# Promotional Forecasting Based on Promotional Indexes in Yoghurt Production

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*Abstract:* Promotional forecasting represents an essential part of effective demand planning in enterprises. However, in the fresh food industry, companies demand planning is complicated due to the short product shelf life, but also due to the pressure from the side of retailers on shortening the delivery time and unwillingness to provide information about future requirements and shopping behaviour of the final consumers. This paper deals with an analysis of the influence of promotions on the sales and with the possibilities of promotional forecasting in a selected fresh food industry enterprise. On the basis of a time series analysis, the paper proposes a forecasting model based on promotional indexes, utilization of which for promotional forecasting can bring a significant forecast accuracy improvement.

*Key-Words:* Demand Planning, Promotional Forecasting, Sales Forecasting, Yoghurt Production

## 1 Introduction

What is now essential for an enterprise to survive is the ability to keep adapting to the changing business environment and take into account interests of all stakeholders [1]. The limited product shelf life, the requirements of the management to decrease the volume of capital tied in the inventory, but also the pressure from the side of the customers on shortening the delivery time create such environment in fresh food industries where it is not possible to imagine effective operations management without a quality demand forecast.

In fresh food industries, the vast majority of final consumers are serviced by retail chains. Severe competition among the producers is for the retail chains a source of bargaining power, which results in further complication in the process of creating forecasts in these segments. The most important problems can be seen in unwillingness to provide information about the future needs and shopping behaviour of the final consumers [2]. The producers thus have to depend on their own information sources and create powerful demand planning to support demand effectively although the final demand and sales are of course affected most by the tactical and operational marketing management of the retail as the last link in the chain [3].

Entrup [4] identifies more than twenty requirements for demand planning in fresh food industries. In yoghurt production, it is considered as the most important thing to create a forecasting system providing a variety of forecasting techniques, automated analysis of forecasting accuracy, consensus-based and self-adaptive forecasting. This system should also include automated forecasting of promotions and events that substantially affect short-term product sales. Sudden sales fluctuations resulting from promotions disturb continuity of the material flow in the supply chain significantly, which places bigger requirements on the operative management in the enterprise.

## 2 Business Forecasting of Promotion

Until the genesis of automated promotional forecasting systems, the common practice for demand planners was to use simple estimate for upcoming promotion. This estimate was the same as quantity of goods that was sold during a similar past promotion [5]. While this was the only approach for decades, advancements in technology offered to use statistical models that result in significant cost savings, as out-of-stock and overstock losses are reduced [6].

Causal analyses help to discover factors that influence an increase/decrease in sales not only in the course, but also after termination of a promotion. However, the relations between variability of

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promotional sales and the factors can only be researched with a sufficient library of past promotions using data mining techniques [7]. Several factors are found to be related to the magnitude of promotional sales. The significant factors mentioned in the literature [8] are the frequency of the promotions for simile products, the advertising mode used (newspapers, TV, radio, etc.), category or product group characteristics, promotions of competitors, radio support of promotions, previous promotions of the same product, the number of variants of the product in promotion, the weather etc. For price-promotions, a characteristic influencing factor is the price, which may result in excessive variations in demand, especially in markets with a high price-elasticity. In such cases, it is essential to carry out a thorough analysis of promotional elasticity and utilization of pricing models [9]. Excessive variations in demand are often accompanied by cannibalization (negative effect on the sales volume of other products by increasing of the sales volume of promotional product) that must be taken into consideration [10].

Cooper et al. [5] published their own promotional forecasting system based on chain-wide historical performance data from retail stores. Combining both individual store-SKU information and chain-SKU information improves the forecasting performance. However, such information is often unavailable for small and medium manufacturers from fresh food industries. They have to depend on their own analysis of time series of historical sales and promotional information obtained from their sales representatives carrying out their own data collection in the terrain. The following promotional forecasting approach is designed for demand planners who need to forecast with lack of information.

# 3 Forecasting in Yoghurt Production: Time Series Approach

The company chosen for analysis is a dairy with long tradition of producing dairy products. It occupies strong position on the Czech market in the segment of cream yoghurts.

## 3.1 Problem Formulation

Operations management in the analysed company is complicated due to the following factors. Considering existence of a large number of tastes, the range of products of the company contains about ten various kinds of yoghurt. They are also sold under a few private trademarks of retail chains in comparable quality, but in individual packages. Shelf life of the products is very short (3-4 weeks). Although the key raw material for products manufacturing is cream which is purchased from farmers with one week lead and average production cycle is three days, the customer service lead time is usually shorter than one day. In addition, customers accept only delivery of products with full usable life or only with its partial expiration. It reflects on increasing requirements of operative management of manufacturing, purchase, but also on other logistic activities along the whole supply chain. Thus, demand planning is one of the few instruments how to control processes in this case.

For the needs of operations management, the company must carry out demand planning with a one-week time horizon. Weekly demand plans are then used particularly for weekly purchase of cream and weekly production scheduling. Operations management in the company draws on long-term experience of the company managers and knowledge of the time series pattern of historical sales. These do not show any significant trends or seasonal fluctuations, which would exceed accidental fluctuations in short-term sales resulting from the P-system product ordering by the retailers. The basic techniques of time series analysis (exponential smoothing) was successfully applied with the forecast error 12.1% at the biggest customer [11].

However, the problems related to forecasting short-term sales cause significant sales fluctuations during promotions, which are used relatively often practically with all the products and retailers. These promotions are carried out for retailers in the form of a discount from the product price, and they are conditioned by performing support events in retail. Retailers usually provide the producers with hardly any information concerning influence of promotions on an increase in the future sales, which are several times as high as the usual sales during the event. Thus, promotional forecasting in the company is based on judgmental forecasting, which is however significantly inaccurate. It is resulting in many negative effects in the economy and the social level of the company.

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### 3.2 Promotional Analysis and Promotional Indexes Determination

For the promotional analysis, we chose the product (yoghurt with one given flavour) with the biggest yearly sales achieved through the key retailer as accuracy of forecast of these sales has the strongest influence on the operations management. As for the chosen product, the research consisted in monitoring weekly sales within the period of one year with respect to the performed promotions. The time series of weekly sales within the monitored period is shown in Appendix at the end of the paper.

In the given year, there were 5 promotional events, always lasting for fourteen days (see Appendix). A significant increase in sales in comparison with the usual sales was noticed in the course of an event only, and that is why the analysis considered influence of the promotions in the first and second week of the event only. The causal analysis discovered only one factor that classified the promotions into two groups, i.e. A type and B type promotions. In the case of an A type promotion, the retailer performed sales support within the supermarket network only, while in the case of a B type promotion, the retailer performed sales support both within the network of supermarkets and within the network of hypermarkets.

Table 1: Descriptive Statistics of Promotional Sales (source: own)

| Promotion | Sales (SKU) | Mean | Std. deviation |
|---|---|---|---|
| A1 | 25760 | 23253 | 3801 |
| A2 | 25120 | | |
| A3 | 18880 | | |
| B1 | 48480 | 47040 | 2036 |
| B2 | 45600 | | |

The other known factors that could significantly affect the volume of sales were constant in all the events. All the events were cases of price-promotions, where the retailer was provided with the same discount from the amount invoiced within the period of the promotion, and the retail prices were discounted to the same extent compared to the regular prices for final consumers. In the course of the events, there were no other promotions related to the competing substitutes in the given retail, nor another promotion related to the same product in the competing retail chains. This significantly decreased cannibalization effects on the sales of the promoted product. All the promotions were performed in the same way, where the sales support was announced through a special offer leaflet informing of the retail shelf discount. From the point of view of the manufacturing company, no other factors affecting promotional sales were noticed. However, variability of the sales achieved within the same type of event was yet high (see Table 1).

However, a deeper time series analysis in A type promotions discovered strong correlation between the values of the promotional sales and the values of sales performed immediately before the event. Nevertheless, in this case it is apparently not causal correlation, but data correlation. That can be explained by a common influence of a group of unknown factors (macroeconomic indicators, seasonal factors, changes in the number of retail stores, shelf placement, etc.), which strongly correlate both with promotional sales and with usual sales. Instability of the above factors in time can then be one of the reasons for the high variability among the promotional sales of the same event type, performed in different time periods. The reference value of the sales achieved immediately before the event ($RV_n$) was determined for each event as the arithmetic mean of n-week sales, achieved immediately before the event:

$$RV_n = \frac{1}{n}\sum_{i=t-n}^{t-1} y_i \quad (1)$$

where $y_i$ are weekly sales in week number of $i$, $t$ is the number of the week in which the promotion takes place, and $n$ is the number of weeks considered in the calculation of average.

The number of weeks $n$ entering calculation of $RV_n$ was optimized to the value of 4. The optimization criterion was maximization of the Pearson's correlation coefficient of relationship between promotional sales and $RV_n$ for $1 \le n \le 4$. With respect to the high frequency of the performed events, the maximum number of periods could be $n = 4$. It is not possible to determine the sales reference value for promotion B1 as it came immediately after an A type promotion (see Appendix). It is obvious that the low values of the number of periods $n$ increase adaptability of indexes towards quick changes of factors in time, while the high values of the number of periods $n$ increase stability of indexes, or decrease distortion of indexes

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due to the effect of accidental fluctuation of the sales.

Through a regression analysis of linear dependence of promotional sales on the reference value of the sales ($RV_4$) in an A type promotion, we obtained linear equation with a non-significant value of the intercept term in the regression equation (see Fig.1). The acquired regression coefficient formally corresponds with the index of the average increase in the sales achieved during the promotion compared to the reference value of the past sales, which can be for simplification called as the so-called "promotional index". Knowledge of promotional indexes in different types of events could help not only with the analysis and evaluation of the effectiveness of the performed events. Utilization of promotional indexes while forecasting the influence of events on sales could also increase accuracy of such forecasts thanks to the expected decrease in variability of sales in the same types of promotions.

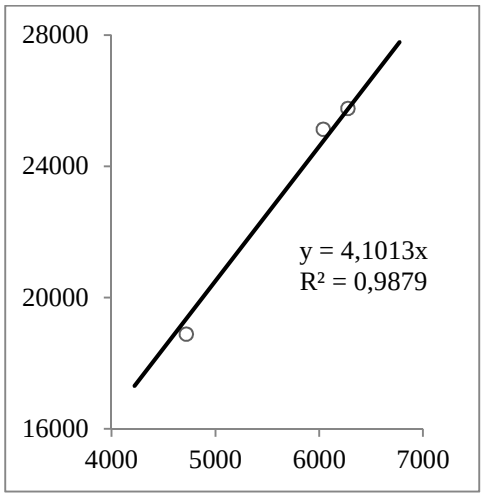


Fig.1: Graph Showing Dependence of Promotional Sales on the Reference Value $RV_4$ (source: own)

For the needs of creation of weekly forecasts, the values of promotional indexes must be determined in each week in which a significant influence on the volume of sales is noticed (i.e. in the cases where the promotional index is significantly different from the value of 1). In the case of an A type promotion, it is practically possible to determine the promotional index for the first week of the performed event $I^{(I)}$ and the promotional index for the second week of the performed event $I^{(II)}$ on the basis of the following relations:

$$I^{(I)} = \frac{1}{k}\sum_{i=1}^{k}\frac{y_i^{(I)}}{RV_{ni}} \quad (2)$$

$$I^{(II)} = \frac{1}{k}\sum_{i=1}^{k}\frac{y_i^{(II)}}{RV_{ni}} \quad (3)$$

where $y_i^{(I)}$ are weekly sales in first week in which the promotion takes place, $y_i^{(II)}$ are weekly sales in second week in which the promotion takes place, and $k$ is the number of events considered in the calculation of promotional index.

Table 2: Comparison of the Forecasting Mods Used for Forecasting Sales during Promotions A2 and A3 (source: own)

| Method | **Simple Estimate** | **Forecast Based on Promotional Indexes** |
|---|---|---|
| *1st week of promotion A2* | | |
| Sales (SKU) | 16480 | 16480 |
| Forecast (SKU) | 17760 | 17095 |
| APE | 7.77% | 3.73% |
| *2nd week of promotion A2* | | |
| Sales (SKU) | 8640 | 8640 |
| Forecast (SKU) | 8000 | 7700 |
| APE | 7.41% | 10.88% |
| *Both of weeks of promotion A2* | | |
| Sales (SKU) | 25120 | 25120 |
| Forecast (SKU) | 25760 | 24795 |
| **APE** | **2.55%** | **1.29%** |
| *1st week of promotion A3* | | |
| Sales (SKU) | 12160 | 12160 |
| Forecast (SKU) | 17760 | 13359 |
| APE | 46.05% | 9.86% |
| *2nd week of promotion A3* | | |
| Sales (SKU) | 6720 | 6720 |
| Forecast (SKU) | 8000 | 6018 |
| APE | 19.05% | 10.45% |
| *Both of weeks of promotion A3* | | |
| Sales (SKU) | 18880 | 18880 |
| Forecast (SKU) | 25760 | 19377 |
| **APE** | **36.44%** | **2.63%** |

Table 2 compares forecasts that would be created while forecasting promotional sales for promotions A2 and A3 using two different methods. The first method is a simple estimate (see chapter 2) based on

the sales achieved during promotion A1. The second method makes use of promotion indexes (2) and (3), determined on the basis of promotion A1. For calculation of the absolute percentage error of forecast (APE), the following relation was used (4).

$$APE = \left|\frac{y_t - \hat{y}_t}{y_t}\right| \cdot 100\% \quad (4)$$

where $y_t$ are actual sales for the period, and $\hat{y}_t$ are forecasted sales for the period.

The comparison of the above forecasting methods implies the fact that forecasts can be made more accurate by using promotional indexes, which is particularly evident in promotion A3.

### 3.3 Design of Forecasting Model Based on Promotional Indexes

However, the proposed way of forecasting has a number of difficulties related to optimization of the reference value (1), which, on top of that, ignores existence of potential trends or seasonal fluctuations in the data. However, for calculation of promotional index, it is possible to replace reference value $RV_n$ with expected value of the sales forecast $\omega(t)$ for the period of the event in the situation the event does not take place. The promotional index (5) would thus represent the expected increase in the sales resulting from the performed promotion compared to the expected sales. The forecast function $\omega(t)$ used as reference value would better express the time series pattern by choosing the most suitable forecasting method.

$$I_p = \frac{1}{k}\sum_{i=1}^{k}\frac{y_i}{\omega(t)_i} \quad (5)$$

where $y$ are sales for the period in which the promotion takes place, $\omega(t)$ is sales forecast for the period of the event in the situation the event does not take place, and $k$ is the number of events considered in the calculation of promotional index.

For the needs of automation of the forecasting model, it is possible to use the indicator variable that is used for indicating pulse intervention event [12]. The general definition of the automated forecasting model based on promotional index uses dummy regressor $\xi_t$ that takes value of one at the time of intervention (promotion), and the rest of its values are zero:

$$\hat{y}_t = \omega(t) + \xi_t \cdot (I_p - 1) \cdot \omega(t) \quad (6)$$

where $\hat{y}_t$ are forecasted sales for the period, $\omega(t)$ is the forecast function for the period $t$, $\xi_t$ is dummy regressor, and $I_p$ is promotional index.

In the cases where the event would affect the sales for a period longer than one period of the time series, the model would have to contain just as many intervention terms as is the number of determined promotional indexes. Before the actual application of the forecasting model, it is however necessary to clear the time series of the monitored events, which only serve for determination and accuracy improvement of the promotional indexes. In the case of such cleared time series, it would be enough to replace the value of sales affected by the event with values $\omega(t)$.

## 4 Conclusion

Knowledge of the influence of promotions on future sales represents an essential precondition for effective demand planning in fresh food industries. Sudden sales fluctuations resulting from promotions disrupt continuity of the material flow within the supply chain, and together with the limited product shelf life they create a demanding environment for operations management. For small and medium fresh food industry companies, promotional forecasting is also complicated due to the retailers' unwillingness to provide information about the future needs and shopping behaviour of the final consumers. In the environment of a lack of information, it is usually only possible to forecast a simple estimate for the upcoming promotion, which might be significantly inaccurate.

We analysed the influence of promotions on the sales and studied the possibilities of promotional forecasting for the key product in a dairy that occupies a strong position on the Czech market in the segment of cream yoghurts. However, we did not succeed in explaining the high variability of the sales achieved during events of the same type by a causal analysis. This led to relatively substantial errors of forecasts based on simple estimates. What brought a significant forecast accuracy improvement was utilization of so-called "promotional indexes", which were derived from a deeper time series analysis. While the weekly promotional sales forecast error was comparable to the error in the forecast of sales achieved in a usual period, the absolute percentage error of forecasts of the total sales for the whole period of the event decreased in both monitored events below 3%.

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For the needs of automation of sales forecasting in the company, we proposed a forecasting model based on promotional indexes. Given the fact that the promotional indexes were only applied while forecasting the sales of only one product, which was analysed more deeply, we would like to focus our future research on verification of the proposed model on a greater amount of data.

*References:*


[1] Tetřevová, L., Sabolová, V., University Stakeholder Management, *Proceedings of the 7th WSEAS International Conference on Engineering Education*, Corfu Island, Greece, 22-24 July 2010, pp. 141-145.

[2] Vlckova, V., Patak, M., Barriers of Demand Planning Implementation. *Economics and Management*, Vol.16, 2011, pp. 1000-1005.

[3] Branska, L., Lostakova, H., CPFR Method Application in Supply Chain Involving Continuous Productions, *Proceedings of 20th Anniversary International Conference on Metallurgy and Materials*, Brno, Czech Republic, 18-20 May 2011, pp. 1252 – 1258.

[4] Entrup, M.L., *Advanced Planing in Fresh Food Industries*, Springer, 2005.

[5] Cooper, L.G., Baron, P., Levy, W., Swisher, M., Gogos, P., PromoCast: A New Forecasting Method for Promotion Planning, *Marketing Science*, Vol.18, No.3, 1999, pp. 301-316.

[6] Trusov, M., Bodapati, A.V., Cooper, L.G., Retailer Promotion Planning: Improving Forecast Accuracy and Interpretability, *Journal of Interactive Marketing*, Vol.20, No.3-4, 2006, pp. 71-81.

[7] Cooper, L.G., Giuffrida, G., Turning Datamining Into a Management Science Tool, *Management Science*, Vol.46, No.2, 2000, pp. 249-264.

[8] Gür Ali, Ö., Sayin, S., Van Woensel, T., Fransoo, J., Pooling Information Across SKUs for Demand Forecasting with Data Mining, *Expert Systems with Applications*, Vol.36, No.10, 2009, pp. 12340-12348.

[9] Foekens, E.W., Leeflang, P.S.H., Witting, D.R., A Comparasion and an Exploration of the Forecast Accuracy of a Loglinear Model at Different Levels of Aggregation, *International Journal of Forecasting*, Vol.10, No.2, 1999, pp. 245-261.

[10] Neslin, S.A., A Market Response Model for Coupon Promotions, *Marketing Science*, Vol.9, No.2, 1990, pp. 125-145.

[11] Patak, M., Vlckova, V., Time Series Forecasting as a Tool of Operative Management, *Sci. Pap. Uni. Pardubice, Ser. A*, Vol.16, 2010, pp. 219-228.

[12] Box, G.E.P., Jenkins, G.M., Reinsel, G.C., *Time Series Analysis: Forecasting and Control*, Wiley, 2008.


Appendix: Time Series of Weekly Sales of the Selected Product (source: own)