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# **VARIABLE RETURNS FROM THE PROMOTION OF AGRICULTURAL COMMODITIES: AN ECONOMETRIC APPROACH\***

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## **ABSTRACT**

Quantitative monitoring of the outcome of promotion of agricultural commodities has been, at best, limited. Two reasons for this, recorded by Quilkey (1986), are the lack of identification of promotion objectives in measurable terms and the failure to recognise the unique characteristics of some agricultural commodities such as the limited control of supply in the short run. The aim of this study was to build a theoretical framework for analysing the effects of promotion and apply it to a specific agricultural commodity. The results from applying a multiple linear regression model to the single commodity bananas indicated that the net effect of promotion on producer surplus could be positive or negative depending upon two factors: the short run supply; and the lagged effects of promotion.

## **INTRODUCTION**

Quilkey (1986), defines promotion as "the provision by an organisation of information to consumers about the qualities and prices of a product or product class". He argues that the promotional goals, or desired changes in consumers' expenditures, should be set explicitly in terms of price and income elasticities and that changes in them are to be expected as a result of promotion and should be monitored.

By restricting his analysis to those occasions when the demand curve (affected by promotion) rotates about the current market price, Quilkey shows that supply shifts may complement promotion strategies to the advantage or disadvantage of producers.

Previous price/quantity and promotion studies undertaken by the Queensland banana industry failed to demonstrate that promotion elicits a positive price and/or quantity response. Therefore, in response to an industry request to identify the market outcomes from the promotion of bananas, this study was undertaken.

Richardson (1976) supported the use of economic theory and models could reduce deficiencies in much market research and assist in promotion decision making. However, this type of research in relation to agricultural commodities is not without its challenges. This is largely due to the fact that agricultural commodity groups who

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sponsor promotion lack control of supply in comparison to promoters of manufactured products. (Clement 1963)

Nerlove and Waugh (1961) first studied the basic economic problems that arise because producer groups lack control over output and prices. Their belief, which is generally supported by Tilley (1987), is that where supply control cannot be exercised, the economically optimal expenditure on advertising in the long run depends on: the price elasticity of demand; the long-run effects of promotion expenditures on demand; the price elasticity of industry supply; the nature and extent of external economies or diseconomies of scale in the industry; and the rate of return on alternative forms of investment.

Tilley believes that identifying demand shifts can often be accomplished using statistical procedures that allow researchers to distinguish the effects of advertising from the effects of changes in prices, consumers' income and other factors that may influence demand. Further, when considering demand relationships, issues such as measuring advertising effort, the treatment of competitive commodities and specifying the length and structure of the lagged effects of promotion should be considered.

For this study, it was hypothesised that factors, in addition to those examined in previous studies, could influence the outcome of promotion. Therefore, an econometric model was established to isolate the effects of promotion and the other factors on the price of an agricultural commodity. In applying this model to the banana industry, evidence was found which supported Quilkey's theoretical examination of the effects of promotion.

## METHODOLOGY

Time series data were collected on all the variables used in the econometric model for a period of 341 weeks from January 1982 to mid-July 1988. The data are comprised of weekly quantities (in tonnes) of grade "No. 1" size "extra large" Cavendish bananas and average weekly wholesaler's sale prices (prices in cents per kilogram) of this grade of bananas arriving at the Sydney Wholesale Fruit and Vegetable Market.

In their analyses, Van der Meulen (1958), Aggrey-Mensah (1966) and Phillips (1967), assumed that banana supplies are fixed in the short run because, as Aggrey-Mensah and Tuckwell (1969) and Dobson et al. (1981) point out, the amount of fruit supplied in the short-run tends to be dependent more on the weather conditions prevailing in the growing areas than on the ruling market prices. The price response becomes particularly evident in times of under or oversupply. The banana industry has been characterised by periods of heavy supply and market gluts in summer. Although the glut keeps prices very low in summer, there are seldom any large quantities of bananas left unharvested as the fruit ripens rapidly after reaching maturity. Individual growers, facing a perfectly elastic demand curve, transport their fruit to the market as long as the price covers the variable costs of harvesting and marketing.

Fundamental in this analysis was the same assumption that banana supplies are fixed in the short-run and that price is the market equilibration variable i.e. the industry has a perfectly inelastic short-run supply curve. This permitted the use of a single equation multiple linear regression equation (with price as a function of quantity supplied) to model the system, instead of the usual simultaneous equation model involving shifting quantities supplied, quantities demanded and prices.

The parameters of the equation were estimated by the Ordinary Least Squares (OLS) method assuming that the model was linear in the logarithms of the variables real prices and quantities.

The coefficient of the logarithmic quantity variable in this analysis is a measure of flexibility or the responsiveness of a change in the price of bananas to a change in the quantity of bananas, holding all other factors constant.

Stuckey and Anderson (1974) preferred a constant elasticity model which was cast in log-linear form for estimation by OLS. They tested the "price is a function of quantity" model and were impressed by the close reciprocal correspondence of their results with those of Aggrey-Mensah's equivalent "quantity is a function of price" model.

Van der Meulen (cited by Stuckey and Anderson, 1974), estimated a quadratic demand function for bananas on the Sydney wholesale market using least squares regression, with nominal monthly price per case (apparently superior to deflated prices) as the dependent variable and number of cases as the basis of the independent variables, in contrast to Phillips' (1967) use of deflated annual prices.

Nominal prices were converted to real prices because the time span of the series was large enough to anticipate that the nominal prices would include an inflation factor. A quarterly Consumer Price Index (CPI) figure for food prices in Sydney was the basis for a deflator used to obtain the real price of bananas over the six year period. This specific figure was used in preference to the general CPI deflator as it was assumed that the proportion of disposable income spent on food is assumed to be fixed and that the allocation of expenditure between items of food is a function of food prices. This is particularly meaningful as competition from other fruit was another factor considered in the model.

The real wholesale price was also assumed to be a proxy for the real retail price, to obtain the retailers' demand curve. This assumption is valid if marketing margins, that cover items such as the cost of transport from the market and the profit margin, are a constant proportion of wholesale price.

The time series observations used in this study were "wholesale price" and "farmers' supply". The farmers' supply should have been converted to retailers' demand (and ultimately consumers' demand) by adding the amount of carryover (held by wholesalers) from the previous week and deducting the amount of carryover and wastage at the end of that week from the quantity supplied during that week at both the wholesale and retail levels. When the market clears, the quantity demanded plus the net carryover equals the quantity supplied. Unfortunately, no quantitative data was available on the weekly carryover so it was assumed that the quantity demanded by retailers (reflecting the quantity demanded by consumers) and the quantity supplied by wholesalers during the week were equal. To test the hypothesis that carryover stock had some effect on price a dummy variable was included in the model. Carryover was also included as a lagged variable to see whether these quantities had any significant effect on the price of bananas in the next week.

The method used by Aggrey-Mensah (1986) and Stuckey and Anderson (1974) to estimate the quantity supplied, allowing for carryover, was not used in this analysis. This was because *a priori* reasoning suggested that market supplies are subject to more volatile movements and do not follow the strict pattern of supply they suggested.

In this analysis, promotion was defined as banana specific television, radio and cinema promotions which occurred in bursts as they were assumed to have the largest measurable impact on the behaviour of the model. It was assumed that the other forms of promotion, such as the continuous low level banana or "soft-sell" generic promotion, had a constant effect throughout the data and could therefore be ignored in this study. It was not possible to identify the objectives, implementation and appraisal of past and present banana promotions in terms of Quilkey's market concepts due to the lack of any evidence supporting the previous promotion campaigns. Furthermore, it was necessary to classify promotion as either having occurred or not occurred, using a dummy variable, due to the lack of reliable data on the cost of banana promotions.

From previous studies and discussions with the promotion organisers within the industry, there was sufficient cause to believe that the effects of promotion may be felt instantly and continue for up to two weeks after the initial promotion. Therefore, the dummy variable promotion was lagged for periods of two weeks and the significance of the coefficients of the variables examined test this hypothesis. It was felt, however, that promotion may affect both the slope and the intercept of the demand curve which led to the inclusion and significance testing of promotion (and its lag values) as additive dummy variables and as multiplicative dummy variables, interacting with the quantity variable.

Apart from industry promotion, it was hypothesised that a number of other explanatory variables had an effect on prices and could be added to the model such as: banana quality; chain store promotion; weather in the marketing area; school holidays; public holidays; carryover stocks of bananas; competition from other fruit; winter season; and time. Based on a priori reasoning it was decided to include these dummy variables as additive variables that affect the intercept term of the demand function but not the slope. The parameters of the equation were estimated and the results used to refine successive models in form and precision to produce the final econometric model as shown in Appendix A and Appendix B.

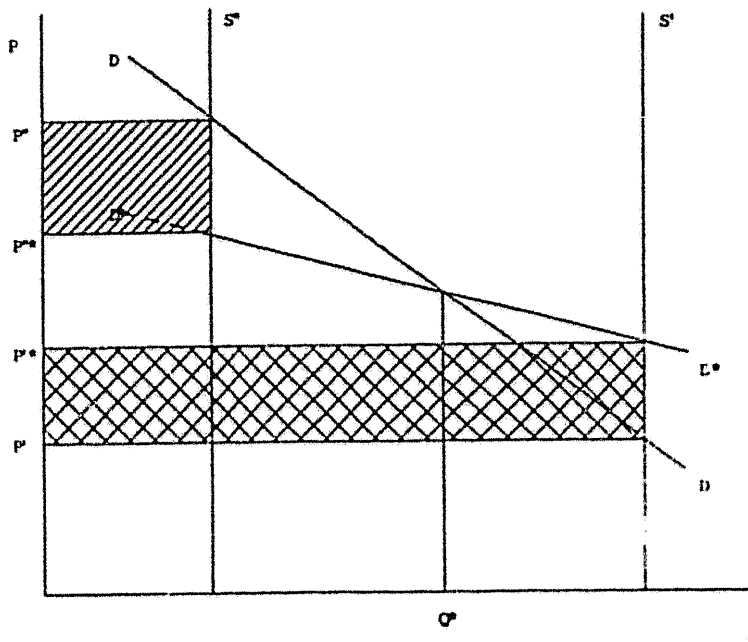
## RESULTS

Based on the overall F test, all of the regression coefficients simultaneously were able to explain a significant amount of the variation in the price of bananas. The results show that there was an inverse relationship between the logarithmic values of quantity and price. As the quantity of bananas increased, the price decreased. This is a typical downward sloping demand curve with an approximate elasticity of  $1/0.358 (= 2.793)$ . Under the circumstances of this analysis, the flexibility values can be approximated as the inverse of the elasticity values. From the sign of the coefficients for the slope and intercept terms, it can be seen that promotion caused the demand curve (D) for bananas to pivot around a particular point, labelled  $Q^*$  on Figure 1 below. The resulting demand curve is represented as  $D^*$  in Figure 1.

The point  $Q^*$  represents the quantity at which promotion has no effect on the price of bananas and was estimated at 990 kilograms. If promotion occurred when the weekly quantity supplied was less than (greater than)  $Q^*$ , respresented by  $S^*$  ( $S'$ ), the price received for bananas, represented by  $P^{**}$  ( $P'^*$ ), would be less than (greater than) the price received ( $P^*$ ) if no promotion had occurred at this quantity. Therefore, promotion should occur at those times when the quantity supplied is above  $Q^*$ . This is because at other times promotion has a negative effect on price. It is also known that range of quantities in the data is from 320 to 1818 kilograms with a mean weekly quantity of 897

kilograms. Therefore, the majority of the data can be expected to be to the left of  $Q^*$  which reinforces the fact that promotion was found to have a negative effect on the price of bananas. Promotion also had a lagged or delayed effect which decreased the prices the first week after promotion.

**Figure 1 Demand Curve Movement in Response to Promotion**



In summary, the net effect of promotion and lagged promotion on banana prices during a particular week depends on three things:-

1. whether current promotion is occurring; and if so
2. the quantity of bananas on the market at which promotion is occurring; and
3. the presence or absence of a negative effect of lagged promotion.

Increasing proportion of good quality bananas on the Sydney market had a negative effect on the price of bananas. The result seems perverse but it must be remembered that the prices recorded were those of the "No 1 extra large cavendish" bananas and not all classes of bananas while the quality reported was an average quality of all classes of bananas on the market. Therefore, when there is a majority of medium to good quality fruit available, premiums may not be paid for fruit that varies only slightly in quality from the next class of fruit. The price of the top class of fruit could be expected to be less in this situation when there are more "lines" to choose from than if there were few medium to good quality fruit and a majority of poorer quality fruit. Alternatively, when there is a large difference between the top and bottom qualities of fruit and a small supply of top quality fruit then it would be reasonable to expect that the top quality bananas would be in higher demand thus forcing their price up until buyers resisted paying higher prices. The lack of data on quality was a problem encountered by Stuckey and Anderson (1974) who were forced to leave such an important variable out of their model.

School holidays in Sydney had a negative effect on the price of bananas. This could be expected if children consume significant quantities of bananas in school lunches and the demand for a convenient "lunch-box" fruit decreases during these holidays. Stuckey and Anderson (1974) also found that the dummy variable for school holidays was responsible for changing the intercept term but not the slope of the demand curve.

Heavy carryover stocks had a negative effect on price during that week. Light, medium and heavy carryover supplies had a negative effect on price in the next week. This is to be expected as these categories of carryover are essentially increasing total (i.e. new + carryover) supplies of bananas on the market. These increased supplies will affect the price at which demand and supply equilibrate. The non-lagged classes of carryover had no effect on current price which is reasonable if it is assumed that ripeners have a limited capacity to manipulate supplies in the very short run.

Fruit that may be substituted for bananas, and therefore competes against bananas, had a negative effect on the price of bananas. The competing fruit mentioned by the market reporters included stone and soft fruit which are seasonal and may be eaten in preference to bananas, which are available all year round. This result was not found by Phillips (1967) possibly due to his use of the prices of other fruit which may not have been as indicative in its effect on prices as the dummy variable for the presence or absence of competition.

The price of bananas increased during winter. This may be due to the lack of substitutes for bananas during this season or the fruit's eating characteristics that make it more appealing to eat during colder weather.

The dummy variables for wet and hot weather were not significant in this model. Possibly the weekly data was too aggregated to be able to detect daily fluctuations in demand as a result of these variables. Further work could be done at a more micro level to develop new hypotheses for the inclusion of these variables in the model. The same reasoning may also explain why public holidays had no effect on the demand curve for bananas.

Chain store activity was not a significant variable in the model. This suggests that this form of promotion had no effect on the price of bananas. This could be explained by the fact that the chain stores' selling prices were not related to their buying prices at the wholesale market. This information merely shows that their buying activities did not significantly increase the price of the quantities they purchased or the remaining quantities on the market. It does not mean that their promotional activities at the store level did not increase the demand for bananas as this aspect was not observable from the data available.

## CONCLUSION

Promotion could have either a positive or negative effect on the price of bananas, depending on the weekly quantity supplied to the market and the presence of promotion and lagged promotion. These results support Quilkey's (1986) theoretical examination of the effect of promotion on producer welfare when the demand curve shifts in response to promotion.

The analysis was complicated by the lagged effect of promotion which, by itself, had a depressing effect on banana prices and should be taken into consideration when

promoting.

Other factors were also found to have an effect on the price of bananas such as carryover stocks, school holidays and the winter season. Therefore, more quantitative information should be available on factors suspected to affect the price the agricultural commodities. Most importantly, the type, timing, thrust and cost of promotion should be detailed and available from promoting bodies to allow *ex post* examinations of promotion campaigns.



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## APPENDIX A

## SUMMARY OF METHODOLOGY

As promotion was the primary variable of interest two regressions were run - the first with no promotion variables included as independent variables and the second having additive, multiplicative and lagged promotion variables.

The two models can be summarised in algebraic form as:-

$$(i) \text{ Model 1 : } \log P = a + d \log Q + fN + gQL1 + hQL2 + iW1 + jW2 + kCSA + lSH + mPH + nC1 + oC2 + pC3 + qC1L + rC2L + sC3L + tC + uS + \mu$$

This log-form equation was derived from the original demand equation which had the form:-

$$P = cQ^d e^{fN} e^{gQL1} e^{hQL2} \dots \epsilon$$

$$(ii) \text{ Model 2 : } \log P = a + b(Pr \times \log Q) + c \log Q + dPr + fP1 + gP2 + hN + iQL1 + jQL2 + kW1 + lW2 + mCSA + nSH + oPH + pC1 + qC2 + rC3 + C1L + tC2L + vC3L + vC + wS + \mu$$

This log-form equation was derived from the a demand equation with the following form :-

$$P = yQ^{(bPr + c)} e^{dPr} e^{fP1} \dots \epsilon$$

where P = price, logs = natural logs, a,b,c etc. = constants, Pr = promotion, Q = quantity, P1 = promotion lagged one period, P2 = promotion lagged two periods, C1L = light carryover lagged one period, C2L = medium carryover lagged one period, C3L = heavy carryover lagged one period,  $\mu$  = error term, QL1 = poor quality, QL2 = good quality, W1 = wet weather, W2 = hot weather, CSA = chain store activity, SH = school holidays, PH = public holidays, C1 = light carryover, C2 = medium carryover, C3 = heavy carryover, C = competition from other fruit, S = season.

The individual significance of the variables (t-statistic) from these two models are summarised in Appendix B. In order to see whether the addition of promotion variables added to the explanatory power of the model, a modified F test was used. The results of this test showed that the addition of the promotion variables significantly increased the R<sup>2</sup> value. Note that the additive promotion variable, interactive promotion times quantity variable, and the two week lagged promotion variables were not significant in Model 2. Only lagged promotion was a significant promotion variable. Based on the a priori hypothesis that promotion would have an effect on both the position and elasticity of the demand curve it was decided to further examine the effect of promotion lagged one week. A third model, which included the lagged promotion variable in an additive and interactive form with the log of the quantities was estimated.

The results showed that the coefficients of these two variables were not statistically

significant from zero, but the remaining results, as summarised in Appendix B, were very similar to the results from the first two models.

To clarify why the variables were not significant when used together in the form used in Model 3, each of the variables was included in an extended version of Model 1. The results from Model 4 (with additive lagged promotion) and Model 5 (with interactive lagged promotion times quantity) provided some insight into the previous results shown in Appendix B. In each of the latter models, the included variable was statistically significant at the five per cent level.

The three models can be summarised in algebraic form as:-

$$(i) \text{ Model 3 : } \log P = a + v(P1 \times \log Q) + wP1 + d\log Q + fN + gQL1 + hQL2 + iW1 + jW2 + kCSA + lSH + mPH + nC1 + oC2 + pC3 + qC1L + rC2L + sC3L + tC + uS + \mu$$

This log-form equation was derived from the original demand equation which had the form:-

$$P = cQ^{(d + vP1)}e^{fN}e^{gQL1}e^{hQL2}.....\epsilon$$

$$(ii) \text{ Model 4 : } \log P = a + c\log Q + fP1 + hN + iQL1 + jQL2 + kW1 + lW2 + mCSA + nSH + oPH + pC1 + qC2 + rC3 + sC1L + tC2L + uC3L + vC + wS + \mu$$

This log-form equation was derived from the a demand equation with the following form:-

$$P = yQ^ce^{dPr}e^{fP1}.....\epsilon$$

$$(iii) \text{ Model 5 : } \log P = a + c\log Q + f(P1 \times \log Q) + hN + iQL1 + jQL2 + kW1 + lW2 + mCSA + nSH + oPH + pC1 + qC2 + rC3 + sC1L + tC2L + uC3L + vC + wS + \mu$$

This log-form equation was derived from the a demand equation with the following form:-

$$P = yQ^{(c + fP1)}e^{dPr}e^{fP1}.....\epsilon$$

As each of the variables was individually significant when regressed without the other and individually insignificant when regressed together, it was evident that the effects of the two closely related variables on the dependent variable could not be separated. Upon an examination of the correlation matrix it was found that the correlation coefficient between lagged promotion and the interactive lagged promotion/quantity variable was extremely high (i.e. 0.99908).

The above discovery led to a re-examination of the results from Model 2 to see whether the two variables promotion and promotion interacting with (log) quantity, may have also shown a high degree of multicollinearity. With a correlation coefficient of 0.99912,

which would explain the lack of significance of the coefficients of their variables when regressed together, the individual explanatory power of these variables could not be distinguished from each other.

Unfortunately, such a problem is not easily overcome when there is a lack of quantitative data on the key variable promotion. This also affects all the other variables related to this variable -- namely lagged promotion and interactive variables.

As Gujarati (1988) points out, when faced with severe multicollinearity, one of the simplest things to do is to drop one of the collinear variables. In this case this would mean dropping either promotion or the promotion times quantity interactive variable from Model 2 depending on whether promotion is believed to have an additive or multiplicative effect. However, by dropping a variable from the model, a specification error may be committed leading to the "remedy being worse than the disease". While multicollinearity may prevent precise estimation of the parameters of the model, omitting a variable may bias the estimates of the parameters. With this in mind it was decided that the most appropriate model to use was Model 2. This model had promotion included as both an additive and a multiplicative dummy variable.

It was decided to test for autocorrelation in the model as it was a problem detected but not remedied by Stuckey and Anderson (1974). Based on the Durbin-Watson  $d$  test, and using the 5 percent level of significance, it was found that the null hypothesis that there was no positive autocorrelation could not be rejected i.e. there was evidence of positive autocorrelation. This was confirmed by the runs test. Using the null hypothesis of randomness, the decision rule was to reject the null hypothesis with 95 percent confidence as the number of runs was outside the estimate limits of the decision rule by Gujarati (1988). Since the OLS estimators in the presence of serial correlation are inefficient, and having found such a situation to exist in the model, it was decided to remedy the situation. The mechanism that was used was the transformation of the data using a value of  $\rho$  which is calculated from the Durbin-Watson  $d$  statistic and following the generalised difference equation procedure shown by Model 6 in Appendix B. Note that first-order autocorrelation was assumed to be the only type of autocorrelation present which ignored the presence of higher-order autocorrelation as there was not a priori reasoning to support its existence.

Model 6 was designed to correct the autocorrelation and had an  $R^2$  value of 0.8279 (compared to 0.6773) which indicated that 83 percent of the variation in the dependent variable was explained by the independent variables. In addition to the significant variables from Model 1, the heavy carryover and lagged light carryover variables were also significant. This model was able to increase the efficiency of the estimates which can be seen in a comparison of the standard errors. This increased efficiency elucidated the fact that carryover plays an important role in the pricing of bananas.

The point around which the demand curve pivots in response to promotion was derived by equating the two demand curves -- one demand curve derived in the absence of promotion and the other derived in the presence of promotion.

# APPENDIX B

Significant Variable	Model 1		Model 2		Model 3	
	Estimated Co-efficient	Level of Significance	Estimated Co-efficient	Level of Significance	Level of Significance	Estimated Co-efficient
log quantity	-0.891	1%	-0.883	1%	-0.868	1%
poor quality	0.051	10%	0.047	10%	0.045	10%
good quality	-0.339	1%	-0.365	1%	-0.349	1%
school holidays	-0.167	1%	-0.167	1%	-0.167	1%
lag medium carryover	-0.116	10%	-0.110	10%	-0.116	10%
lag heavy carryover	-0.272	1%	-0.270	1%	-0.273	1%
competition from others	-0.116	5%	-0.120	1%	-0.122	1%
season	0.115	1%	0.119	1%	0.121	1%
constant	9.739	1%	9.723	1%	9.620	1%
promotion lag 1 week	-	-	-0.113	10%	-	-
Degrees of freedom	339		338		339	
No. of observations	340		339		340	
R squared	0.6766		0.6773		0.6758	
Adjusted R squared	0.6573		0.6560		0.6565	
Variance of the estimate	0.0678		0.0683		0.0680	

# APPENDIX B

Significant Variable	Model 4		Model 5		Model 6	
	Estimated Co-efficient	Level of Significance	Estimated Co-efficient	Level of Significance	Level of Significance	Estimated Co-efficient
log quantity	-0.855	1%	-0.854	1%	-0.358	1%
poor quality	0.045	10%	0.045	10%	.	.
good quality	-0.340	1%	-0.338	1%	-0.175	5%
school holidays	-0.167	1%	-0.167	1%	-0.099	1%
heavy carryover	.	.	.	.	-0.098	10%
lag light carryover	.	.	.	.	-0.080	10%
lag medium carryover	-0.116	10%	-0.116	10%	-0.126	1%
lag heavy carryover	-0.273	1%	-0.273	1%	-0.208	1%
competition						
from others	-0.119	1%	-0.119	1%	-0.108	1%
season	0.120	1%	0.119	1%	0.192	1%
constant	9.536	1%	9.524	1%	6.244	1%
Promotion lag 1 week	-0.082	5%	.	.	-0.010	1%
Promo lag 1 week						
times log quantity	.	.	-0.012	5%	.	.
Degrees of freedom		339		339		339
No. of observation		340		340		340
R squared		0.6766		0.6754		0.8279
Adjusted R squared		0.6573		0.6572		0.8165
Variance of the estimate		0.0678		0.0680		0.0365