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The impact of sales promotions on store performance: a structural vector autoregressive (SVAR) approach

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Abstract

The present paper analyses the impact of sales promotions on store performance, in the short and long term, from the retailer's point of view. Relationships among promoted and regular sales in the hypermarkets of a large-scale retail chain of national importance, are investigated by means of a structural vector autoregressive model (SVAR).
Statistically significant effects of sales promotions in the heavy household section on store sales are found in the short-run; these promotions produce additional sales and thus act as an attractive factor. Promotions in textile category, on the contrary, produce an immediate negative effect on net sales. In the long-run, negative statistically significant effects on regular sales are detected when continuative promotions are implemented within perishables' category.

Keywords: promotional effectiveness, retail promotions, structural VAR, short- and long-term effects.

1. Introduction

In a very general definition, promotions are temporary offers of an additional advantage to consumers designed to achieve a specific objective. They represent an important amount of marketing budgets of both manufacturers and retailers. Many studies have shown that promotions have a significant impact on individual consumers' purchase decisions, which, as a result, increases the promoted-brand sales during the period of promotions (promotional bump) and may induce any change after the promotion has finished due to stockpiling or brand switching (carryover effect).

In the present work we are mainly concerned on how promotions affect the aggregated store sales from retailers' point of view. Unlike manufacturers, retailers are less concerned on brand or category gains or losses and, in a greater extent, they are interested in the effects of the promotions' bundle on stores traffic, extra-sales generated in the store and profits. Therefore, the purpose of the present paper is to measure the impact of promotions on aggregate regular store sales in short- and long-term with the aim of answering to the following questions: do promotions produce immediate, statistically significant effects on the non-promoted products sales? Can such effects be identified and quantified? If the answer is yes, then are such effects significant at long leads?

To this end, the rest of the paper is organised as follows. In Section 2 the positioning of the paper within the literature is briefly discussed. In Section 3 the methodology and the main lines of the analysis are traced. In Section 4 the empirical results of the model are discussed and simultaneous and carryover effects analysed. Finally some concluding remarks with managerial implications are given in Section 5.

2. Positioning within literature on sales promotions

There is a large body of literature on promotions; the early contributions have been developed since the 1970s. Many papers have shown the effects of promotions on main consumer's purchase decision aspects, such as brand choice, purchase time and quantity, brand loyalty and brand switching (see, among others, Bemmaor and Mouchoux, 1991; Ehrenberg, 1972; Ehrenberg et al., 1991; Filippucci and Pacei, 2004; Guadagni and Little, 1983; Gupta, 1998; Imman et al., 1990; Nijs et al., 2001; Schoemaker and Shoaf, 1977). It is beyond the scope of this paper to provide a comprehensive review on this topic; the interested reader may refer to Blattberg et al. (1995) and East (1997) for a synthesis of empirical generalizations about promotions and a basic list of references. Most of these research efforts concern the manufacturer's question of how promotions affect the sales of a brand. Findings of temporary increases in brand sales and cross-effects on other brand or categories have been observed. A pioneering contribute on this issue is due to Gupta (1988), who has disentangled that the prominent component of sales increase is due to brand switching rather than to time acceleration and stockpiling.

In the present work the perspective is different since the attention is posed on the retailer's question of how promotions affect the sales of the store. Regarding the impact of promotional activities to retailer, the greatest interest is in the effects on extra-sales generated by the increase in traffic as a direct result of the promotional campaign. In fact to the retailer, the promotional plan is designed to produce an increase in customer traffic, and, thus, in sales of both promoted and non-promoted goods. At the same time, a positive result should also propagate to short- and long-term profits. However, there is little empirical work on the evidence of the impact of promotions on store traffic, sales and profits, as pointed out by Blattberg et al. (1995). The wisdom that sales of promoted items stimulate sales of non-promoted ones is not supported by experimental data analysed using a latent variables structural equations model (Walters and MacKenzie, 1988). At the same time, the impact of advertised promotional strategies to attract customers, measured by means of a time series intervention analysis, has been found to increase sales but not to affect store traffic (Muhlern and Leone, 1990). It should be remarked that, in this setting, the promotional impulse has a deterministic nature. Recently, the effects of feature promotions on store traffic and sales under the moderating impact of the main socio-demographics factors, store and competition characteristics has been analysed in great length by Gijsbrechts et al. (2003), within a micro-marketing context. They identify the focal importance of composition of the store flyers on the short-term store traffic and total sales; these are affected by discount deepness, featuring private labels or a surprise element on the cover page.

The present work focuses on the impact of promotions on aggregate net store sales (that is net of the promotional sales) in short- and long-term on the basis of times series observations. Unlike Muhlern and Leone and Gijsbrechts et al., this approach aims at capturing effects on regular sales. In particular, we examine the extent of promotional bump and carryover effect at store aggregate level by category. This is obtained by jointly modelling the short- and long-terms patterns of total store sales net of promotional sales and sales of promoted items by category. Compared with the intervention analysis, we consider continuative promotional campaigns whose dynamics is better suited by stochastic than deterministic specifications. To this purpose the very general specification of the vector autoregressive model (VAR) is selected.

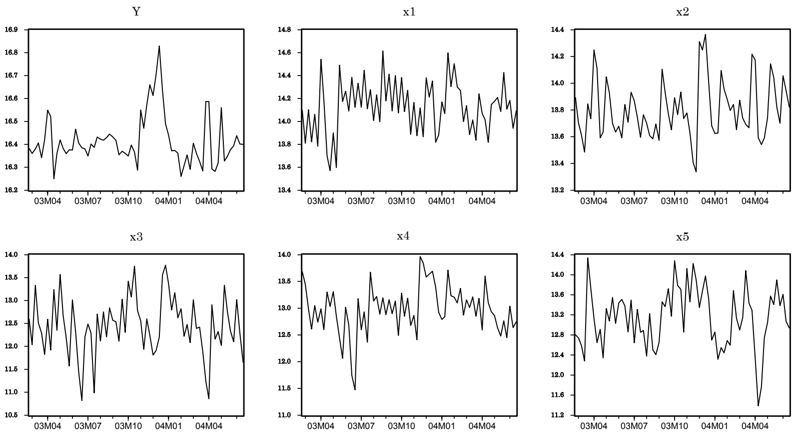
3. Data and methodology

Scanner sales data have been drawn from 13 hypermarkets belonging to a national retail chain. The chain utilizes a Hi-Lo pricing strategy and bundles of products are offered on promotion every week. The sample spans the 70-week period from 24/02/2003 to 27/06/2004. Sales of promoted items are classified into the following categories: grocery (x_1), perishables (x_2), textile (x_3), light household (x_4) and heavy household (x_5), and include all sales involving promotional mechanisms. Regular sales (Y) are not considered by category but as a whole. Thereinafter total sales are considered net of promotional sales. During the sample period most impacting promotion in terms of value is the so-called *price off* (61% of turnover of promoted goods), followed by the *percentage discount* (17%) and the *quantity offer – buy M get N* - promotion (5%). All the other schemes of promotion account for the remaining 17%. Table 1 shows the percentage composition of total, promoted and regular sales by category, while Figure 1 presents the logarithmic transformations of the series.

Table 1. Total, promotional and regular stores sales by categories (shares).

Sales %	**Grocery**	**Perishables**	**Textile**	**Light household**	**Heavy household**
Total	35.1	36.2	6.7	10.3	11.4
Promoted	36.9	26.7	8.1	12.5	15.7
Nonpromoted	34.6	38.9	6.3	9.7	10.2

Figure 1. Net store sales and promotional sales by categories (logarithms).



The series exhibit a strong variability. Total sales display peaks in the weeks running up to, and during the Easter and Christmas weeks; while the sales of promoted items reveal less marked calendar effects. Graphical inspection seems to suggest that all the series are stationary; the findings are not rejected by the univariate unit root tests (Table 2). As expected, in fact, stationary sales (or not evolving sales in the marketing nomenclature) indicate a mature competitive market for the large-scale retail sector in Italy.

Table 2. Univariate Augmented Dickey-Fuller Tests

	Y	x1	x2	x3	x4	x5
Lag	0	0	0	0	0*	0
Test	-4,219	-4,875	-6,458	-3.634	-2,798	-4,999
p-value	0,001	0,000	0.000	0,008	0,064	0.000

Instead of imposing a priori restrictions on the interactions among series, in the first step we have chosen to specify a vector autoregressive (VAR) model, which is a multivariate model where each series is regressed on lags of all the series jointly considered.

Thus, assuming $X_t = (Y_t, x_{1t}, x_{2t}, x_{3t}, x_{4t}, x_{5t})'$, the VAR(p) specification is

$$A(L)X_t = \Phi d_t + \varepsilon_t ,$$

where $A(L) = I_6 - A_1 L - \cdots - A_p L^p$ is the matrix polynomial in the lag operator L, A_j, j=1,…,p are 6×6 parameter matrices, d_t is a $s\times 1$ vector of the deterministic components (constant, dummy, trend, etc.), Φ is the $6\times s$ matrix of the deterministic components' parameters, while ε_t is a *white noise* vector ($VWN(0,\Sigma)$).

Since the variables are jointly covariance stationary, then the process X_t has a dual Vector Moving Average representation given by:

$$X_t = A(L)^{-1}\Phi d_t + A(L)^{-1}\varepsilon_t = \Psi d_t + C(L)\varepsilon_t ,$$

where $C(L) = I_6 + \sum_{j=1}^{\infty} C_j L^j$ is the matrix polynomial in the lag operator L, C_j, j=1,… are 6×6 parameter matrices, Ψ is the new $6\times s$ matrix of the deterministic components' parameters. The VMA representation enables to measure the response of each variable to an impulse arising from an another variable some time before. For example, perturbing the i-th element of ε_t with a unitary shock or impulse, the response to the impulse of the l-th element of X at time t+h, X_{lt+h} , is measured by the coefficient c_{lih} of the h-th matrix of the VMA specification. However this operation does not take into account the instantaneous correlations among the elements of ε_t. In order to obtain correct economic interpretation by considering the effects of the individual impulses, the shocks should be uncorrelated, that is, the matrix Σ should be diagonal. To this end, it is useful to specify structural vector autoregressive (SVAR) models. Among different classes of Structural VAR models, the AB model (Amisano and Giannini, 1997) provides a general framework by imposing identification restrictions through the specification of matrices A and B in the following way,

$$AA(L)X_t = A\Phi d_t + A\varepsilon_t \qquad (1a)$$

$$A\varepsilon_t = Be_t \qquad (1b)$$

$$E(e_t) = 0 \qquad E(e_t e_t') = I_6 \qquad (1c)$$

This specification enables to explicitly model the instantaneous relations between endogenous variables; in fact the matrix A in the (1a) explains instantaneous interactions. Moreover the specification induces a transformation on the ε_t disturbance vector in the (1b), which can be conceived as being generated by linear combination of independent (ortho-normal) disturbances e_t as shown in (1c). In this way, the impact of random shocks on each variables of the system can be simulated. The moving-average representation thus becomes:

$$X_t = A(L)^{-1}\Phi d_t + A(L)^{-1}A^{-1}Be_t = \Psi d_t + D(L)e_t$$

where $D(L) = I_6 + \sum_{j=1}^{\infty} D_j L^j$ is the matrix polynomial in the lag operator L, D_j, j=1,… are 6×6 parameter matrices and d_{lih} measures the response to a unitary shock of the i-th element, e_{it}, on the l-th element at time t+h, X_{lt+h}. The cumulative responses are given by measuring the cumulated effect of shocks protracted in time.

For our purposes, the specification provides both a matrix of coefficients that describe the simultaneous relations among the investigated variables and a system of responses to ortho-normal impulses which describe the interrelations among the promoted and regular sales at long leads.

4. Empirical results

The empirical analysis consists of the various steps taken towards specification of a structural VAR model. Initially, we estimate the VAR lag by including the constant and two dummies as deterministic components, which take unitary value in the weeks leading up to and covering the Easter and Christmas holidays. The choice of lag specification is jointly guided by informative criteria and by the likelihood ratio test (Table 3). The likelihood ratio and the criteria point alternatively to a specification consisting of three, one or seven lags.

Table 3. Test for the VAR model dimension

Lag	LogL	LR	AIC	SC	HQ
0	-27.6	-	1.449	2.061	1.690
1	47.3	128.6	0.211	2.048*	0.934*
2	93.0	69.6	-0.096	2.966	1.108
3	148.2	73.6*	-0.705	3.581	0.981
4	185.1	42.2	-0.734	4.777	1.434
5	236.4	48.8	-1.218	5.517	1.431
6	291.3	41.8	-1.819	6.142	1.312
7	329.2	21.7	-1.881*	7.304	1.732

*indicates lag order selected by the criterion

The selected lag is one, for reasons of parsimony and in the light of the standard residual-based mis-specification analysis. Maximum likelihood estimation of the parameters of the one-lag VAR model is illustrated in table 4. Sales series seem to be correctly specified; the residuals are only slightly auto-correlated with no departure from Normality (see Table 5). The q-q plots of residuals are reported in figure 2. As a whole the congruence of selected specification with the model hypothesis seems satisfactory.

Table 4. Unresticted VAR(1) estimates

	Y_{-1}	$x1_{-1}$	$x2_{-1}$	$x3_{-1}$	$x4_{-1}$	$x5_{-1}$	Constant	Christmas	Easter
Y	0.269	-0.026	-0.195	0.003	0.007	0.035	14.432	0.332	0.181
	(0.094)	(0.037)	(0.045)	(0.015)	(0.021)	(0.014)	(1.583)	(0.054)	(0.036)
x1	-0.094	0.178	-0.257	-0.033	-0.145	-0.060	19.758	0.256	0.196
	(0.322)	(0.126)	(0.154)	(0.053)	(0.073)	(0.048)	(5.435)	(0.185)	(0.123)
x2	-0.049	-0.076	0.095	-0.004	-0.032	0.013	14.632	0.439	0.403
	(0.275)	(0.108)	(0.132)	(0.045)	(0.062)	(0.041)	(4.642)	(0.158)	(0.105)
x3	1.489	-0.805	0.406	0.311	-0.199	-0.212	-4.692	-0.042	-0.767
	(0.854)	(0.335)	(0.409)	(0.140)	(0.194)	(0.126)	(14.394)	(0.489)	(0.327)
x4	0.210	-0.433	-0.182	-0.228	0.406	-0.162	17.857	0.432	-0.182
	(0.559)	(0.219)	(0.268)	(0.092)	(0.127)	(0.083)	(9.431)	(0.320)	(0.214)
x5	-0.915	-0.524	-0.482	0.046	-0.394	0.532	39.719	1.232	-0.278
	(0.703)	(0.276)	(0.337)	(0.115)	(0.159)	(0.104)	(11.856)	(0.403)	(0.269)

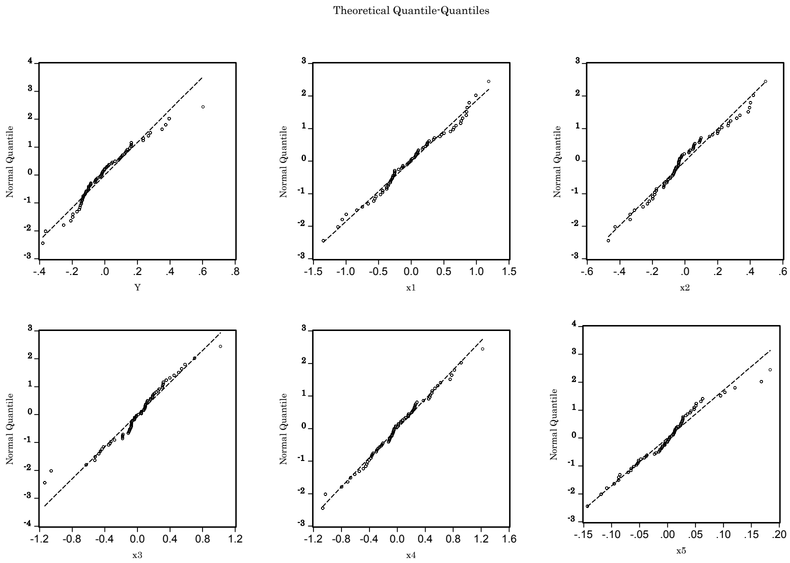
Table 5. Mis-specification residuals tests (p-vales in parentheses).

	Autocorrelation[1]		Non normality[2]		Adjusted R^2
Y	6.32	(0.176)	1.102	(0.576)	0.699
x1	10.72	(0.030)	3.147	(0.207)	0.208
x2	8.45	(0.076)	2.816	(0.245)	0.374
x3	12.82	(0.025)	3.001	(0.220)	0.282
x4	8.89	(0.064)	0.585	(0.746)	0.367
x5	2.21	(0.695)	0.571	(0.752)	0.435
VAR	45.31[3]	(0.137)	1.122	(0.510)	-

[1]Box-Ljung test at lag 4, [2]Jarque-Bera test, [3]LM test at lag 4.

The identification of the structural relations, based on evaluations deriving from the theoretical context, here, focuses on matrix A of the instantaneous correlations among the observed variables, while matrix B is specified as diagonal. In fact, disturbances e_t are simply seen as idiosyncratic shocks, not having any *a priori* about their interactions. To take into account of the cascade of transmission mechanisms of the impulse, the variables are ordered in the SVAR by decreasing Granger-exogenity test statistics. The imposed order is: perishables (x_2), textile (x_3), grocery (x_1), heavy household (x_5) and light household (x_4). Aggregate regular sales have been placed last in the sequence, since the *a priori* of endogenity makes intuitive sense, and, in any case, it is the analysed element.

Figure 2. Q-Q plots dei residui del S-VAR



The final structure of matrix A (shown in Table 6) has been obtained by starting from the specification of A as a lower triangular matrix, and, successively, by deleting coefficients not significantly different from zero. The LR test does not reject the identification restrictions.

The most interesting equation regards net sales, which are instantaneously affected in a positive sense by promotions in the heavy household section, and in a negative sense in the textile category. Given that the specification is double-logarithmic, the parameters represent the direct promotional elasticities of net sales. Heavy household and textile promotional elasticities of net sales are respectively –0.041 and 0.062, so that the promotional marginal effects on net sales (computed on average values of variables) are $\frac{\partial Y}{\partial x_3} = -0.041 \times \left(\frac{\overline{Y}}{\overline{x_3}} \right) = -1.837$ (that means that 1 euro of sales of promoted items in the textile category lowers net sales by

1.8 euro) and $\frac{\partial Y}{\partial x_5} = 0.062 \times \left(\frac{\overline{Y}}{\overline{\overline{x_5}}} \right) = 1.405$ (that means that 1 euro of sales of promoted items in the heavy household category increases net sales by 1.4 euro). Therefore, the heavy household category makes the largest contribution to raising store sales and proves an active marketing instrument. Promotions in the textile category, on the other hand, seem to substantially modify temporary consumers' expenditure allocation with negative aggregate effects. Finally, promotions of goods in the other categories fail to produce immediate effects, and correspond to a defensive marketing approach of the *do or die* type.

Other equations detect a series of instantaneous relations among the sales of promoted goods, from perishables to grocery, from textile to heavy household, and from heavy household to light household. The absence of instantaneous interactions between the series of promoted goods sales, subjected to testing using diagonal specification in the sub-matrix of A regarding promotional equations, has been rejected by data. Besides, the existence of relations of this kind is theoretically possible: in fact, consumers who buy promoted goods within a category may decide to purchase additional goods belonging to other categories, and may choose other promoted goods from the latter categories. These behaviours display clear promotion proneness, thus supporting management's choice of promoting a bundle of products.

Table 6. Estimates of SVAR parameters

$$\underset{}{\varepsilon_{x2}} = \underset{(11.75)}{0.186}\, e_{x2}$$

$$\varepsilon_{x3} = \underset{(11.75)}{0.577}\, e_{x3}$$

$$\varepsilon_{x1} - \underset{(0.12)}{0.532}\,\varepsilon_{x2} = \underset{(11.75)}{0.194}\, e_{x1}$$

$$\varepsilon_{x5} - \underset{(0.07)}{0.343}\,\varepsilon_{x3} = \underset{(11.75)}{0.322}\, e_{x5}$$

$$\varepsilon_{x4} - \underset{(0.14)}{0.350}\,\varepsilon_{x5} = \underset{(11.75)}{0.456}\, e_{x4}$$

$$\varepsilon_{Y} + \underset{(0.01)}{0.041}\,\varepsilon_{x3} - \underset{(0.02)}{0.062}\,\varepsilon_{x5} = \underset{(11.75)}{0.059}\, e_{Y}$$

Estimation by ML, Std. Error in brackets.

LR over-identification test: $\chi^2_{(10)} = 12.308$ (p-value=0.26)

Responses to short- and long-term impulses are calculated using the estimated model. Figure 3 shows net total sales reactions to extemporaneous promotional impulses within each category. Figure 4 describes the patterns if impulses are protracted, as it happens in continuative promotional plans.

Figure 3. Impulse response of stores sales to promotions

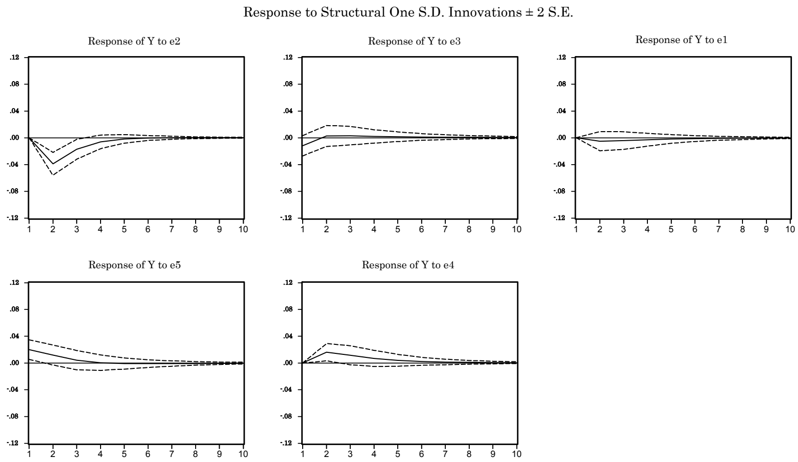
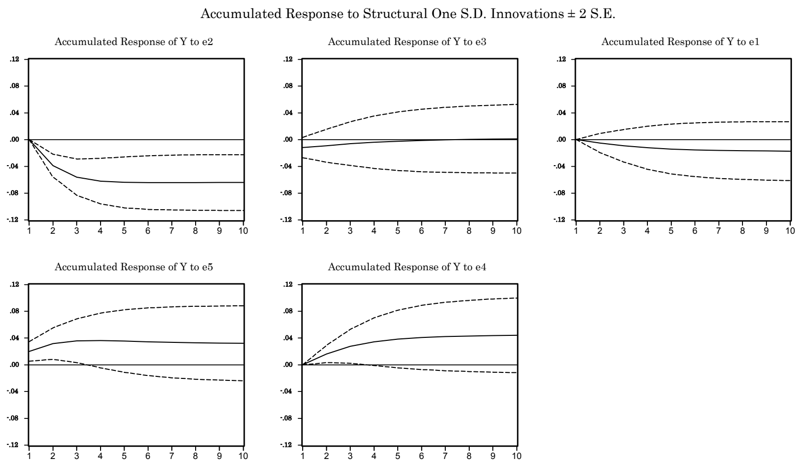


Figure 4. Accumulated impulse responses of stores sales to promotions



As expected, the dynamic simulation of the response to promotional impulses confirms that many of the effects are insignificant in the long-run and that promotions are short-term marketing activities. A negative effect on net sales is detected in the case of the promotion of perishables (Fig. 3) within a two weeks delay. Positive responses on net sales are found for promotional impulses in heavy and light household goods but these are insignificant at long leads. The cumulated effects of promotions on net sales are significant only for perishables but negative (Fig. 4). This means that total regular purchases are significantly cannibalized by perishable purchases on deal if promotions within this category is continuative. In this way perishables is the category where the present phenomenon of promotional warfare (the so-called *do or die* approach) is most clearly evident. Protracted impulses, that is continuative promotions, in all the other categories are not significant in the long-run.

5. Concluding remarks

Given the increasing importance of the promoted goods sales for large retailers, the present paper aims at evaluating the effectiveness of promotional campaigns on net store sales. The presence of short- and long-term statistically significant effects from promoted item sales to non-promoted ones and their duration is investigated.

Results show that promotions have significant effects on short-term regular sales at store aggregate level too. In particular, sales of promoted goods in the heavy household category are observed to induce significant, simultaneous increases in total non-promotional sales (1 euro of sales of promoted items in the heavy household category increases net sales by 1.4 euro), whereas promotions in the textile category tend to depress them (-1.8 euro for each euro of promoted goods sold). By promotions within other categories no significant simultaneous effects on regular sales are detected in aggregate.

As expected, carryover effects are few and sales promotions produce a substantially short-term response. An exception is represented by promotions of perishables which, if continuative, cannibalize regular purchases with negative impact in the long-run.

Heavy household category appears to be the focus of aggressive sales promotion in the short-run, whereas the perishables' category seem to be of more defensive nature. Promotions in the heavy household sector

induce consumers to make *ad hoc* shopping trips, and produce increases also in the regular total sales, and thus act as an attractive factor in the short-run. Continuative promotions of perishables, on the other hand, lower the aggregate dynamics of net sales due to the cannibalization effect among promoted and non-promoted items. In this latter category, promotional activities correspond to the *do or die* type of defensive marketing approach. Promotions of textile induce short-term changes in consumers' expenditure allocation producing negative aggregate effects.
An other aspect that is of related interest for future research is the relation with traffic and profits, supposing the costs are known. In addiction it could be useful to consider the moderating factors, such as the nature and intensity of competition, and the socio-demographic characteristics of the local market. However, this requires management and consumers panel data which are not easy accessible.

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