customer. The most important advantages are:

- convenience -- the customer does not have to leave home or office to shop;
- lower price -- the popular notion is that mail order catalogs offer items more cheaply than retail channels;
- exclusivity -- the catalogs offer some exclusive items not found elsewhere easily, such as rare imports or unusual items like odd sizes, special safety clothing, etc.;
- more useful information and more service -- each item in the catalog is often described in detail, in contrast to the indifference and self-service of retail stores;
- serve customers who are unable to get to retail stores -- those who are disabled, the elderly, and many who do not have access to transportation.

The disadvantages are:

- the apparent delay -- for many, no matter how long the delay in deciding to buy, once the decision is made, the product must be obtained immediately;
- the customers do not have the opportunity to examine the item directly -- they must rely on illustrations, descriptive language and written promises of benefits;
- the inconvenience and expense of returning an item that is unsatisfactory for any reason -- some items need to be assembled and then disassembled if they need to be returned;

- the inconvenience of storing the original packaging material -- perhaps for the entire guarantee period;
- the time to replace an item that is returned;
- the inconvenience in getting a refund, if desired;
- the potential misuse of the credit card number;
- the fear of doing business with an unknown firm, sometimes located hundreds of miles away;
- the concern over deforestation and waste;
- the concern about violation of consumer privacy.

In order to overcome these potential disadvantages, to face the competition, and to differentiate themselves from the conventional retail stores, the catalog industry has emphasized customer service such as: extended day service, toll free numbers that make ordering easier, overnight delivery systems that decrease the time lag between ordering and receiving shipments, liberal return policy, money back guarantee, and so on.

## 2 - INDUSTRY PRACTICE

In this section we present the common practice of the catalog industry for designing mailing strategies, i.e., the decision model used by some of the best organized companies in the marketplace. In the next section we comment on the basic deficiencies of that model.

### 2.1 - COMMON PRACTICE

The overall business strategy of the catalog companies is composed of two parts: the offense and the defense. Virtually all firms employ some combination of offensive and defensive strategies (Fornel 1991). The offense is concerned with customer acquisition and deals with rental lists; the defense is concerned with the customer retention and deals with house lists.

**Rental lists** are lists of potential buyers whose names the catalog companies rent from the brokers in order to acquire new customers. The firms pay a rental fee to use the name of these potential customers and send them catalogs. The potential buyers can be identified on the basis of cultural, social, personal and economical factors, as well as previous mail-order purchase. Once potential buyers respond with an inquiry or order, their names and addresses become property of the firm and it does not have to pay for using them in the future. The data of these customers become part of the house list database. Usually the house list is updated in segments after each campaign according to a **R-F-M** classification (Kloter 1991), where R = **Recency**: time since the last purchase; F = **Frequency**: total number of purchases in a given period of time; and M =

Monetary amount: amount spent in the last purchase. This classification is also used in other businesses (Buchanan 1987). The firms consider the best segments those with customers who bought most recently, who buy frequently, and who spend the most. Nevertheless, from the literature survey and contacts with catalog companies we feel that much more emphasis is given to recency and monetary amount than to the frequency.

For the best house segments, the monetary amount per order and the response rate (percentage of orders received per mailing) are higher than those for other segments and for the rental lists. For these best segments, firms send catalogs several times during a campaign in a strategy called multiple mailings.

Typically, much more effort is needed to acquire customers from rental lists than to retain them in the house list. Also, firms can no longer depend on offensive strategies only because the availability of rental names is scarce. Therefore, they must act defensively to activate the customer base in the house list and increase their profitability through repeated purchases (Schmittlein 1987). To plan a campaign, some of the best organized companies in the marketplace frequently use a decision model as shown in the flow diagram of Figure 2. The focus of our study is within the dotted box in this figure.

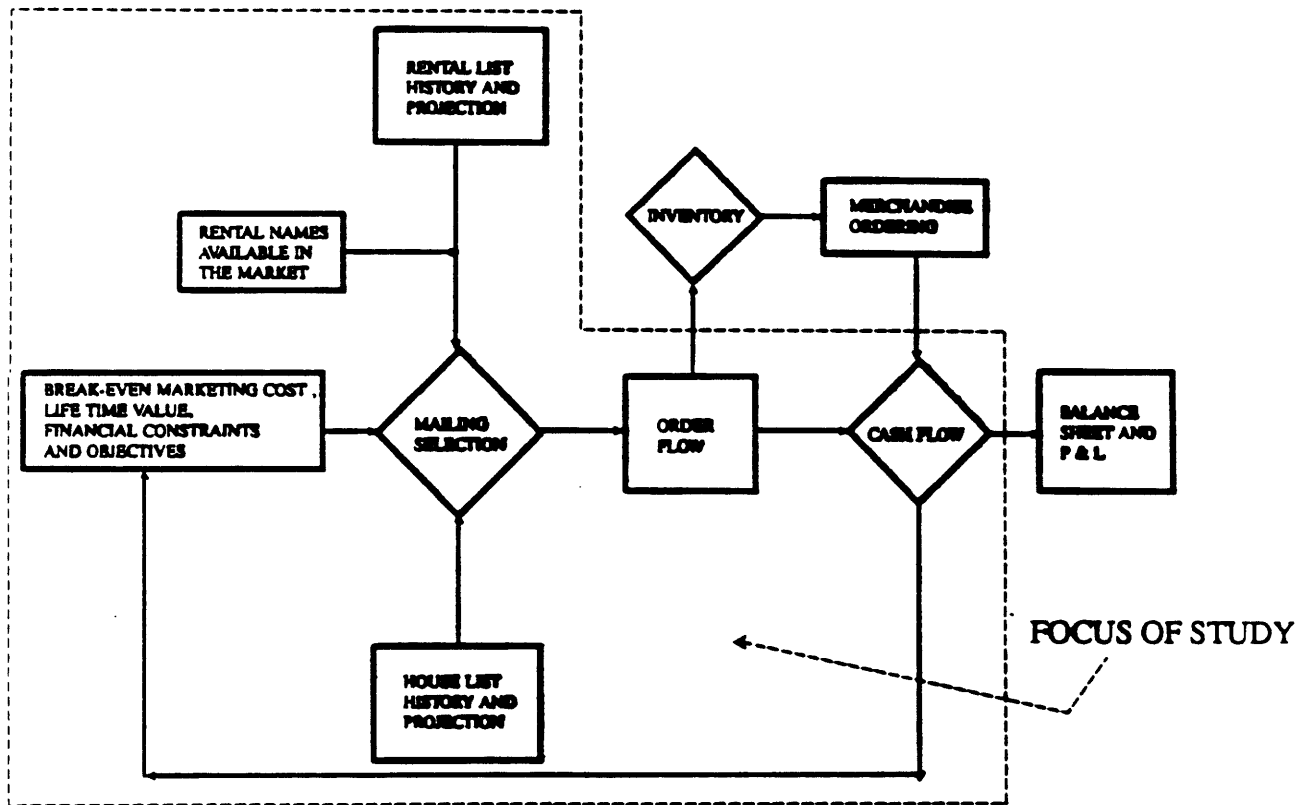


Fig. 2 - Decision Model Used to Plan a Campaign

Based upon: **break-even variable marketing cost percent**, (this is industry nomenclature) **lifetime analysis**, financial constraints and specific objectives, and with information from rental lists and house segments, the companies make their mailing selection, i. e., they decide how many names to rent on each rental list, how many catalogs to mail to each house segment in each mailing (drop), and how many mailings (drops) to make for each house segment.

The **break-even variable marketing cost percent**, or just **break-even cost**, used by companies, determine the maximum they can spend to acquire a new buyer, without considering his future contributions to profit (Hill 1989). Spending money for printing catalogs, renting a particular list, mailing, etc. is a decision to spend money for variable marketing. The break-even cost is calculated by disregarding fixed cost of all types, as follows:

$$\begin{aligned} \text{break-even cost (\%)} &= \\ &= [ 1 - (\text{cost of goods} + \text{variable operating cost})/\text{net sales} ] \times 100. \end{aligned}$$

The variable operating cost includes the costs of shipping, order processing, etc., while net sales is revenue after refunds for returned merchandise.

To calculate the break-even cost the companies analyze the history of all the rental lists already tested and/or used in previous campaigns. They keep track of the net quantity of catalogs mailed for each particular rental list as well as its performance given by: net sales, average monetary amount per order, response rate and number of buyers . Response rate and number of buyers are determined using net sales, average monetary amount per order and net quantity of catalogs mailed, as follow:

- response rate = net sales per catalog mailed /average monetary amount per order;
- number of buyers = response rate x net quantity of catalogs mailed.

Net sales per catalog and average monetary amount are updated for each rental list. For a new campaign a projection is carried out to adjust for seasonal variations and economic trends.

The **lifetime analysis** calculates the expected present value of the future contribution to profit to be generated by a customer. The ultimate value of a customer is determined by the profit made on all his/her purchases over time, less the customer acquisition and maintenance costs. Knowing the future value of a customer allows an objective decision to be made as to how much it is worth spending to acquire a new customer (Hill 1989).

Companies usually calculate the lifetime value for a 5 years planning horizon and for a customer in their most recent house segment. The calculation assumes a sales decay from campaign to campaign and from drop to drop in multiple mailings, to project the future sales within the planning horizon. The sales decay is obtained from the past history of the house list.

With break-even variable marketing cost percent and lifetime analysis used as reference point, companies set the objectives for a campaign, subject to their economic constraints (mainly cash



flow). They target new buyer acquisitions and customer activation at an acceptable variable marketing cost, resulting in a final mailing selection. Then a purge/merge stage is carried out to eliminate duplicated names and to get a final mailing list. Afterward they estimate the order flow, evaluate inventory and place orders. All this information is used to calculate the cash flow, the impact on the balance sheet and finally the profit/loss results are determined.

## 2.2 - SOME WEAKNESSES OF THE COMMON PRACTICE

Most catalog companies use the break-even variable marketing cost and lifetime value of a customer to make mailing decisions (Fleischmann 1991).

The mailing decisions based on break-even variable marketing cost focus on short term performance and typically understate the long-term impact of a campaign. For instance, mailing catalogs to rental lists may result in a short term loss but the future contribution of the new buyers may pay off in the long run. Also, using this analysis, companies often do not consider the impact of future changes in economic conditions when making a decision for the current campaign.

In order to take into account long-term effects, some companies use lifetime analysis. However, since they calculate the lifetime value considering only a given number of campaigns, usually for 5 years, they tend to overlook the residual value after this period which may not be negligible.

With respect to multiple mailings, some catalog companies make decisions by evaluating each possible drop alternative separately, they do not seem to have a procedure to evaluate them jointly. Often, the decision of making a drop is only made if the profit of the mailing is positive, neglecting its future contribution to profit.

Further, both break-even marketing cost and lifetime analysis do not guarantee the optimality of mailing decisions. We have not encountered in the literature a tool that takes into account the costs and revenues, the financial and operational constraints, to optimize the decisions of mailing to rental and house lists over the long run.

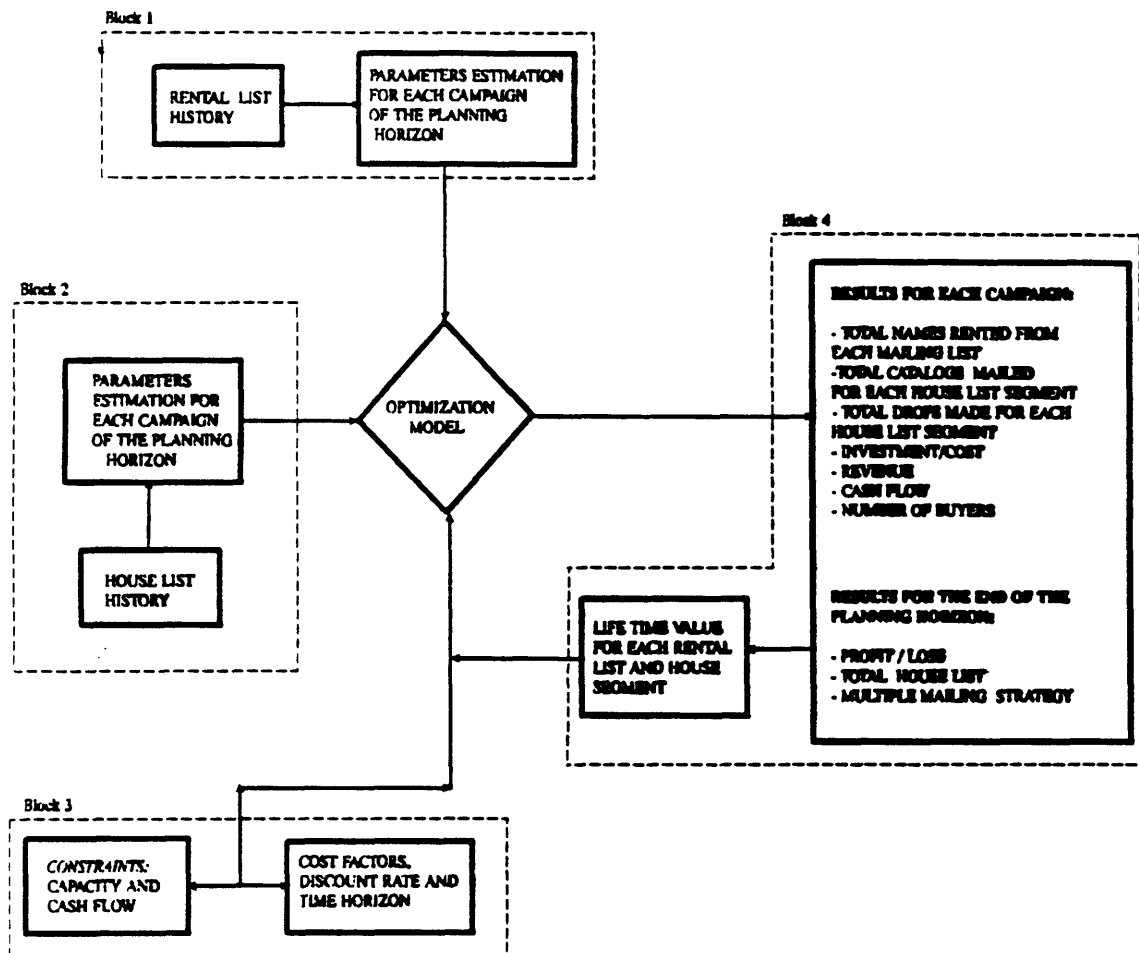
## 3 - THE MODEL

In this section we propose a model to address the decisions associated with mailing catalogs avoiding some of the pitfalls of the industry common practices described above. It was developed in close cooperation with a major catalog company.

### 3.1 - PROPOSED APPROACH

The model outlined in Figure 3 overcomes most of the deficiencies identified in the industry practices. The emphasis of this paper is on the optimization model which requires **input data** contained in blocks 1, 2 and 3. Block 4, shows the **results** of the optimization model.

**Block 1, input data**, refers to rental lists. The parameters required from the rental lists are: net sales per thousand catalogs mailed, average monetary amount and probability of buyers to make a purchase within a given monetary range. These parameters are often estimated for the whole planning horizon using past history. Also, the availability of names in the rental lists for each campaign has to be estimated.



**Fig. 3 - Decision Model for the Planning Horizon**

**Block 2, input data**, refers to the house list. The parameters required from the house segments for each mailing are: net sales per thousand catalogs mailed, average monetary amount, probability of customers to make a purchase within a given monetary range and availability of names in each

house segment. These parameters, except the availability of names, are often estimated for the whole planning horizon using past history; the availability of names in each house list is needed to characterize the initial conditions of the system.

Block 3, **input data** consists of the constraints and cost factors. There are two kinds of constraints: one is related to the operational capacity in handling and fulfilling orders and the other consider financial constraints associated to cash flow.

The operational capacity constraints are tighter when companies are starting in the business because they can not afford to install large facilities, train and hire many employees.

The cash flow constraints are needed because catalog companies usually lose money for an undetermined period of time until their house list reaches proportions that contribute to cover the costs of acquiring buyers and overhead. To take into account the short and long term, the model considers two cash flow constraints: one for a single campaign and the other to represent the cumulative amount of cash consumed.

The other sets of data of this block are related to cost factors: cost of goods, variable operating cost, marketing cost, and fixed costs. The cost of goods includes incoming freight if the company does not produce them. The variable operating costs are a combination of: interest due to the investment in inventory; order processing including telephone, general payroll and taxes, fax, office and shipping supplies, miscellaneous expenses, bank charges, credit card fees, and shipping charges.

The variable marketing costs are all the costs incurred to promote sales. They include cost of printing catalogs, merge/purge, list maintenance, mailing and label costs, postage costs and cost of renting names from the mailing lists.

We only consider the fixed costs directly related to run a campaign, so the results of discounted cash flow do not take into account overhead and depreciation. The fixed costs for each campaign include costs of catalog production: design, layout, photography, color separations, typography, paste-up, stripping, proofing, and press startup.

Block 4 of this model is related to **results** of the optimization model. There are two types of **results**: one for each campaign and another for the end of the planning horizon.

The **results** for each campaign are the expected:

- number of names rented from the rental lists;
- number of catalogs mailed to each house segment;
- number of mailings made to each house segment;
- total cost involved with the campaign;
- total revenue obtained from the campaign;
- resulting cash flow;
- number of new buyers;

- number of orders;
- number of buyers in each house segment.

Basically, after each campaign, new buyers from the rental lists are incorporated to a newly formed house segment of most recent buyers. As each house segment is represented by the R-F-M classification (recency, frequency and monetary amount), the buyers from rental lists and those from house lists are moved to different house segments even though their purchases were made with the same recency. On the other hand, those customers from the house file who did not make a purchase are carried over to the next older segment, at the start of the next campaign, keeping the same frequency and monetary amount characteristics.

At the end of the planning horizon we have the following **results**:

- present value of the profit/loss for all campaigns;
- length of time when cash flow breaks even, if it occurs within the planning horizon;
- number of buyers in each house segment;
- number of received orders;
- multiple mailing strategy.

The lifetime values are used to determine the residual value of the company at the end of the planning horizon. The lifetime value is the future contribution to profit for a potential buyer in each rental list and each house segment. The residual value of the company is obtained by multiplying the lifetime value of each customer segment by the number of customers in that segment and adding them up. We used a Markov chain model to calculate the lifetime values.

### 3.2 - OPTIMIZATION MODEL

According to the approach described in the previous section, we present an optimization model for the catalog industry; it is a linear program. The sequential decisions over the planning horizon determine how to best use resources to maximize profit. The model yields optimal mailing strategies that specify for each campaign within the planning horizon, how many names should be rented, how many catalogs should be mailed to the house segments and how many multiple mailings to make for each house segment. Following the usual industry practice we do not consider multiple mailings to rental lists.

### ***Notation and Parameters***

$t$  = index for time period (campaign),  $t = 1, 2, \dots, T$ ;

$i$  = index for the number of rental lists,  $i = 1, 2, \dots, I$ ;

$j$  = index for the number of house list recency groups,  $j = 1, 2, \dots, J$ . For the most recent group  $j=1$ , and for the oldest  $j = J$ ;

$m$  = index for the number of monetary amount classes in the house list,  $m = 1, 2, \dots, M$ .  $m = 1$  represents the lowest monetary amount class while  $m = M$  is the highest one;

$f$  = index for the number of purchases by a customer since the starting period of the planning horizon.  $f = 1, 2, \dots, F$ . New buyers from the rental lists start with  $f = 1$ .

$k$  = index for the number of mailings (drops) to the same house segment within the same campaign,  $k = 1, 2, \dots, K$ ;

$r$  = discount rate per campaign.

The **input data** for the optimization model are given below:

$SL_i^t$  = expected net sales per thousand catalogs mailed to rental list  $i$  for campaign  $t$ ;

$AL_i^t$  = expected average monetary amount per order (net sales per net number of orders) of rental list  $i$  for campaign  $t$ ;

$p_i^t(m)$  = probability that buyers in rental list  $i$  make a purchase in monetary amount class  $m$  for campaign  $t$ ;

$HN_{j,m,f}^1$  = number of names in the house segment with: recency  $j$ , monetary amount class  $m$  and frequency of purchase  $f$  for the first campaign. This data represent the initial conditions;

$SH_{j,m,f,k}^t$  = expected net sales per thousand catalogs mailed to the house segment with: recency  $j$ , monetary amount class  $m$ , frequency of purchase  $f$ , for the  $k^{\text{th}}$  mailing for campaign  $t$ ;

$AH_{j,m,f,k}^t$  = expected average monetary amount per order (net sales per net number of orders) of the house segment with: recency  $j$ , monetary amount class  $m$ , frequency of purchase  $f$ , for the  $k^{\text{th}}$  mailing for campaign  $t$ ;

$ph_{j,m,f}^t(m^*)$  = probability that buyers in the house segment with: recency  $j$ , monetary amount class  $m$ , frequency of purchase  $f$ , make a purchase corresponding to the monetary amount of class  $m^*$  ( $m^*$  can be equal, greater or lesser than  $m$ ) for campaign  $t$ ;

$UA_{j,m,f}$  = attrition rate of the house segment with: recency  $j$ , monetary amount class  $m$ , and frequency of purchase  $f$ . We call attrition rate the fraction of the catalogs returned because the

customers are no longer at a known address. We assume that the attrition rate is constant over the planning horizon;

$RV_{j,m,f}$  = lifetime value of a customer in the house segment with: recency  $j$ , monetary amount class  $m$  and frequency of purchase  $f$ ;

$CAP^t$  = operational capacity in terms of orders that the firm can handle and fulfill in campaign  $t$ ;

$CAF^t$  = cash flow for campaign  $t$ , that is, the financial capacity of the firm;

$ACAF$  = cumulative cash flow limit;

$GC^t$  = cost of goods as a fraction of net sales for campaign  $t$ ;

$OC^t$  = operating cost as a fraction of net sales for campaign  $t$ ;

$PC^t$  = variable marketing cost ( per thousand catalog) for campaign  $t$ , (basically printing, mailing, merge/purge and postage);

$RC_i^t$  = cost of each rented name from rental list  $i$  for campaign  $t$ ;

$KF^t$  = fixed costs, including operating and marketing costs, for campaign  $t$ .

$LN_i^t$  = number of names available in list  $i$  for rent in period  $t$ .

**Decision variables** in the model are defined as:

$X_i^t$  = number of rented names from rental list  $i$  for campaign  $t$  in thousands;

$Y_{j,m,f,k}^t$  = number of catalogs mailed to the house segment with: recency  $j$ , monetary amount class  $m$  and frequency of purchase  $f$ , for mailing  $k$  times in campaign  $t$ , in thousands;

*Other variables*

$H_{j,m,f}^t$  = total number of buyers in the house segment with: recency  $j$ , monetary amount class  $m$ , frequency  $f$ , in campaign  $t$ , in thousands;

$TCAT L^t$  = total catalogs mailed to the rental lists in campaign  $t$ , in thousands;

$TCATH^t$  = total catalogs mailed to the house list in campaign  $t$ , in thousands;

$CPC^t$  = number of orders received in campaign  $t$ , in thousands;

$REV^t$  = discounted revenue in campaign  $t$ , in thousands;

$COST^t$  = discounted cost incurred in campaign  $t$ ;

$CASH^t$  = discounted cash flow in campaign  $t$ ;

$ACASH^{t^*}$  = cumulative discounted cash flow until campaign  $t^*$ , where  $t^* = 1,2,\dots,T$ .

### Assumptions

The following assumptions, that we have observed hold in most practical applications, allow us to formulate the problem as a linear programming program:

1. The decision variables and the other variables tend to be fairly large numbers, whenever they are not zero. Hence, there is no major loss of optimality, in our case, by considering them continuous.
2. During a given campaign, the  $k^{\text{th}}$  mailing is worse than the  $(k-1)^{\text{th}}$  mailing for  $k = 2, 3, \dots, K$ . That is the  $k^{\text{th}}$  mailing has a lower response rate and in addition it is less profitable than the  $(k-1)^{\text{th}}$  mailing. Therefore, the optimization program, below, will not recommend the  $k^{\text{th}}$  mailing to a customer class unless the  $(k-1)^{\text{th}}$  mailing has been sent to all the elements in that customer class. Subsequent mailings activate more customers even though these customers are less profitable in the short run. Once these customers become active they can generate more profit in the long run. Figure 4 represents a typical curve for multiple mailings that we have observed in practice.

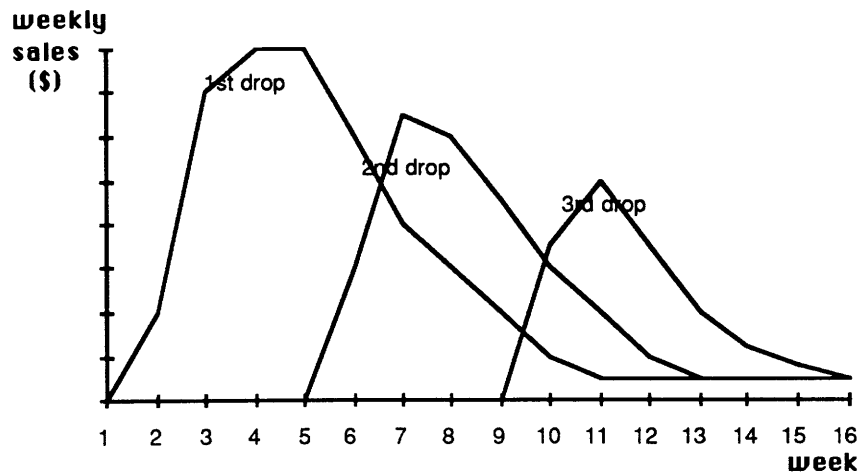


Fig. 4 - Typical Sales per Drop

3. The company will mail catalogs in every campaign over the planning horizon. This is a typical practice in the mailing catalog companies that we have encountered. As a consequence, the fixed cost  $KF^t$ , which include operating and marketing costs for campaign  $t$  is always incurred for  $t = 1, 2, \dots, T$ .

### **Objective Function**

The objective is to maximize the sum of the expected discounted cash flows over the planning horizon. This cumulative cash flow, before tax, does not include overhead and depreciation costs.

The problem is formulated as follows:

$$\begin{aligned} \max. Z = & \sum_{t=1}^T \sum_{i=1}^I X_i^t \times SL_i^t / (1+r)^t \\ & + \sum_{t=1}^T \sum_{j=1}^J \sum_{m=1}^M \sum_{f=1}^F \sum_{k=1}^K Y_{j,m,f,k}^t \times SH_{j,m,f,k}^t / (1+r)^t \\ & + \sum_{j=1}^J \sum_{m=1}^M \sum_{f=1}^F RV_{j,m,f} \times H_{j,m,f}^T / (1+r)^T \\ & - \sum_{t=1}^T (GC^t + OC^t) \times \sum_{i=1}^I X_i^t \times SL_i^t / (1+r)^{t-1} \\ & - \sum_{t=1}^T \sum_{j=1}^J \sum_{m=1}^M \sum_{f=1}^F \sum_{k=1}^K (GC^t + OC^t) \times Y_{j,m,f,k}^t \times SH_{j,m,f,k}^t / (1+r)^{t-1} \\ & - \sum_{t=1}^T \sum_{i=1}^I (PC^t + RC_i^t) \times X_i^t / (1+r)^{t-1} \end{aligned}$$



$$- \sum_{t=1}^T \sum_{j=1}^J \sum_{m=1}^M \sum_{f=1}^F \sum_{k=1}^K PC^t \times Y_{j,m,f,k}^t / (1+r)^{t-1} - \sum_{t=1}^T KF^t / (1+r)^{t-1}$$

The first term of the objective function represents the revenue (net sales) from the rental list buyers; the second, the revenue (net sales) from the house list buyers; the third, the customers' residual value; the fourth, the variable costs of goods and the operational costs as a fraction of the net sales from the rental list buyers; the fifth, the variable costs of goods and operational costs as a fraction of the net sales from the house list buyers; the sixth, the variable marketing costs to mail catalogs to the rental lists; the seventh, the variable marketing costs to mail catalogs to the house list and the eighth, the fixed cost incurred to run each campaign.

As can be observed, the positive terms (the revenues) of the objective function are discounted by  $(1+r)^t$  while the negative ones (costs) are discounted by  $(1+r)^{t-1}$ . This formulation assumes, without loss of generality, that all costs are paid at the beginning of the campaign and all revenues are received at the end of the respective campaign.

## CONSTRAINTS

1. Discounted cash flow constraints for each campaign  $t$ .

They also do not include the overhead and depreciation costs. The discounted cash flow is calculated as the difference between the discounted revenue and cost, as follows:

The discounted revenue for campaign  $t$  is given by:

$$REV^t = \sum_{i=1}^I X_i^t \times SL_i^t / (1+r)^t$$

$$+ \sum_{j=1}^J \sum_{m=1}^M \sum_{f=1}^F \sum_{k=1}^K Y_{j,m,f,k}^t \times SH_{j,m,f,k}^t / (1+r)^t \quad t = 1, 2, \dots, T.$$

The discounted cost for campaign  $t$  is given by:

$$\begin{aligned}
\text{COST}^t &= \sum_{i=1}^I (\text{GC}^t + \text{OC}^t) \times X_i^t \times \text{SL}_i^t / (1+r)^{t-1} \\
&+ \sum_{j=1}^J \sum_{m=1}^M \sum_{f=1}^F \sum_{k=1}^K (\text{GC}^t + \text{OC}^t) \times Y_{j,m,f,k}^t \times \text{SH}_{j,m,f,k}^t / (1+r)^{t-1} \\
&+ \sum_{i=1}^I (\text{PC}^t + \text{RC}_i^t) \times X_i^t / (1+r)^{t-1} \\
&+ \sum_{j=1}^J \sum_{m=1}^M \sum_{f=1}^F \sum_{k=1}^K \text{PC}^t \times Y_{j,m,f,k}^t / (1+r)^{t-1} + \text{KF}^t / (1+r)^{t-1} \quad t = 1, 2, \dots, T.
\end{aligned}$$

Hence, the discounted cash flow for campaign  $t$  is defined as:

$$\text{CASH}^t = \text{REV}^t - \text{COST}^t \quad t = 1, 2, \dots, T.$$

An upper bound reflecting the financial capacity of the firm is often imposed on negative cash flows:  $-\text{CASH}^t \leq \text{CAF}^t \quad t = 1, 2, \dots, T.$

2. Cumulative discounted cash flow constraints:

The cumulative discounted cash consumed until campaign  $t^*$  is given by:

$$\text{ACASH}^{t^*} = \sum_{t=1}^{t^*} \text{REV}^t - \sum_{t=1}^{t^*} \text{COST}^t \quad t^* = 1, 2, \dots, T.$$

Similarly to the discounted cash flow constraints, upper bounds on negative cumulative cash flows are imposed.

$$-\text{ACASH}^{t^*} \leq \text{ACAF} \quad t^* = 1, 2, \dots, T.$$

3. Operational capacity constraints to handle and fulfill orders for campaign t:

The numbers of orders handled by the company per campaign is given by:

$$CPC^t = \sum_{i=1}^I X_i^t \times SL_i^t / AL_i^t + \sum_{j=1}^J \sum_{m=1}^M \sum_{f=1}^F \sum_{k=1}^K Y_{j,m,f,k}^t \times SH_{j,m,f,k}^t / AH_{j,m,f,k}^t \quad t = 1, 2, \dots, T.$$

The first term of the right hand side represents the orders that come from the rental list buyers, while the second term corresponds to those from the house list buyers.

These orders must not exceed the firm's operational capacity per campaign. The constraints are given by:

$$CPC^t \leq CAP^t \quad t = 1, 2, \dots, T.$$

4. Constraints reflecting the availability of lists and names to rent for each campaign:

$$X_i^t \leq LN_i^t \quad i = 1, 2, \dots, I \quad \text{and} \quad t = 1, 2, \dots, T.$$

The expressions above indicate that the total number of catalogs mailed to rental list i must not exceed the availability of names in that list, during campaign t.

5. Constraints on the availability of names to mail catalogs to the house segments:

$$Y_{j,m,f,k}^t \leq H_{j,m,f}^t \quad t = 1, 2, \dots, T; \quad j = 1, 2, \dots, J; \quad m = 1, 2, \dots, M, \quad k = 1, 2, \dots, K, \quad \text{and}$$

$$f = 1, 2, \dots, F$$

These constraints indicate that the total catalogs mailed to the house segment with: recency j, monetary amount class m, frequency of purchase f, for all k mailings must not exceed the number of names in this house file for campaign t. In other words, it is not possible to mail more catalogs than the existing number of available names in the house file.

6. The total catalogs mailed to the rental lists in campaign t is given by:

$$TCATL^t = \sum_{i=1}^I X_i^t \quad t = 1, 2, \dots, T.$$

7. The total catalogs mailed to the house segments for campaign t is given by:

$$TCATH^t = \sum_{k=1}^K \sum_{j=1}^J \sum_{m=1}^M \sum_{f=1}^F Y_{j,m,f,k}^t \quad t = 1, 2, \dots, T.$$

**Constraints to update the house list:**

8. House segments at the beginning of the planning horizon (t=1):

$$H_{j,m,f}^{t=1} = HN_{j,m,f}^1 \quad j = 1, 2, \dots, J; m = 1, 2, \dots, M \text{ and } f = 1, 2, \dots, F$$

The number of names in each house segment at the beginning of the planning horizon is an input to the model.

9. Most recent house segment (j=1) for first time buyers (f=1) for campaign t > 1:

$$H_{j=1,m,f=1}^t = \sum_{i=1}^I X_i^{t-1} \times SL_i^{t-1} \times pl_i^{t-1}(m) / AL_i^{t-1} \quad t = 2, 3, \dots, T \text{ and } m = 1, 2, \dots, M$$

The most recent buyers who never bought before from the company come from the rental lists. Once these customers enter the house list, the model does not care where they came from. The expected number of customers added to the house segment with: j = 1, m, f = 1 in campaign t is obtained by multiplying: the number of catalogs mailed to the rental lists during campaign t-1 ( $X_i^{t-1}$ ) by their expected net sales ( $SL_i^{t-1}$ ) and by the probability of making a purchase corresponding to the monetary amount of class m ( $pl_i^{t-1}(m)$ ), and dividing the result by the expected sales per buying customer ( $AL_i^{t-1}$ ).

10. Most recent house segment (j=1) for buyers with at least two purchases but less than the maximum number allowed by the model ( $2 \leq f < F$ ) for campaign t > 1:

$$H_{j=1,m^*,f}^t = \sum_{j=1}^J \sum_{m=1}^M \sum_{k=1}^K Y_{j,m,f-1,k}^{t-1} \times SH_{j,m,f-1,k}^{t-1} \times ph_{j,m,f-1}^{t-1}(m^*) / AH_{j,m,f-1,k}^{t-1}$$

$$t = 2,3,\dots,T; \quad m^* = 1,2,\dots,M \quad \text{and} \quad f = 2,3,\dots,F-1.$$

The customers in this segment come from the house list. The expected number of customers in the house segment with:  $j = 1$ ,  $m^*$ ,  $f$ , in campaign  $t$ , is obtained by multiplying: the number of catalogs mailed to the house file during campaign  $t-1$  ( $Y_{j,m,f-1,k}^{t-1}$ ) by the expected net sales ( $SH_{j,m,f-1,k}^{t-1}$ ) and by the probability of making a purchase corresponding to the monetary amount class  $m^*$  ( $ph_{j,m,f-1}^{t-1}(m^*)$ ), and dividing the result by the expected sales per buying customer ( $AH_{j,m,f-1,k}^{t-1}$ ).

11. Most recent house segment ( $j=1$ ) for the most frequent buyers that have already bought the maximum number of purchases allowed by the model ( $f = F$ ) for campaign  $t > 1$ :

$$H_{j=1,m^*,f=F}^t = \sum_{j=1}^J \sum_{m=1}^M \sum_{k=1}^K Y_{j,m,F-1,k}^{t-1} \times SH_{j,m,F-1,k}^{t-1} \times ph_{j,m,F-1}^{t-1}(m^*) / AH_{j,m,F-1,k}^{t-1} +$$

$$\sum_{j=1}^J \sum_{m=1}^M \sum_{k=1}^K Y_{j,m,F,k}^{t-1} \times SH_{j,m,F,k}^{t-1} \times ph_{j,m,F}^{t-1}(m^*) / AH_{j,m,F,k}^{t-1}$$

$$t = 2,3,\dots,T \quad \text{and} \quad m^* = 1,2,\dots,M$$

The expected number of customers in this segment is calculated in the same way as for the preceding equation, however here are added not only the customers that have already made  $F-1$  purchases, but also those who have bought at least  $F$  times.

12. Generic house segment with non recent buyers ( $1 < j < J$ ) for campaign  $t > 1$ :

$$H_{j,m^*,f}^t = H_{j-1,m^*,f}^{t-1} \times (1 - UA_{j-1,m^*,f}) - \sum_{m=1}^M \sum_{k=1}^K Y_{j-1,m,f,k}^{t-1} \times ph_{j-1,m,f}^{t-1}(m^*) \times SH_{j-1,m,f,k}^{t-1} /$$

$$AH_{j-1,m,f,k}^{t-1}$$

$$t = 2,3,\dots,T; \quad j = 2,3,\dots, J; \quad m^* = 1,2,\dots,M \quad \text{and} \quad f = 1,2,\dots,F$$

The customers that did not buy during the current campaign and are in the recency class  $j-1$  are carried over to the next older house segment  $j$  keeping the same monetary amount class  $m$  and frequency of purchase  $f$  characteristics. To arrive at the expected number of these customers to start the next campaign  $t$ , we subtract from the customers that survived attrition in the house segment  $j-1$ ,  $m$ ,  $f$ , the customers that bought in period  $t - 1$ .

13. Oldest house segment ( $j = J$ ) for campaign  $t > 1$ :

$$H_{j=J,m^*,f}^t = H_{J-1,m^*,f}^{t-1} \times (1-UA_{J-1,m^*,f}) - \sum_{m=1}^M \sum_{k=1}^K Y_{J-1,m,f,k}^{t-1} \times ph_{J-1,m,f}^{t-1}(m^*) \times SH_{J-1,m,f,k}^{t-1} \\ / AH_{J-1,m,f,k}^{t-1} \\ + H_{J,m^*,f}^{t-1} \times (1-UA_{J,m^*,f}) - \sum_{m=1}^M \sum_{k=1}^K Y_{J,m,f,k}^{t-1} \times ph_{J,m,f}^{t-1}(m^*) \times SH_{J,m,f,k}^{t-1} / AH_{J,m,f,k}^{t-1}$$

$$t = 2,3,\dots,T; \quad m^* = 1,2,\dots,M \quad \text{and} \quad f = 1,2,\dots,F$$

The oldest house segment  $J$  for campaign  $t$  is built using the same concept as for the generic segment given in the previous equation. But here, the customers come not only from the preceding recency group  $J-1$  but also from within their own ranks, group  $J$ . It is important to notice that once customers enter the house list, they leave only when their address is no longer known. The house file keeps the names of customers regardless of how old they are on the file, how little they spent and how few times they made purchases. Also, because the probability of buying is less than that of not buying, the oldest house segment tends to grow faster than any other segment during the life of the company.

14. Non-negativity constraints:

$$X_i^t, Y_{j,m,f,k}^t, H_{j,m,f}^t, TCATL^t, TCATH^t, CPC^t, REV^t, COST^t \geq 0$$

for  $t = 1,2,\dots,T$ ;  $j = 1,2,\dots,J$ ;  $f = 1,2,\dots,F$ ;  $m = 1,2,\dots,M$ ;  $i = 1,2,\dots,I$ ; and  $k = 1,2,\dots,K$ .

### 3.2 - COMPUTATIONAL CONSIDERATIONS

We have used a modeling language called GAMS - General Algebraic Modeling System - released in 1989, because of the following advantages (Brooke 1988):

- it provides a compact representation of large and complex models
- it allows simple and safe changes in model specifications
- it allows unambiguous statements of algebraic relationships
- it permits model descriptions independent of data and solution algorithms.

For further details for GAMS and other modeling languages see (Fourer 1991) and (Geoffrion 1992).

Our test runs were performed on an IBM 4381 machine at the Sloan School of Management at the Massachusetts Institute of Technology. This machine is a uniprocessor system VM/SP release 5.0 with 16 Megabytes of shared memory, and 9 Gigabytes of hard disk and 3.0 mips.

In this operating system environment we have used the solver Mathematical Programming System Extended/370 Version 2 (MPSX/370 V2), release 1988.

A typical configuration tested contains 20 periods of planning horizon (5 years with 4 campaigns per year), 10 rental lists per campaign, 5 recency groups of 3 months each one, 2 monetary amount classes, 2 frequencies of purchase and up to 3 multiple mailings per campaigns. In terms of size, it has approximately 4,000 variables, 5,500 constraints and 33,000 non zero elements. Running times were about 1 hour.

### 4 - MODEL APPLICATION

A data set with some minor modifications, to protect the catalog company which provided the information was used to test the performance of the model. The parameters and assumptions were:

- 4 campaigns per year, 25% discount rate per year.
- 5 recency groups: 0-to-3, 4-to-6, 5-to-9, 10-to-12, and over 12 month buyers; and 2 monetary amount classes: high and low amount;
- cost of goods: 33% of net sales; operating cost as 12% of net sales; \$450.00 of variable marketing cost per thousand catalogs, including merge/purge, printing, mailing and postage costs; \$50,000.00 of fixed cost per each campaign including production of the catalog;
- 10 available rental lists per campaign, each one with 100,000 names. Table 1 gives for each rental list, the rental costs per thousand names, expected net sales per thousand catalogs mailed and the expected average monetary amount per order. We assume this data is the same for all periods of the planning horizon.

- Five house segments, up to 3 mailings for each segment and 2% attrition rate for all segments. Tables 2 and 3 give, for each house segment and for each drop, respectively, the expected net sales per thousand catalogs mailed and the expected average monetary amount per order. We assume that this data is the same for all periods of the planning horizon.

**Table 1 - Data for Rental Lists**

Rental list	Rental Cost (\$)/M	Expected net sales (\$)/M	Average monetary amount (\$)
1	90	1050	60
2	91	1051	61
3	92	1052	62
4	93	1053	63
5	94	1054	64
6	95	1055	65
7	96	1056	66
8	97	1057	67
9	98	1058	68
10	99	1059	69

**Table 2 - Data of net sales for house segments per drops**

House segments	Expected net sales per drop (\$)/M		
	Drop 1	Drop 2	Drop 3
1	4,000.00	2,990.00	1,990.00
2	3,000.00	1,995.00	850.00
3	2,000.00	900.00	800.00
4	1,500.00	850.00	750.00
5	1,150.00	760.00	650.00



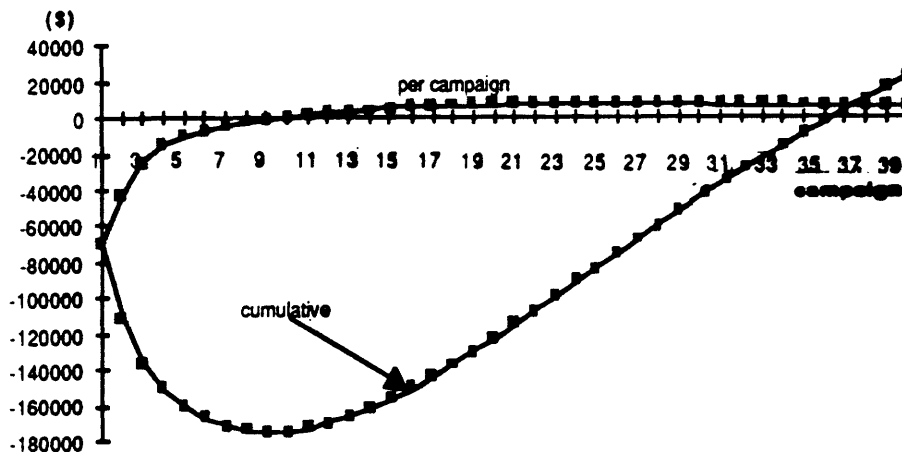
**Table 3 - Data of average monetary amount for house segments per drops**

House segments	Expected average monetary amount per drop (\$)/M		
	Drop 1	Drop 2	Drop 3
1	80.00	79.00	78.00
2	80.00	79.00	78.00
3	80.00	79.00	78.00
4	80.00	79.00	78.00
5	80.00	79.00	78.00

We modeled four alternate scenarios that represent interesting cases for analysis. For these alternatives we assumed that the following parameters are constant over the planning horizon: probability of buying, cost structure, performance of the rental lists and house segments in terms of expected net sales and average monetary amount. Also, we relaxed the cash flow constraints.

**First example:** 10 years time horizon (40 campaigns) and single mailing (up to one drop of catalogs for each house segment per campaign). The results for the discounted cash flow analysis are summarized in Figure 5.

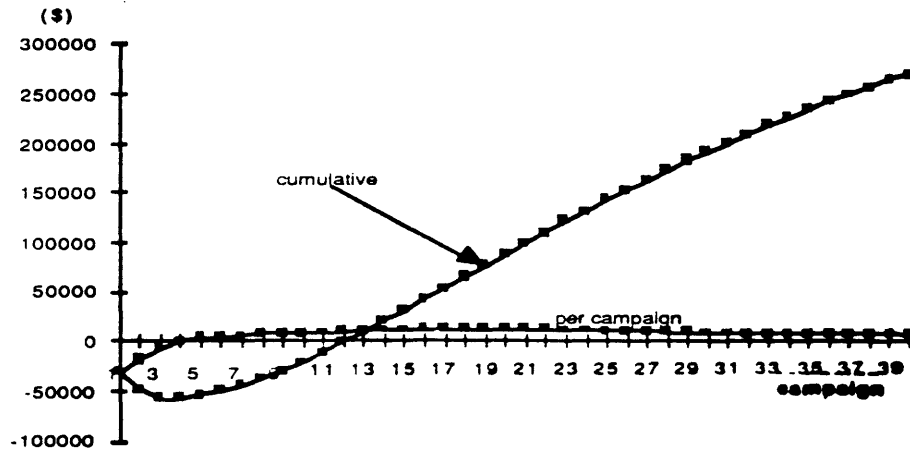
In this case the cumulative discounted cash flow shows that the company recovers its investment only after the 36<sup>th</sup> campaign (~ 9 years). However after the 10<sup>th</sup> campaign (2.5 years) its cash flow becomes positive. This is a common result in the catalog industry.



**Fig. 5 - Discounted Cash Flow Results (No names in house file at the start and single mailing)**

**Second example:** 10 years (40 campaigns), single mailing but with 100,000 names in the house list at the beginning of the planning horizon. The results are shown in Figure 6.

As we can see, the company recovers its investment and starts making a profit after the 12<sup>th</sup> campaign ( 3 years). Then it keeps on growing at a rate that is nearly proportional to the house file growth rate. This shows the effect of names in the house list. With no names the return of the investment occurs at the 36<sup>th</sup> campaign as seen previously.



**Fig. 6 - Discounted Cash Flow Results (Names in house list and single mailing)**

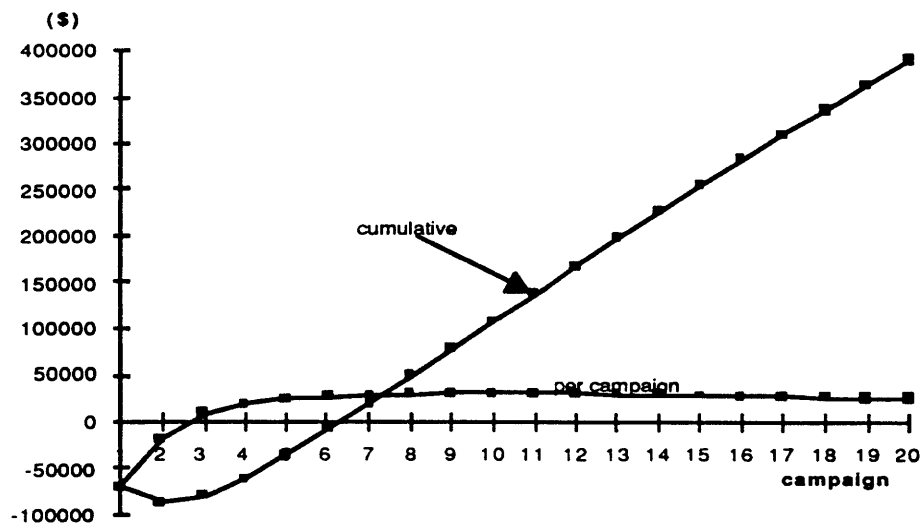
**Third example:** 5 years planning horizon, up to 3 mailings to the same house segment during a campaign and no names in the house file at the beginning of the planning horizon. We provide additional results for this example to illustrate other characteristics of the catalog business.

First, we give the results concerning the number of drops per campaign:

- the optimal number of drops per campaign for each house segment is stationary, i. e., it does not change over time;
- the strategy is three drops to the house segments with recency 0-3 and 4-6 months, two drops to those with recency 7-9 and 10-12 months, and one drop to those with recency over 12 months.

With respect to the economic performance, Figure 7 shows results quite different from those in Figure 5. The company recovers its investment and starts making a profit as early as the 6<sup>th</sup> campaign (~1.5 year).

By analyzing this result, we realize the great effect that multiple mailings have in generating profits earlier, which happens because multiple mailings activate more customers within the house list. We did not consider the eventual cannibalization effect in sending similar catalogs many times to the same household in a short period of time because we could not find a strong evidence of this fact. There is no available data, at least to our knowledge on how customers feel about receiving many similar catalogs. Are they angry, saturated, indifferent, motivated to buy, and so on? Also, what is the cannibalization effect on the long run purchase rate? The catalog companies do not seem so worried about it because, probably, multiple mailings are very profitable. To analyze this effect we need to conduct specific tests during several campaigns. This has not been done. Hence we believe this subject needs further investigation.



**Fig. 7 - Discounted Cash Flow (With Multiple mailings)**

Figure 8 shows the number of catalogs mailed to rental lists, house lists and total. For each campaign there are 1,000,000 available names to rent and as we can see, the company sends catalogs to all of them over time.

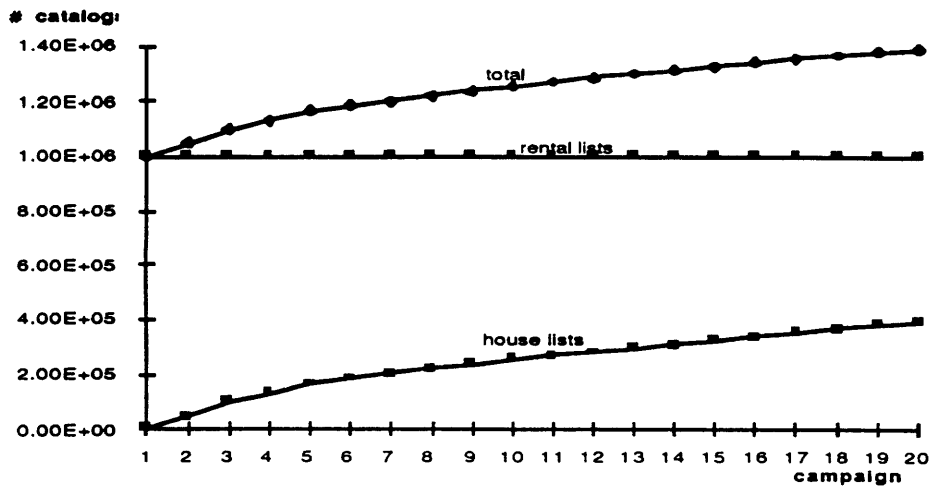
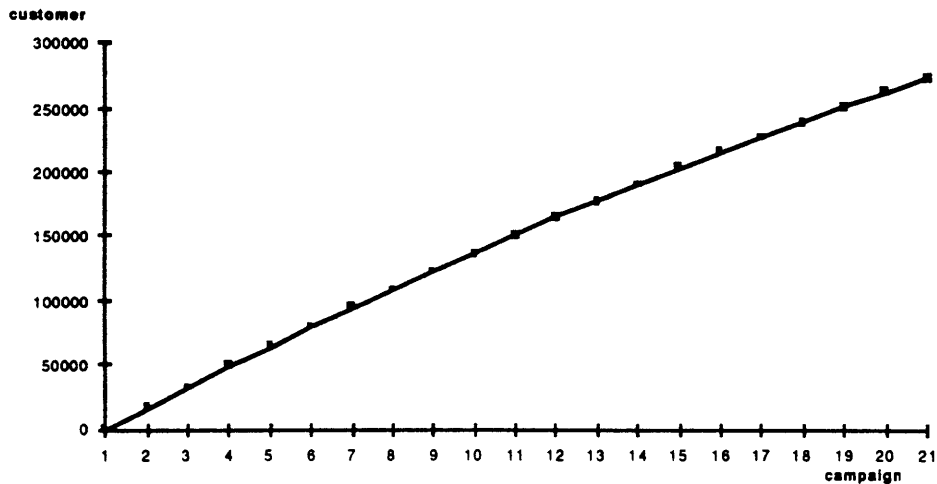


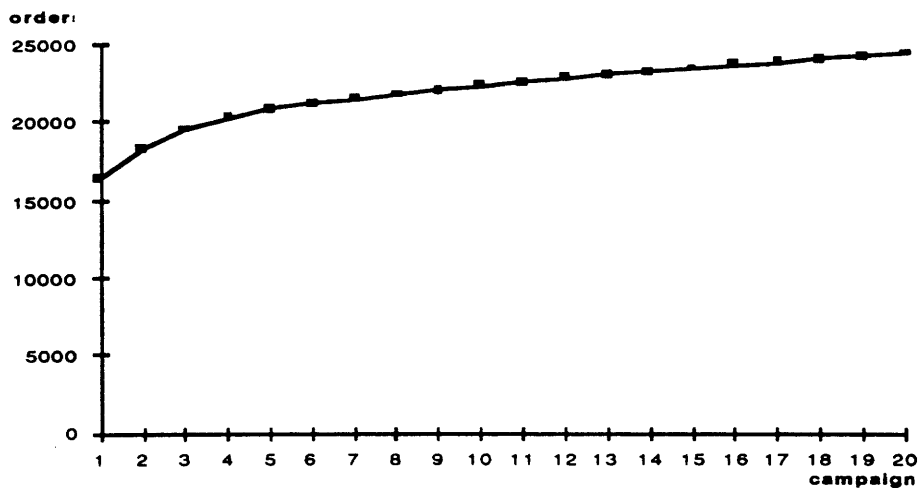
Fig. 8 - Catalogs mailed per Campaign

Figure 9 presents the number of customers in the house list and Figure 10, the number of orders per campaign. It is not difficult to show that both the number of customers in the house list and the number of orders have an asymptotic behavior in the number of campaigns. The explanation for this fact is the following: as the campaigns are undertaken, the number of customers in the house list increases and, consequently, the number of customers lost by attrition keeps growing until it reaches the number of new customers acquired from the rental lists in each campaign, which for this example, is constant over time. From this point onward, the number of customers and orders do not change.

Since the number of campaigns is not large enough in our example, the asymptotic behavior is only partially observed in Figure 10 and almost not noted in Figure 9. If the attrition rate was higher, the asymptotic behavior would be observed earlier; on the other hand, the lower the attrition rate the later this phenomenon would be observed. If the attrition rate is zero, the number of customers in the house file keeps increasing.

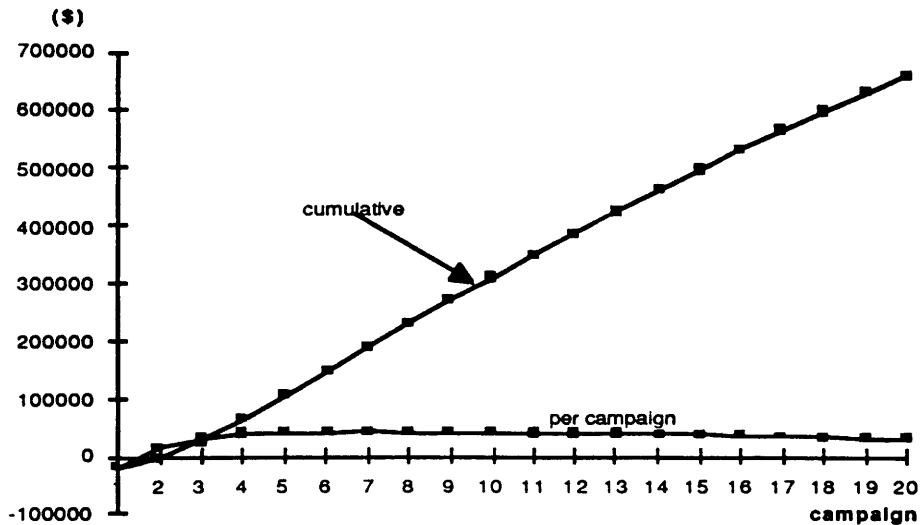


**Fig. 9 - Number of Customers in the House Lists as a Function of the Number of Campaigns**



**Fig. 10 - Number of Orders per Campaign**

**Fourth example:** 5 years time horizon, with multiple mailings and with 100,000 names in the house list at the beginning of the planning horizon. This example differs from the third one only by the initial conditions of the house list. Figure 11 shows the discounted cash flow results. As we can see, starting with names in the house list leads to better economic results. The improvement depends on how many names we have in the house list and their distribution among the house segments at the starting period of the analysis. In this particular case, the initial number of customers in the house list is 10% of the total number of available potential buyers in the rental lists.



**Fig. 11 - Discounted Cash Flow Results ( Names in house file and multiple mailings)**

## 5 - CONCLUSIONS AND RECOMMENDATIONS

In this paper we presented a realistic optimization model to help catalog companies select the most profitable mailing strategy over a planning horizon under mild assumptions. To the best of our knowledge the technical literature has not focused enough on this problem.

The model relies on data that is readily available. It provides managers with the ability to directly link the most important factors in managing rental and house lists.

The main results of the model over the planning horizon lie in how deeply the company should go into rental lists; how much it should invest in acquiring new customers from these lists, how many multiple mailings it should make to the same house segment; and what groups of customers it should activate.

With this tool it is possible to test the performance of the company under a variety of conditions including: rental lists performance, house lists performance, structure of costs, cost of products, types of catalogs, marketing efforts, financial constraints, operational constraints, maximum number of multiple mailings, number of campaigns per year, seasonal conditions, and so on. Also, it allows the testing of different economic scenarios that can affect consumer behavior. This model can be applied to existing companies with different number of customers in the house file at the beginning of the planning horizon. In addition, it can be applied to prospective companies for the purpose of testing several hypotheses before they enter this business. A company can find out how long it would take to recover its investment and how much its profits will be. Indeed, this

model can be used as part of evaluating the value of the company, based on the lifetime value of a buyer, number of customers in its house list and the company's ability to acquire new buyers.

However a few issues remain to be addressed:

First, the model relies on rental lists that have already been tested since we use past history to estimate the **input data** for future campaigns. In case of new rental lists, some tests would have to be performed in order to estimate its parameters, We believe that some attention should be given in future research to find efficient procedures for testing rental lists as well as designing tests with catalogs, products, offerings, rental lists, and so on, to evaluate future performance. We hope to investigate this subject, and integrate these results with the optimization model.

Finally, it seems necessary to research the eventual cannibalization effect that can occur with multiple mailings when customers receive more than one catalog from the same company during a short period of time.

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## REFERENCES

- Brooke, A., D. Kendrick and A. Meeraus (1988), "GAMS: A User's Guide," Scientific Press, Redwood City, CA.
- Buchanan, B. and D. G. Morrison (1987), "Sampling Properties of Rate Questions with Implications for Survey Research," *Marketing Science*, 6, 286-298.
- Fleischmann, J., R. Weeb and P. Minton (1991), "Circulation Management: Techniques for Achieving Financial Goals," notes presented at 8th Annual Catalog Conference.
- Fornell, C., M. Ryan and W. Qualls, (1991), "Market Driven Quality: Maximizing Customer Satisfaction and Firm Performance," Working Paper, Sloan School of Management, M.I.T.-Massachusetts Institute of Technology, Cambridge, MA.
- Fourer, R., D. M. Gay and B. W. Kernighan (1990), "A Modeling Language for Mathematical Programming," *Management Science*, 36, 519-554.
- Geoffrion, A. M. (1992), "The SML Language for Structured Modeling: Levels 1 and 2," *Operations Research*, 40, 38-57.
- Hill, L. T., (1989). "Profit Strategies for Catalogers," The Hanson Publishing Group, Inc., Stamford, CT.
- Holtz, H., (1990), "Starting & Building Your Catalog Sales Business: Secrets for Success in One of Today's Fastest-growing Business," John Wiley & Sons, Inc.
- Kotler P. (1991), "Marketing Management: Analysis, Planning, Implementation, and Control," eighth edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
- Schmittlein, D. C., D. G. Morrison and R. Colombo (1987), "Counting Your Customers: Who Are They and What Will They Do Next?," *Management Science*, 33, 1-24.
- "1990/1991 Statistical Fact Book," Direct Marketing Association, Inc. 1990.
- Direct Marketing Association: "USPS Revenue, Pieces, and Weight by Class of Mail Report," 1990.
- 1989 Guide to Mail Order Sales, Marketing Logistics Inc., 1989.