

Optimizing Rhenania's Mail-Order Business Through Dynamic Multilevel Modeling (DMLM)

Ralf Elsner • Manfred Krafft • Arnd Huchzermeier

Rhenania Group, 56061 Koblenz, Germany

Westfälische Wilhelms-Universität Münster, Institut für Marketing, Am Stadtgraben 13-15, 48143 Münster, Germany

Wissenschaftliche Hochschule für Unternehmensführung (WHU), Otto-Beisheim Graduate School of Management,

Burgplatz 2, 56179 Vallendar, Germany

r.elsner@rhenania-buchversand.de • mkrafft@uni-muenster.de • ah@whu.edu

Rhenania, a German direct mail-order company, turned its catalog mailing practices around within one year and consequently moved up in market position from number 5 to number 2. A dynamic multilevel modeling (DMLM) approach uses elasticities to determine the optimal frequency of catalog mailings, a customer-segmentation approach allows for optimization of mailings, and a recency, frequency, monetary-value (RFM) segmentation in combination with a chi-square automatic interaction detection (CHAID) algorithm determines when customers should receive a reactivation package—as opposed to a catalog—to optimize mailing efficiency further. The DMLM approach was so effective that Rhenania acquired two competitors (one a subdivision of Springer Verlag).

(Marketing: buyer behavior. Statistics: elimination.)

Direct marketing, selling goods and services through such channels as catalogs, outbound call centers, and the Internet, is important in North America, Europe, and Asia. For example, the advertising budgets for direct marketing represent more than half of total advertising expenditures. The advertising expenditures for direct marketing in the US and the 15 largest economies worldwide were estimated to total around US \$380 billion in 2001. About one quarter of these expenditures are spent for direct mail. After the US and Japan, Germany has the highest advertising expenditures for direct marketing with more than 460 million catalogs mailed to end customers per year (<http://www.the-dma.org>). However, the catalog-sales industry is characterized by maturing markets and slowing growth in market volume. Over the years, the number of customers interested in purchasing products or services through direct-mail channels has become fairly stable. Many direct-mail segments are

served by a fairly steady group of companies that try to succeed in these mature markets with low margins.

Nevertheless, selling books, CDs, videos, DVDs, and CD ROMs through direct-marketing channels via catalogs is a well-established business. In Germany, this business was dominated by Weltbild (with sales of about US \$500 million), Mail Order Kaiser, and the publishing company "2001." In the mid-1990s, these three companies served more than 50 percent of the market. At that time, Rhenania was one of the top 10 companies in the business, competing with such firms as Akzente, Conlibro, Frölich und Kaufmann, Humanitas, and Taubert. The German business environment can be characterized as mature. Growth in sales can come primarily from gaining market share from competitors.

With regard to the so-called four Ps (price, product, place, promotion), promotion is the most effective marketing instrument for differentiating a company's offerings from those of competitors. Because of legal

constraints, prices for new books are fixed, and price competition, even for older books, is limited across companies. This price fixing (in German *Buchpreisbindung*) has been in place since 1878 and is intended to prevent large bookstore chains from dominating the

Promotion is the single most important marketing instrument.

business and forcing smaller retailers out of business. Price promotions or discounting are permitted only for books publishers have delisted (<http://publishing.about.com/library/weekly/aa080700a.htm>). Discounted books are usually distributed through catalog companies, and price promotions therefore differentiate mail-order businesses from stationary retailers (bookstores). The products mail-order companies offer do not differ substantially, because they all buy their assortments from a limited number of publishing companies. Naturally, the locations of mail-order companies do not play a significant role. The trend is towards outsourcing order management to international providers of logistics services that have extensive networks of warehouses and online procedures for filling orders. Because the competing companies all use similar professional subcontractors to handle orders and deliveries efficiently, they gain no sustainable advantage in this area either.

Promotion is the single most important marketing instrument. In the mail-order business, making promotion effective is equivalent to optimizing mailings. Although the design, layout, and content of catalogs can also influence success, a comparison of different companies' catalogs revealed few differences. Consequently, companies face three major questions in determining their mailing strategies (Bitran and Mondschein 1996, 1997):

- the number of catalogs to mail over a given period (frequency),

- the customers or customer segments that should receive mailings, and

- whether mailings should be tailored to individuals or to customer groups (segments).

Because margins in the mail-order business are low, sending out too many catalogs can be counterproductive (Campbell et al. 2001, p. 78), while sending out too

few can lead to opportunity losses, because customers willing to order cannot do so without first getting catalogs. If profitable and loyal customers do not receive mailings frequently from their mail-order company, their propensity to get interested in competitors' offerings will increase.

The Rhenania Company

Rhenania was founded in 1946 and is a medium-sized (with revenues between US \$10 and 50 million) mail-order company, selling books, CDs, and related products through catalogs. In the mid-1990s, the company mailed up to 20 catalogs per year to a large number of customers and prospects. Rhenania's customer data is stored in a house list, a proprietary customer database containing the addresses of customers who have ordered in the past. It augments this list of customers with addresses that it either rents from commercial address brokers (rental lists) or gains directly through campaigns in print or similar media. In the mid-1990s, Rhenania's database contained about 600,000 names, and every year it mailed about 2,400,000 catalogs and other materials. In 1996, the then-CEO of Rhenania found that the company was in trouble: it had a sustained trajectory of declining sales, a declining market share, and declining profits. He hired Ralf Elsner as the new marketing director. The company downturn had occurred even though Rhenania had followed the standard marketing approach to managing customer contacts and choosing the best customers for each mailing. In other words, it sent clients catalogs only if expected revenue was higher than the cost of the merchandise, the order fulfillment, and the mailing itself. Rhenania had increased the productivity of its separate, single mailings, but its customer base was shrinking (Figure 1). Elsner's task was to increase Rhenania's customer base and to increase the firm's profitability.

Elsner, with a background in economics and considerable experience in modeling and quantitative methods, recognized that mail-order companies' traditional, worldwide practice of optimizing the productivity of individual mailings is actually suboptimal even in the medium term, since it leads to shrinking bases of active customers (customers who ordered in the last 12

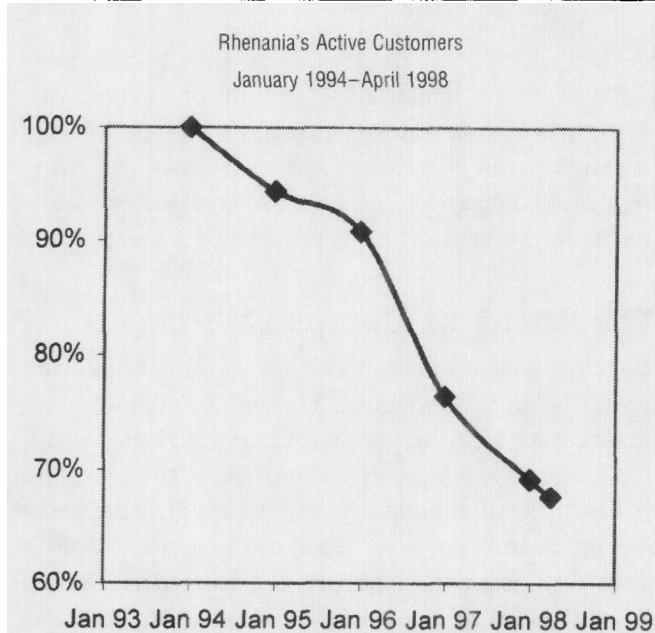


Figure 1: Optimizing single mailing campaigns is the accepted practice in the mail-order industry, that is, firms send catalogs to individuals for whom they expect marginal sales to exceed marginal costs. Consequently, they increase the effectiveness of the mailing campaigns (as measured by the profitability of the mailing per customer). However, total annual sales, total annual profit, and the number of active customers usually decline over time.

months) and lower profitability over time. It can be proven, using straightforward mathematical modeling, that it pays in the long term to mail to clients who would be considered unprofitable from a traditional, short-term standpoint (Elsner 2002). Depending on the resources available, even customers who have not ordered for a while or have placed only small orders can contribute to a mail-order company's bottom line. Elsner proposed a nontraditional, analytical approach that uses a rolling-horizon model to optimize catalog mailings. His generic, basic model proved that short-term losses with low-valued customers can be more than compensated for in the long run because of economies of scale per mailing and per customer, and because low-valued customers can become active customers in the near future. However, this approach was so contrary to common knowledge and conventional thinking in the mail-order business that Elsner did not get the then-CEO's approval to move forward. Rhenania's downturn continued. It replaced the then-CEO in

April 1998 with Frederik Palm. Palm was very open minded and recognized the potential value of Elsner's new basic model. He agreed to give it a try.

Best Practices in the Global Mail-Order Business

Until 1998, Rhenania sent 20 catalogs a year to its active customers following the traditional industry approach of optimizing the performance of individual mailings. Until 1997, Rhenania did not even evaluate whether 20 catalogs a year was the optimal frequency—it just followed traditional practice in the industry. Its active customer base shrank continuously. Elsner and Palm recognized this shrinking as a consequence of a sub-optimal mailing frequency and a suboptimal choice of customers or customer segments to receive the mailings. Rhenania's active base of profitable customers decreased, as their addresses changed or their creditworthiness deteriorated or as they switched to competitors or died. In following the traditional mailing strategy, Rhenania optimized single mailing campaigns, that is, it sent mailings only to people for whom it expected marginal sales to exceed marginal costs. Although this method increases profitability per mailing per customer, it also leads to contacting a shrinking number of customers. Given its resources in 1997, Rhenania could handle contacting as many as 400,000 customers. However, in applying the traditional method, it contacted only 200,000. Over time, Rhenania's volume and market share decreased dramatically. In 1995, 1996, and 1997, the market volume grew annually by about five percent, while Rhenania lost around 10 percent in sales volume per year. In early 1998, Rhenania's problem was to identify the optimal frequency and timing of mailings to which customer segments. With Frederik Palm as CEO, Elsner got the opportunity to apply his new dynamic mailing approach.

Thinking Outside the Box—Dynamic Multilevel Modeling (DMLM) at Rhenania

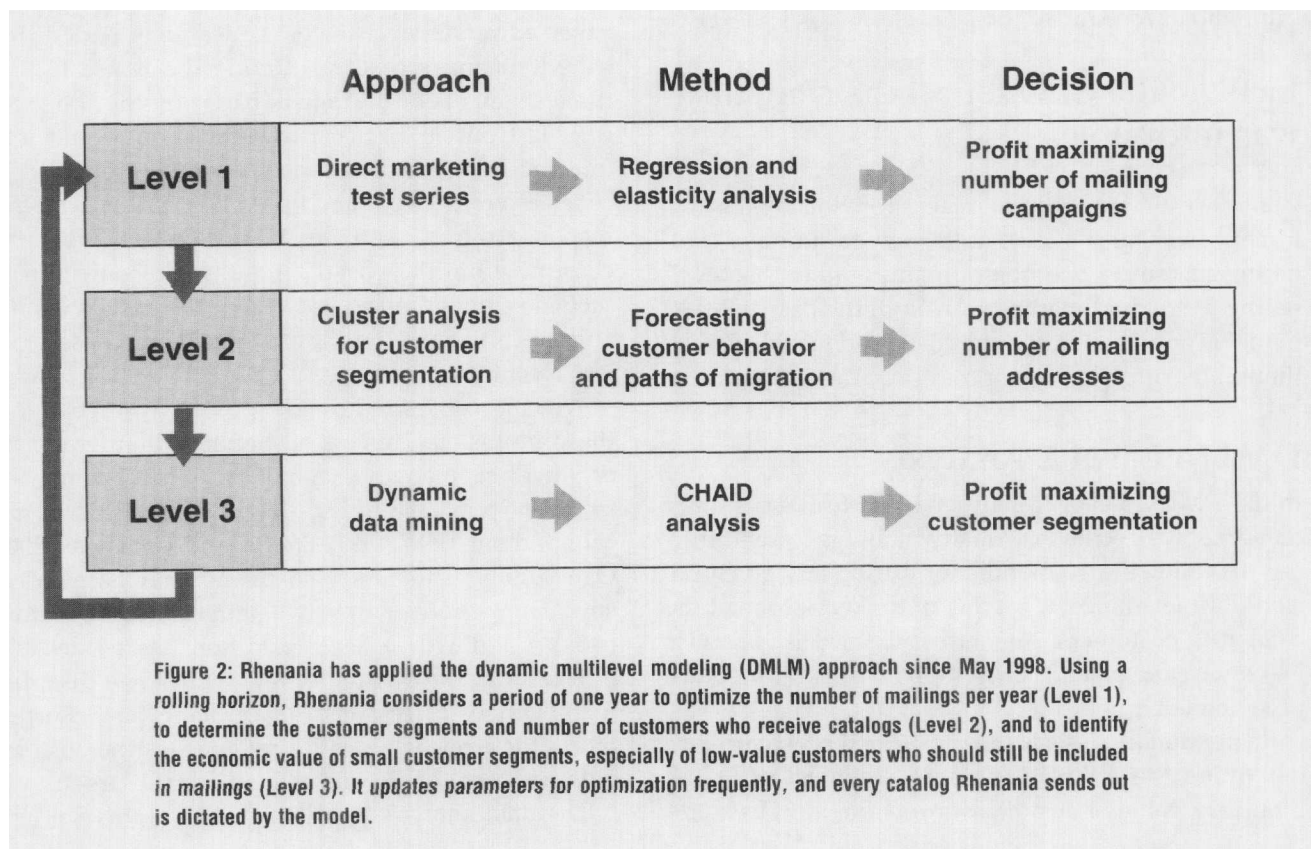
The dynamic multilevel modeling (DMLM) approach is a multiperiod optimization model of catalog mailings that allows for dynamic promotion or demotion

of customers across a large number of customer segments. In DMLM, the customers within segments are characterized by similar responsiveness to mailings and homogeneous value. The DMLM approach is based on the idea that low-value or low-frequency customers that yield short-term losses are profitable in the long term because a fraction of these low-valued customers can be expected to become good customers in the near future and because the company can obtain economies of scale per mailing. The economies of scale stem from lower costs per unit for printing, handling, and shipping larger numbers of catalogs.

The model operates at three levels (Figure 2). First, in a test phase, we vary the frequency of the mailings to estimate the elasticities for order size, purchase frequency, and customer response (when receiving the mailing on a given day of the week). Any firm could adopt this Level 1 analysis of the direct-marketing approach. Second, we segment the pool of customers further, for example, based on customers' actual purchasing behavior. The company must decide whether to

include or to exclude particular customer segments from the catalog mailings (Level 2 analysis). We segment customers based on the recency of their last purchase only when we observe a decline in marginal sales. What is unique about our approach is that we derive a threshold level u^* (a minimum required sales level) that we can use to evaluate the attractiveness of individual customers (in the Level 3 analysis). Third, we can fine-tune the firm's mailing strategy further by analyzing whether customers who belong to a particular customer segment should be demoted or treated in a special way. We can base this decision either on the RFM criteria (recency, frequency, monetary value) alone or on the CHAID-analysis (chi-square automatic interaction detection).

For example, a customer who places an order moves up immediately into the highest customer segment. However, the customer may not order again for a while, and thus, at the end of a prespecified period, the firm sends a reactivation package to stimulate additional purchases. It (temporarily) excludes the cus-



tomer from the catalog mailing list. It can apply the same type of review and reactivation procedure to other segments as well (Level 3 analysis). While the firm does not have to alter the overall number and choice of customer segments, it does change the size of each segment in each period to curtail mailing to one-time buyers or to unprofitable accounts. The firm bases its classification of customers as active and inactive and its decisions to send reactivation packages instead of catalogs on demographic data combined with customer-specific RFM values. We analyze Rhenania's customer base periodically and label individual customers that do not contribute to profitable sales as inactive. To remain on the catalog mailing list, customers must exceed the critical threshold level of sales u^* . Consequently, the termination rate of customer relationships based on the Level 3 analysis can be explicitly accounted for in a slightly altered model formulation for the Level 2 mailing optimization (Appendix).

The major challenge we faced in developing this direct-marketing approach was coordinating the experimental testing and analysis with the data-estimation procedures. For example, it took almost two

In 1996, the CEO found the company was in trouble.

years to estimate the parameters for Rhenania's customer base. Our model is in the new tradition of evaluating customers over their lifetimes rather than evaluating individual mailings. Overall, the basic DMLM model is only moderately sophisticated technically, although the approach is nontraditional and pioneering.

DMLM Level 1 Analysis

In the DMLM Level 1 analysis of the firm's customer database, we decide how many mailings to send during the following 12 months (or during any given period of time) and on what day of the week to mail the catalog to customers. (In Germany, the postal service is very reliable, and thus delivery lead times are predictable.)

Regression analysis is the major method we used to determine the elasticity of how mailings affect the monetary value of customer orders, the purchase fre-

quency, and the response rate across all segments. We did two years of experimental testing to develop stable elasticity coefficients. Sometimes Rhenania learned painful lessons from errors made by the logistics service providers. For example, mailing identical catalogs to the same customers over short intervals does not increase revenue. To the contrary, it has a negative effect on customer satisfaction.

Given a customer base of 1.1 million addresses, 30+ employees primarily in sales and marketing, and the limited financial resources of a medium-sized company, Rhenania saw 25 mailings as the volume that it could handle efficiently to obtain substantial gains in profit. Today, it sends out a total of 75 catalog mailings a year across all of its three subdivisions (consisting of Rhenania and the two acquired companies).

DMLM Level 2 Analysis

Based on the optimal number of mailings per year as determined in the first level of the DMLM model, in Level 2, we determine how many customer segments Rhenania should contact in each mailing to optimize expected profits over the entire planning period.

In Rhenania's case, we divide the house list into three segments of customers based on the time since their last purchase; that is, we focus on recency only (not the frequency or monetary value of orders). Recency is a reasonably good predictor for the customer-response rate. Customers in the first segment purchased within the past 12 months. Customers in the second segment purchased within the past 24 months, and customers in the third segment purchased even less recently.

We suppose a Markov-like process whereby, given the stimulus of a catalog, customers will migrate from all lower segments to segment number 1 when they make a purchase (Biggs et al. 1991; Bitran and Mondschein 1996, 1997; Pfeifer and Carraway 2000). Over time, customers who do not purchase for the specified period of time will migrate from segment number 1 downwards. In addition, the model takes into account the possibility that names will disappear for a variety of reasons (death being one). Furthermore, the firm periodically replenishes the customer database through list rentals and ads (Figure 3).

The data analysis revealed that the rate of promo-

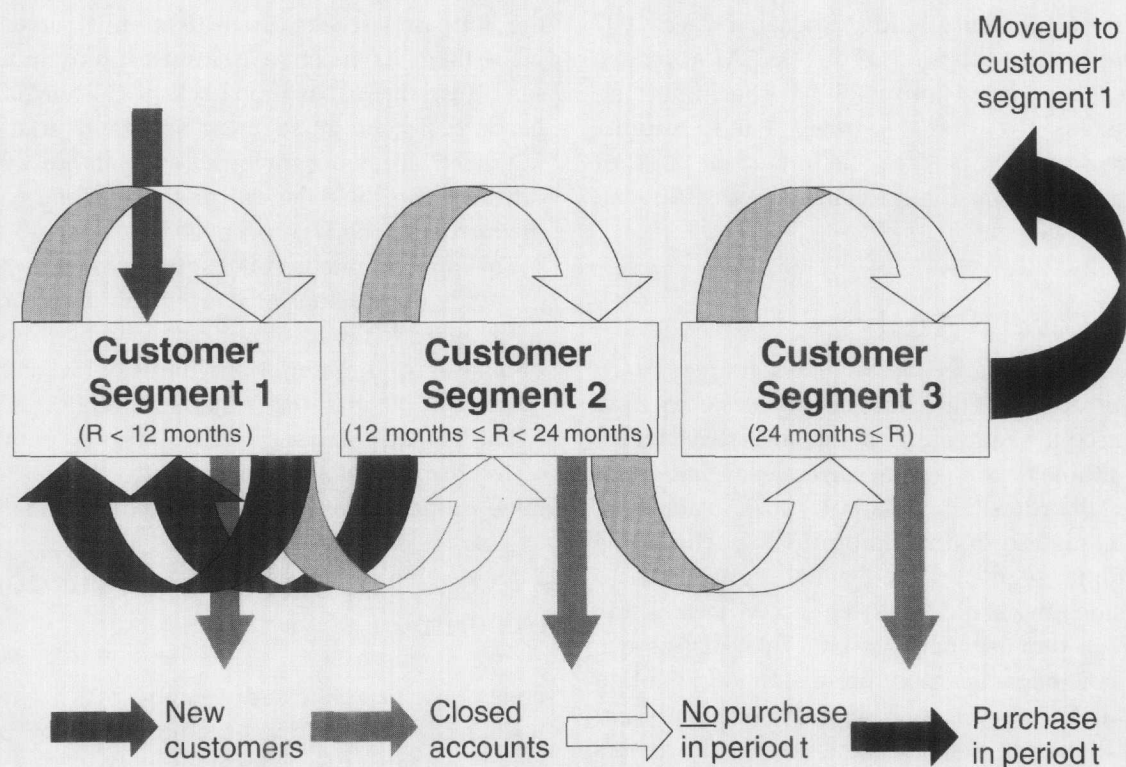


Figure 3: Customers are segmented using the recency (R criteria) of the last purchase. The rate of promotions and demotions for the chosen customer segments is almost constant throughout the year. We can make the same assumption for new customer accounts and for closing accounts. Consequently, a fixed number of customers per mailing either buy and thus move up into customer segment number 1 or do not buy and thus either remain in their current segment or drop down into a lower customer segment.

tions and demotions for the chosen customer segments is almost constant throughout the year. Consequently, we can assume that a fixed number of customers per mailing either buy and thus move up into customer segment number 1 or do not buy and thus either remain in their current segment or drop into a lower customer segment. We can make the same assumption for new customer accounts and for closing accounts. Thus, to simplify, we have assumed that a constant number of customers are being added for each mailing and a constant number are being dropped per mailing.

The optimization approach works as follows. First, for the chosen planning horizon, we determine the total number of addresses in each segment. Second, we determine the expected profit assuming that mailings go either to the top one, the top two, or all three customer segments. The model accounts for scale econo-

mies in mailing. Third, we determine the profit-maximizing number of customer segments to include in the mailings.

In the application case study, we concluded that mailing to all three customer segments of Rhenania is optimal. Moreover, we can analytically derive the threshold level for the minimum required sales per customer per segment per mailing u^* . This threshold value u^* depends on the overall number of mailings, the rate of customers becoming active, and the marginal costs of mailing for the lowest customer segment. It captures the trade-off of costs for continued catalog mailings and the expected long-run profitability from repeat buying. Moreover, we show that, in the optimum solution, the marginal revenue of the lowest segment to be included in the next mailing is less than the marginal cost of the catalogs (Elsner 2002).

In an early feasibility study, Rhenania used 1997 data to verify that adoption of the DMLM approach would in fact improve profitability. The impact on profit of mailing to customer segments 1 and 2 resulted in an increase of two percent, the impact on profit of mailing to all three customer segments was estimated as close to six percent.

DMLM Level 3 Analysis

So far, we have discussed classifying customers based only on the recency of their purchase. Another method typically used in segmenting customers is RFM, which focuses on three factors: recency, frequency, and monetary value of orders (Hughes 1994, p. 87). In addition, the CHAID algorithm can be applied to partition the three customer segments into smaller segments (Kass 1980). Besides the standard *R*, *F*, and *M* factors, the CHAID algorithm uses demographic data, such as age, sex, academic degree earned, profession, and mailing destination. Thereby, in each segment, one can separate from the active customers the inactive customers who should no longer get the regular mailing. The decision is based solely on the predetermined threshold level of sales u^* . Rhenania sends the customers identified as inactive reactivation packages in an attempt to motivate renewed activity. This reactivation package is more costly than a standard mailing and contains special offers, such as price promotions or free gifts. The process of reactivating a customer at Rhenania is personalized (for example, each customer is personally addressed by the CEO of Rhenania or the head of marketing at the various phases of the reactivation process) but highly standardized.

Overall, Rhenania's scheme for classifying customers into segments remained the same as in Level 2, that is, it grouped customers by recency of last purchase. However, we introduced a new distinction. For example, in customer segment 1, we reviewed all customers who made their last purchases more than nine months ago and separated them into two categories based on past purchase frequency *F*, that is, customers who had bought once ($F = 1$) or several times ($F > 1$). In the first case, the monetary value of their orders had to exceed M_1 , for example US \$75, for them to remain in customer segment number 1 and continue to receive

the standard package (up to 18 months); otherwise we view them as inactive customers and immediately send them the reactivation package (Elsner 2002). Similarly, customers in segment number 2 and segment number 3 are being reviewed as well, however, with different threshold levels for the monetary value of their orders M_2 , M_3 respectively.

This analytic method does not use scoring systems or divide up the house list arbitrarily into equal parts with regard to the customer's last purchase, number of purchases, or amount of purchases (which is common practice in the mail-order industry today).

The CHAID analysis produces a strict segmentation of the firm's available customers so that it can maximize profits. This third-generation RFM analysis has

We had very little time to conduct experiments.

none of the evident disadvantages of its predecessors. It does not show address segments that are probably better than others, but it identifies the profit-maximizing segmentation. Moreover, it can be combined with variables other than recency, frequency, or monetary value.

Calibrating the Model: Mail Tests at Rhenania

Since 1997, Rhenania has constantly tested new mailing approaches. In that we developed the DMLM approach for application to all mailings, Rhenania definitely needed to test the model before the first full run in the summer of 1998. We ran multiple tests to determine the optimal frequency of mailings per year. For the mail test, we chose a minimum of 10,000 customers and randomly assigned them to the test group and the control group. Rhenania sent the control group mailings according to its standard mailing procedure. It sent those in the test group catalogs at a lower or higher frequency, ranging from one mailing a year up to weekly mailings. Prior to 1997, Rhenania usually mailed up to 18 catalogs per year. On the one hand, we checked whether this number was far too high by mailing eight, six, four, two, and one catalog to the test

groups. On the other hand, we checked the outcome of frequencies similar to those Rhenania traditionally used (20, 15, and 10 mailings) and of more frequent mailings, with a maximum of weekly mailings (actually 48 mailings a year because mailings at Easter, Christmas, and similar holidays do not generate substantial revenue and have to be considered blackout dates).

In the spring of 1998, we obtained strong evidence that 20 to 25 mailings was the optimum range of frequencies of mailings for the most attractive customers. We ran a series of large-scale tests to compare the performance of these frequencies. We identified the optimum frequency by comparing the elasticities of additional mailings with regard to average order size (ϵ_A) and response rate (ϵ_r). As long as these elasticities are larger than 0, additional mailings generate above-average changes of order sizes and response rates. If the elasticities are smaller than -1, additional mailings cannibalize response rates and order sizes. Elasticities between 0 and -1 are equivalent to below-average changes in order sizes and response rates, meaning that additional mailings still produce higher total order sizes and responses, while the mean order size and response rate decreases. However, such mailings would still lead to higher earnings. The tests clearly show that higher frequencies of mailings still generate additional revenue (Table 1).

We conducted different series of mail tests to check which day mailings were delivered to customers and which minimum interval between mailings to individual customers generates the best results (Figure 4). We tested days of delivery to customers (Monday through Saturday) and time interval between mailings (180, 90, 45, 30, 14, seven, or one day(s)) in depth against each other. Taking into consideration the result that bi-monthly mailings of catalogs generate the highest profit gains, we concluded that 26 mailings a year is the optimum frequency for Rhenania's clients. However, because of the holiday blackout dates it would not actually send out mailings every second week. With these blackout dates dropped, a realistic frequency of 25 mailings to the most attractive customer segment is optimal. Given the size of Rhenania's customer base, its staff and financial resources, 25 mail-

n	ϵ_A	ϵ_r
$1 \leq n \leq 3$	13.4%	17.7%
$4 \leq n \leq 12$	-11.0%	-7.2%
$13 \leq n \leq 19$	-9.4%	-17.6%
$20 \leq n \leq 26$	-8.9%	-24.8%
$27 \leq n \leq 48$	-31.0%	-58.0%
Range of R^2	83% - 95%	74% - 95%

Table 1: Each entry in this table represents the elasticity of the average order size (ϵ_A) and response rate (ϵ_r) if Rhenania mails one additional catalog. For example, if it mails two catalogs instead of one (+100 percent), the average order size per catalog increases by 13.4 percent. We computed the elasticities based on OLS regressions with average order size and response rate as dependent variables and frequency of mailings (n) as the only predictor. The high R^2 values indicate that the standard errors of the regression coefficients are extremely low.

ings is also a frequency it can handle while still increasing profits.

We analyzed subsamples of the test groups in a similar way. All in all, we identified 28 different subsegments based on 24 groups of active customers (grouped by recency of order, that is, date of last order, ranging from one month ago to 24 months ago), and four groups of inactive customers whose most recent order was more than 24 months ago (basing our four categories on average order size while the customers were still active, covering order sizes of less than US \$50, US \$50-250, US \$250-500, and more than US \$500). To assign the members of the test groups to these clusters, we ran regressions on the responsiveness of each subsegment to different frequencies of mailings. We used this information to identify the economic value of smaller segments.

Implementing DMLM at Rhenania

Since Rhenania's economic situation in early 1997 was serious, we had very little time to conduct experiments. Although we gained some insight from the mail tests in 1997 about the optimal range of mailing frequencies, we never tested Level 2 of the DMLM approach prior to running our first test series in May 1998. After verifying the first positive results, we began a full run of the basic model in August 1998. However, at the same time, a senior member of Rhenania's holding organization who was responsible for supervising

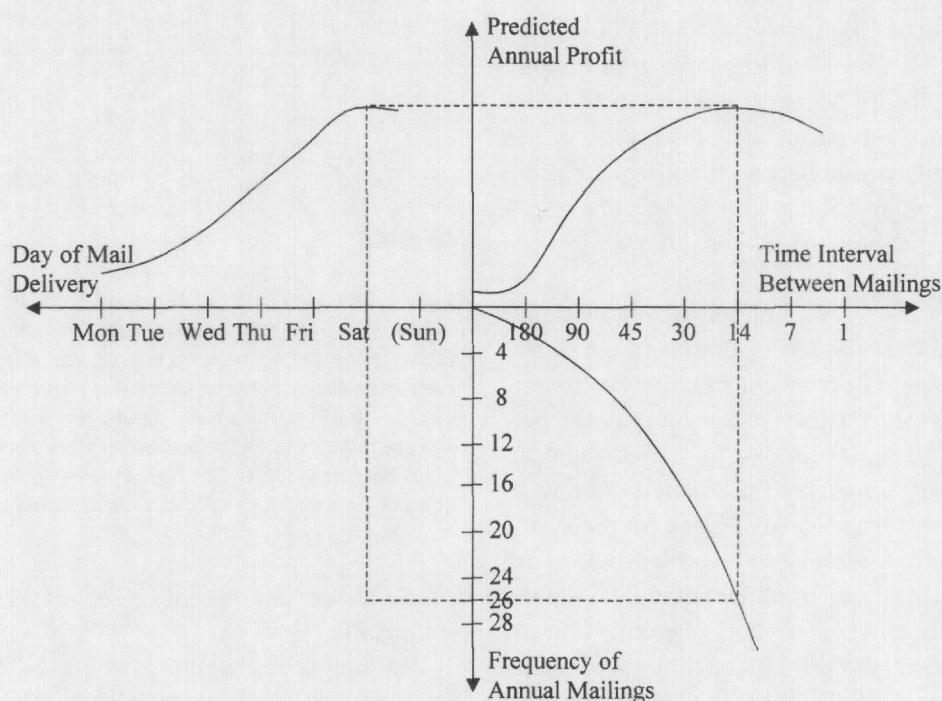


Figure 4: A series of mail tests provided clear evidence that 26 bimonthly mailings delivered to customers on Saturdays is the optimal mailing strategy.

the company intervened because mailing costs were increasing and revenues were more or less stable. He also objected to investing in midterm customer relationships because doing so was contrary to traditional industry wisdom and risky. Furthermore, the new mailing strategy based on DMLM's recommendations also led to short-term deteriorations of accounting metrics, such as the measure of the productivity of mailing budgets (the ratio of total order volume divided by the cost of mailings). Frederik Palm and Ralf Elsner explained why they expected (even intended) accounting metrics to deteriorate. They convinced this senior manager to permit a few more mailings, persuading him that he would see that the new approach would produce higher earnings and lower costs per unit of mailings. After two more months, Rhenania's holding organization was more than happy with the new approach and never again complained about short-term deteriorations in accounting results. To the contrary, when we applied DMLM to Akzente, the company Rhenania acquired in late 2000, the holding

organization never intervened as the short-term metrics initially deteriorated. In other words, we overcame this major resistance for good in late summer 1998.

Since then, every catalog Rhenania has sent out has been dictated by the model. Rhenania relies completely on the model in making all of its mailing decisions, which are at the heart of the mail-order business. We update DMLM continuously; however, the parameters have shown little variation so far. The modeling system runs on a COMPAQ/SIEMENS client-server system, operates on a database system called PROGRESS, and uses 4GL (a fourth generation language similar to SQL). For the multivariate analyses, we use SPSS and SAS. The cost of DMLM is less than two percent of Rhenania's total IT budget, with out-of-pocket expenditures of about US \$7,000 for additional software. After acquiring Akzente in December 2000 and Mail Order Kaiser in June 2001, Rhenania has based its mailing decisions for both companies on DMLM, keeping everything else (management systems, employees, product offering, and so forth) constant. The results of

applying this nontraditional mathematical model have been startling.

DMLM's Impact on Company Performance

Rhenania was in serious economic trouble in late 1997. Customers, sales, and profits were spiraling downward. When Frederik Palm was appointed CEO, his trust in Elsner's nontraditional approach helped Rhenania to turn around, and the DMLM model literally saved the company. Since we implemented the model, the numbers have proved that the company's business has improved across the board and that the model we applied was the turning point. The company has gone from fifth in the industry (closer to US \$10 million) to second (closer to US \$50 million) since the first model in the summer of 1998. Of course, its growth most recently came from its acquisition of Akzente and Mail Order Kaiser, two of Rhenania's direct competitors. However, even considering only Rhenania, we can clearly see that before applying DMLM, Rhenania underperformed the market, and after applying the model in 1998, it has outperformed the market (Figure 5).

Rhenania's profitability has also increased. While Rhenania showed profit losses in the late 1990s, its profitability quadrupled in 1999 and grew even further in 2000 and 2001. The project paid for itself within weeks. Another important success metric in the catalog-sales business is the number of active customers. Rhenania's customer base was decreasing until it introduced DMLM, and then it grew by more than 55 percent between April 1998 and the end of 2000 (Table 2). While Rhenania had lost 11.5 percent of its customer base between January 1997 and April 1998, it took only four months of following DMLM's recommendations to regain these customers (Figure 6). Interestingly, the new mathematical approach to optimizing the mailing frequency and the choice of customers to receive mailings seems to become less effective over time. Since DMLM helps the firm to take full advantage of the potential of its current customers, how much it can gain by applying DMLM has an upper limit. We modified DMLM in 1999 and further extended it in 2000 when Manfred Krafft and Arnd Huchzermeier became an in-

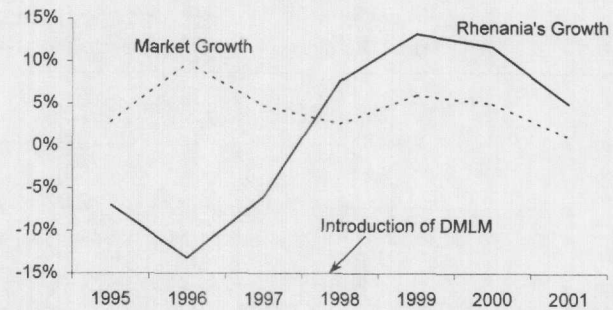


Figure 5: While the overall market volume grew by an average of about five percent between 1995 and 2001, Rhenania was losing market share before it introduced DMLM in 1998. In every year since then, Rhenania has outperformed the market by a considerable margin.

tegral part of the DMLM team. The extension of DMLM's third level helped to increase the customer base in 2000. Currently, the team is working on two additional modifications of DMLM.

The increase in profitability in 1997 resulted from Rhenania's decision to reduce mailings to a minimum and send out catalogs only to its most profitable customers. In following DMLM recommendations in 1998, the firm sent catalogs to many "unprofitable" customers. In that year, the profitability was reduced because Rhenania also changed its location and had to move its stock.

Applying DMLM helped Rhenania to gain economic strength and a substantial competitive advantage. Its superiority also led Akzente, one of its competitors, to seek acquisition by Rhenania in 2000. Rhenania acquired Akzente in December 2000 along with its customer database, which contained individual clients' purchase histories (timing, order size, returns, some demographic data, and so forth). Rhenania immediately used this data in the DMLM model. For this acquisition, Rhenania changed only the mailing procedure. It wanted to maintain the appearance of the old company, retaining the same merchandise, catalog, and name. It even kept the same people in important management positions (for example, procurement). Rhenania first applied the DMLM model to Akzente's customer list in February 2001. A startling and immediate turnaround is evident in the numbers. While Akzente had lost close to one third of its active customers during the previous two years, Rhenania stopped this

Year	Annual Rate of Market Growth	Rhenania's Rate of Growth in Sales	Rhenania's Rate of Growth in Profit	Rhenania's Rate of Growth in Active Customers
1995	+2.8%	-7.0%	-29.2%	-3.7%
1996	+9.8%	-13.2%	-47.9%	-15.9%
1997	+4.7%	-6.0%	+51.2%	-9.4%
1998	+2.6%	+7.7%	-69.9%	+24.0%
1999	+6.0%	+13.2%	+417.7%	+3.7%
2000	+5.0%	+11.7%	+10.4%	+14.4%
2001	+1.0%	+5.0%	+6.0%	± 0.0%

Table 2: Rhenania's performance lagged that of the market until 1997. Since introducing DMLM's basic model in 1998, the company has shown dramatic increases in growth, profitability, and the number of active customers.

trend immediately and reversed the downturn within less than a year (Figure 7). The results also show that a substantial number of new active clients came from the list of customers who had not ordered during the previous year. In other words, contacting customers that traditional mailing strategies would have ignored clearly pays off. Following DMLM's recommendations

to contact customers from low-value segments was key to saving and revitalizing Akzente. In acquiring Akzente, Rhenania moved from fifth to third in the German mail-order market for books, CDs, and related products.

Rhenania obtained similar results for Akzente's profitability. Before acquiring the company, Rhenania

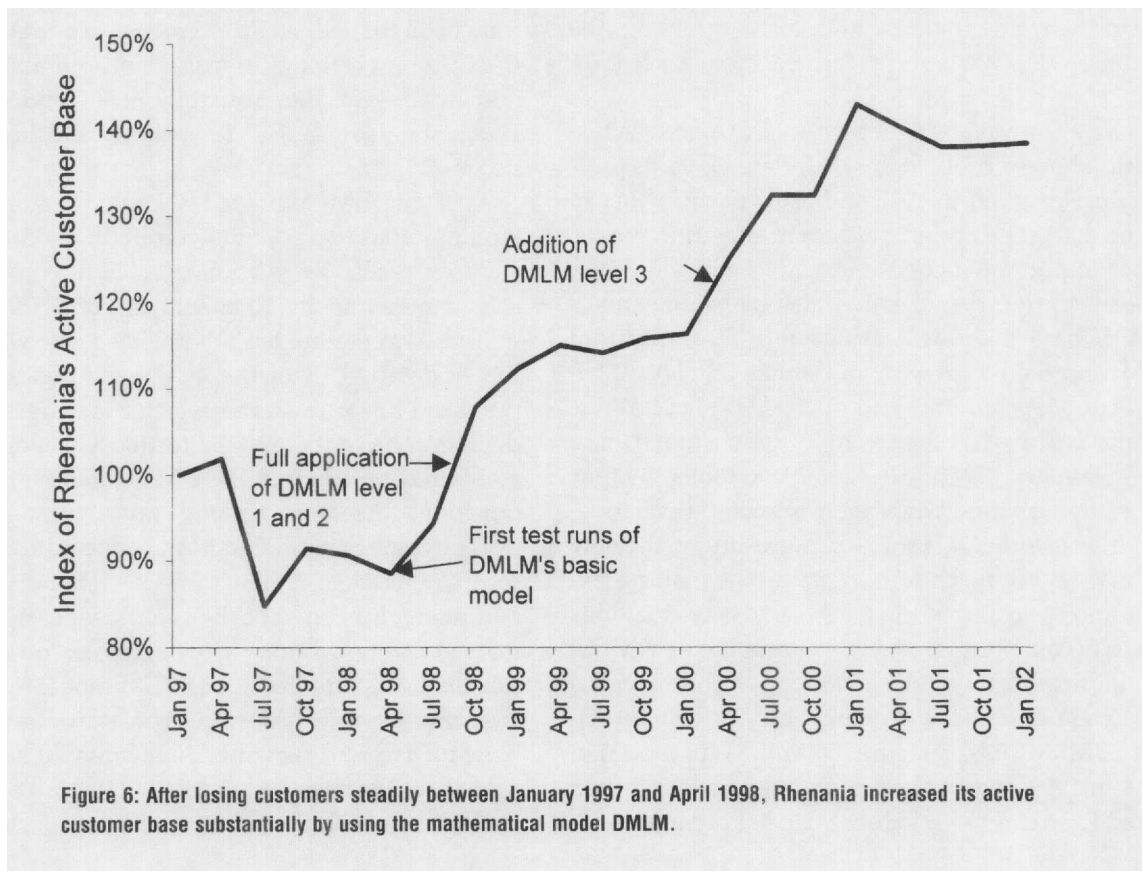


Figure 6: After losing customers steadily between January 1997 and April 1998, Rhenania increased its active customer base substantially by using the mathematical model DMLM.

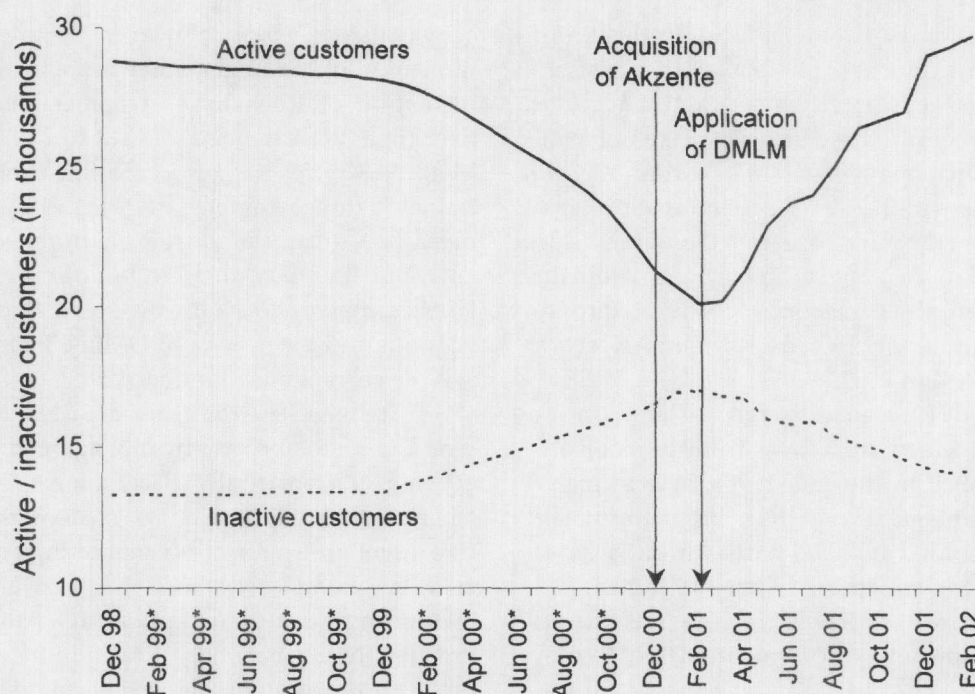


Figure 7: After the acquisition of Akzente, one of Rhenania's major competitors, the application of DMLM helped to turn around Akzente's loss of customers, leading to a recovery within less than a year. (Numbers marked with * are estimates.)

checked its performance. Akzente earned no money in 1998, 1999, and 2000, even though its revenue increased substantially in 1998 and 1999. It had tried to gain market share by increasing unprofitable sales, which did not pay off in the long run. After Rhenania acquired Akzente and applied DMLM early in 2001, it reversed its loss of market share and made the company profitable for the first time in three years (Table 3). According to Frederik Palm, this development is

clearly a consequence of applying DMLM to Akzente, which had previously followed conventional mail-order strategies. Moreover, the changes in Akzente's customer base were nearly identical to the changes in Rhenania's after following DMLM's recommendations.

In June 2001, Rhenania acquired Mail Order Kaiser. Although this acquisition contributed to taking Rhenania from third to second in the market, turning Mail Order Kaiser around is taking much longer than

Year	Annual Rate of Market Growth	Akzente's Rate of Growth in Sales	Akzente's Annual Profit	Akzente's Rate of Growth in Active Customers
1998	+2.6%	+11.7%	-301,000	not available
1999	+6.0%	+2.8%	-147,000	-2.4%
2000	+5.0%	-23.2%	-640,000	-24.2%
2001	+1.0%	+12.5%	+130,000	+29.1%

Table 3: Rhenania's direct competitor Akzente lost money three years in a row. After Rhenania acquired Akzente in December 2000 and applied DMLM in February 2001, it won back Akzente's lost customers and returned the company to profitable growth.

turning Rhenania and Akzente around. In this acquisition, Rhenania acquired only Mail Order Kaiser's name, stock, and customer names and addresses. However, customer purchase histories were not available. While Rhenania reversed Mail Order Kaiser's substantial losses within half a year and made a small profit, the active customer base and the overall sales volume are still decreasing (Table 4). As it obtains more information about customer behavior through mail tests and purchasing records, Rhenania expects to fully utilize DMLM in 2002.

DMLM helped Rhenania to turn around in extremely difficult times, to recover from its poor economic performance in the mid-1990s, and to gain a competitive advantage. It went from fifth in the market in late 1997 to second in 2001, partly through its acquisition of larger competitors (Figure 8). Industry experts consider its record of achievement over the last four years astonishing (Börsenblatt 2001; <www.buchmarkt.de>).

On the one hand, Rhenania's success can be attributed to the courage and leadership of Rhenania's CEO, Frederik Palm, and his willingness to try innovative and perhaps risky nontraditional approaches. On the other hand, the evidence shows Rhenania succeeded because of the strength of a superior mathematical model. Its competitors had similar merchandise and services. What differentiated Rhenania in a mature market was the DMLM model.

Extensions and Modifications

The DMLM approach is a modular concept that can be modified or extended. The application of DMLM's Level 1 and 2 analysis led to an increase in Rhenania's

active customer base. However, the effects of the optimization of mailing frequencies and the rough segmentation of Rhenania's customer base diminished over time. We extended DMLM to Level 3, following Manfred Krafft's suggestion to fine-tune the segmentation of the customer base. This disaggregated segmentation greatly increased the number of active clients, but its effect also leveled out after some time. Huchzermeier and Krafft proposed two major modifications and extensions of DMLM intended to leverage the current customer base.

Krafft suggested that Rhenania should further exploit the customer base by managing customer recovery more systematically. Based on his recent research, he argued that inactive or lost customers are an attractive target group for direct-marketing activities. However, systematic procedures for recovering customer relationships are the exception rather than the rule in the mail-order business. Krafft initiated a research project to determine the expected value of formal recovery-management activities. Uwe Rutsatz, a full-time doctoral student at WHU's marketing department, was responsible for this project. Using the negative binomial distribution (NBD)/Pareto model, he ran extensive analyses of Rhenania's inactive customers to determine individuals' activity levels based on the timing and frequency of their orders. This led to an even more differentiated segmentation of inactive customers. In a series of tests of different mailing and regaining strategies, Rutsatz identified a highly responsive and profitable group among the inactive customers. While Rhenania's and the mail-order industry's traditional response rates for recovery activities is about 1.5 percent, Rutsatz could increase the response rate to more than four percent (Rutsatz 2002).

Year	Annual Rate of Market Growth	Mail Order Kaiser's Rate of Growth in Sales	Mail Order Kaiser's Annual Profit	Mail Order Kaiser's Rate of Growth in Active Customers
1999	+ 6.0%	- 8.6%	- 1,314,000	not available
2000	+ 5.0%	- 8.6%	- 2,148,000	not available
2001	+ 1.0%	- 25.1%	+ 160,000	- 21.4%

Table 4: The acquisition of Mail Order Kaiser's name and stock helped Rhenania to become second in the market. However, it did not acquire the firm's customer data, which prevented full application of DMLM. Data from current mail tests and improved mailings will help Rhenania to fully utilize DMLM in 2002.

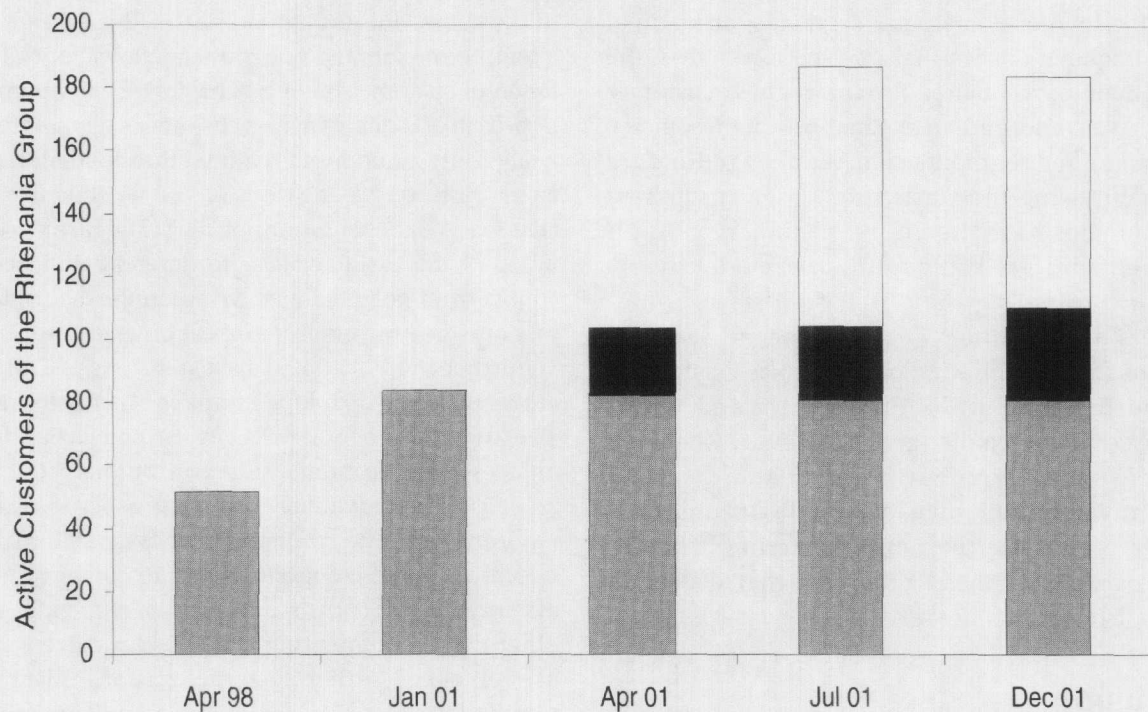


Figure 8: Rhenania (grey) was fifth in the market in the late 1990s. With its application of DMLM, its acquisition of Akzente (black) in January 2001, and its acquisition of Mail Order Kaiser (white) in June 2001, the Rhenania group became second in its market.

He found that reactivation efforts after a fairly long period of inactivity are more promising and effective than mailings sent immediately after a short period of inactivity. Furthermore, personalized reactivation packages for test groups led to response rates three times higher than those effects for nonindividualized mailings to the control group. The integration of such timing effects of recovery activities in DMLM will be fully implemented in 2002. The analytical part of this project was completed in March 2002. Uwe Rutsatz joined Rhenania in the spring of 2002, and his major task will be to apply this modification to Rhenania, to Akzente, and in 2003, to Mail Order Kaiser's list of customers.

Huchzermeier is working on different extensions of the model. First, Rhenania has not coordinated its ordering decisions across the three companies' catalogs, because each division has its own purchasing department. The main argument for retaining separate operations is that each mailing company has its own mailing

list and thus targets nonoverlapping customer segments. However, there are pooling effects in procurement. Second, the three companies plan their catalogs independently and launch them simultaneously, with no category optimization. The companies do not fully utilize sales information, for example, by testing market response to a focused offering in one catalog first. Because most customers respond within two or three working days of receiving a mailing, the company could use information about their responses almost immediately in designing the other catalogs and in (pooled) restocking decisions. Third, we could further refine the model setup, for example, by using a mixed-integer programming formulation with piecewise-linear cost functions and inventory-balancing equations for the customer segments. This would cut further the number of mailings sent to customers who purchase the least and make up the largest group. Rhenania could thus reduce its overall mailing costs and obtain maximum customer purchases. Fourth, for

each of the low-level customer segments, an optimal mailing frequency exists that may be lower than the optimal mailing frequency for the highest customer segment. We could find an optimal mailing frequency for all customer segments that reduces redundant mailings by using the elasticities for each segment instead of those for the entire customer pool. Finally, we could easily fine-tune the model by explicitly incorporating the purchase histories of all customers and customer segments. Small seasonal variations in the likelihood of purchases exist, however, and the assumption that the demand rate is uniform could be challenged. However, Rhenania targets customers who buy books at a fairly stable rate mainly for their own personal consumption. Thus, we do not see the lumpy ordering behavior around particular times of the year that we see in some mail-order businesses.

Conclusion

Although Rhenania followed the industry's "best practice" to optimize single mailings, its customer base, total sales volume, and profitability decreased substantially in the mid-1990s. Ralf Elsner, as a new hire, identified the economic causes of this downturn and

Business has improved across the board, and the model we applied was the turning point.

recommended a nontraditional approach to reverse this development. However, he did not get the then-CEO's consent and had to wait until Frederik Palm was hired as Rhenania's new CEO. A basic version of DMLM was tested in a series of mail experiments in the spring and summer of 1998. After overcoming some resistance inside the company and from the holding organization, this approach was fully implemented in summer 1998 and has been used since then to optimize Rhenania's mailing strategy. A substantial extension of DMLM was implemented in early 2000 when Manfred Krafft joined the project team and suggested a fine-tuned segmentation as an additional component of DMLM. All in all, the combination of three optimization principles contributed

to the successful turnaround of the Rhenania group: (1) a long-term planning horizon that allows for the exploitation of customer buying behavior, (2) an optimization approach of mailings across customer segments to derive analytically a minimum required threshold level of sales as the basis for making decisions on whether to continue customer relationships or not, and (3) a further segmentation of the customer base to differentiate inactive accounts from potentially active accounts, that is, to separate one-time buyers from repeat buyers.

Further modifications and extensions of DMLM are currently being developed or have already been tested. The dynamic model not only turned around Rhenania's serious economic situation, but helped it to gain a competitive advantage and to prosper in a difficult environment. The company was even able to acquire two of its major competitors and to convert the losses at Akzente into substantial profits, changing nothing other than implementing DMLM. Our current projects are to collect further customer-response data and to run mail tests for Mail Order Kaiser's customers so that we can apply DMLM soon to this recent addition to the Rhenania group. Although our analytical approach has proven very effective, its effects are diminishing after two years of application. The DMLM team continues to work on integrating promising extensions and modifications to further increase this model's high performance.

Acknowledgments

We are grateful to Leon Schwartz and Peter Norden, who coached the team, for their comments and suggestions. We also acknowledge Sönke Albers, and Surya Mantrala as well as Murali K. Mantrala for their valuable comments on preliminary versions of this manuscript.

Appendix

Notation

- A_k = average order size for customer segment k .
- F = frequency of customer orders.
- M = monetary value per customer order.
- n = total number of catalog mailings.
- P = total profit.
- R = recency of last purchase.
- r_k = response rate for customer segment k .
- u_k = marginal sales for segment k , i.e., $u_k = r_k \cdot A_k$.

v_1 = newly gained customers (joining customer segment 1).

x_{in} = number of customers in address segment i in mailing campaign n .

X_{in} = total number of customers in segment i over n mailing campaigns.

z_k = number of customers from customer segment k who did not order and thus moved to the next lower segment.

ϕ = number of customers with $F = 1$ and $R > R_1$ for whom reactivation failed.

μ = number of customers with $F > 1$, $M < M_{\min}$, and $R > R_3$ for whom reactivation failed.

σ_k = number of customers from customer segment k leaving the house list per catalog.

To simplify, we are assuming here that Rhenania included all three customer segments in the round of mailings over the planning horizon. (Elsner (2002) gives a more detailed analysis.) If it includes fewer segments, the inflow of customers to segment 1 will be reduced accordingly. In a first step, we forecast how many addresses are expected to be in each segment over the entire planning period n ($n > 1$):

$$\begin{aligned} X_{1n} = & nx_{11} + n(n-1)(v_1 - z_1 - \sigma_1)/2 \\ & + (x_{21} [n - [(1-r_2)^n - 1]/(-r_2)] \\ & + (z_1 - z_2 - \sigma_2 - \phi) [(n-1)n/2 \\ & - n/r_2 - [(1-r_2)^n - 1]/r_2^2]) \\ & + (x_{31} [n - [(1-r_3)^n - 1]/(-r_3)] \\ & + (z_2 - \sigma_3) [(n-1)n/2 - n/r_3 \\ & - [(1-r_3)^n - 1]/r_3^2]), X_{2n} = x_{21} \\ & [(1-r_2)^n - 1]/(-r_2) \\ & + (z_1 - z_2 - \sigma_2 - \phi) [nr_2 - 1 \\ & + (1-r_2)^n]/r_2^2, X_{3n} = x_{31} [(1-r_3)^n \\ & - 1]/(-r_3) + (z_2 - \sigma_3 - \mu) \\ & [nr_3 - 1 + (1-r_3)^n]/r_3^2. \end{aligned}$$

Second, we determine the expected profit, accounting for scale economies in printing as well as costs for publishing, mailing, order fulfillment, and the merchandise:

$$\begin{aligned} P(X) = & u_1 (nx_{11} + n(n-1)(v_1 - z_1 - \sigma_1)/2) \\ & + u_1 (x_{21} [n - [(1-r_2)^n - 1]/(-r_2)] \\ & + (z_1 - z_2 - \sigma_2 - \phi) [(n-1)n/2 \\ & - n/r_2 - [(1-r_2)^n - 1]/r_2^2]) \\ & + u_1 (x_{31} [n - [(1-r_3)^n - 1]/(-r_3)] \\ & + (z_2 - \sigma_3 - \mu) [(n-1)n/2 - n/r_3 \\ & - [(1-r_3)^n - 1]/r_3^2] + u_2 (x_{21} \\ & [(1-r_2)^n - 1]/(-r_2) + (z_1 \\ & - z_2 - \sigma_2 - \phi) [nr_2 - 1 + (1-r_2)^n]/r_2^2) \\ & + u_3 (x_{31} [(1-r_3)^n - 1]/(-r_3) \\ & + (z_2 - \sigma_3 - \mu) [nr_3 - 1 + (1-r_3)^n]/r_3^2) \\ & - \text{costs for printing, mailing, order} \\ & \text{fulfillment and merchandise.} \end{aligned}$$

Third, we determine the profit-maximizing number of customer segments to include, that is, whether to mail to customer segment 1 only, to customer segments 1 and 2, or to all three customer segments.

References

- Biggs, D., B. de Ville, E. Suen. 1991. A method of choosing multiway partitions for classification and decision trees. *J. Appl. Statist.* 18(1) 49-62.
- Bitran, G., S. Mondschein. 1996. Mailing decisions in the catalogue sales industry. *Management Sci.* 42(9) 1364-1381.
- . 1997. A comparative analysis of decision making procedures in the catalogue sales industry. *Eur. Management J.* 15(2) 105-116.
- Börsenblatt 2001. Rhenania kauft den Versender Mail Order Kaiser (Rhenania acquires Mail Order Kaiser). *Börsenblatt* 23 1.
- Campbell, D., R. Erdahl, D. Johnson, E. Bibelnicks, M. Haydock, M. Bullock, H. Crowder. 2001. Optimizing customer mail streams at Fingerhut. *Interfaces* 31(1) 77-90.
- Elsner, M. 2002. *Optimiertes Direkt- und Datenbankmarketing unter Einsatz von mehrstufigen und dynamischen Modellen (Optimized Direct and Database Marketing Using Multilevel and Dynamic Models)*. Gabler, Wiesbaden, Germany.
- Hughes, A. M. 1994. *Strategic Database Marketing*. McGraw-Hill, Chicago, IL.
- Kass, G. 1980. An exploratory technique for investigating large quantities of categorical data. *Appl. Statist.* 29(2) 119-127.
- Pfeifer, P. E., R. L. Carraway. 2000. Modeling customer relationships as Markov chains. *J. Interactive Marketing* 14(2) 43-55.
- Rutsatz, U. 2002. *Kundenrückgewinnung im Direktmarketing (Customer Recovery in Direct Marketing)*. Gabler, Wiesbaden, Germany.

Frederick Palm, CEO Rhenania Buch Versand, 56061 Koblenz, Germany, writes: "During the years 1994 to April 1998 we had decreasing numbers of active customers, diminishing sales and profits. When I joined Rhenania in April 1998, the marketing director, Mr. Ralf Elsner, convinced me to try a completely new method to select customers. Up to now the industry standard in direct marketing and the mail-order business (and as far as I know in every other business too) is maximizing profits by using the marginal law (marginal sales = marginal costs). In a mathematical model called Dynamic Multilevel Modeling (DMLM), Ralf Elsner proved that under dynamic conditions this marginal law is no longer valid. My job was to "sell" this revolutionary outcome to Rhenania's owner and together with Ralf to put it into practical operations.

"Professors Manfred Krafft and Arnd Huchzermeier joined our team in 2000 and helped to develop several enhancements. Today DMLM is fully implemented

and every address we are mailing to is chosen by this algorithm. Since the implementation, we are doing extremely well in contrast to most of our competitors. Now we are gaining market shares out of our own business and very recently we are gaining market shares because of acquisitions. In addition to these dramatic economic improvements based on this model, it is an excellent forecasting tool. We are able to look 12 months in the future to see the development of active customers, sales, and profit. Since April 1998, we can say the predictions of the model have been valid!

"Of course we are trying to improve our business in every possible field, and in some of them, like optimizing the catalog design, the merchandising, the chosen products, and so on, we have been successful since April 1998. All of this is important fine tuning—but the crucial point that caused the fast turn around and the outstanding economic development of Rhenania was and still is DMLM."