DEMAND ANALYSIS OF THE SYDNEY BANANA MARKET

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The demand for bananas on the Sydney market is studied at both wholesale and retail using time series data at wholesale and cross-section data at retail. The cross-section data come from a pricing experiment in Sydney supermarkets. Estimates of price elasticity of demand are presented for wholesale and retail; comparisons are made and several variables affecting demand are identified.

1 INTRODUCTION

Previous research on the Sydney banana market has examined the hypothesis that industry profits can be improved under supply control [1, 13, 19]. Decision making on supply requires, among other things, an understanding of wholesale demand relationships for bananas including most importantly, price elasticity of demand. If demand is price inelastic industry revenue would increase under supply control (at least theoretically [13, pp. 5–6]). Section 2 reports an attempt to estimate wholesale demand functions. Section 3 reports a cross-sectional study of retail demand for bananas in Sydney. No previous work on this latter topic appears to be available.

2 ESTIMATION OF WHOLESALE DEMAND FOR BANANAS

2.1 PREVIOUS WORK

Previous Australian work on wholesale demand for bananas is represented by the contributions of van der Meulen [19], Phillips [13], and Aggrey-Mensah [1]. Van der Meulen estimated a demand function for bananas on the Sydney wholesale market from monthly data for the period 1952–57. He estimated a quadratic function using least squares regression, with price per case as the dependent variable and number of cases as the basis of the independent variables. Using annual data from the twenty-one year period 1942–43 to 1962–63, Phillips estimated a linear demand function by least squares regression. Deflated average annual wholesale banana price per bushel was the dependent variable

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and annual supply the independent variable.[1] Most recently, Aggrey-Mensah's work on the redistribution of supplies of bananas over time to exploit the differences in demand between seasons, involved the estimation of weekly demand functions. While he found little scope for profitable temporal redistribution, it is his estimation of demand curves in which we are interested. Aggrey-Mensah estimated 52 weekly linear demand functions from weekly observations on price and quantity over the 15-year period 1953–67. Once again price was taken as the dependent variable, while quantity, time and lagged price were the independent variables. The estimated weekly demand functions differed widely one from another as might be anticipated when each was based on only fifteen observations.

An attempt has been made in this study to derive an improved estimate of the demand function using weekly data. This attempt was guided by the previously published results and by the results of a recent survey of consumers' preferences [17]. Phillips [13, p. 7] suggested that income, lagged price and other fruit prices do not significantly affect the demand relationship and van der Meulen [19, p. 162] concluded that functions fitted for different seasons of the year were not significantly different from one function for the entire year. Aggrey-Mensah [1, pp. 97–98] noted that the data collected on supply are quantities of fruit consigned each week to the Sydney market rather than the quantities actually auctioned on the wholesale market each week, as bananas spend 3 to 16 days in ripening rooms before being auctioned. He adjusted his supply data accordingly, so that the quantity of bananas on the wholesale market in any week t was approximated by summing 25 per cent of bananas arriving in Sydney in week t–1, 50 per cent of arrivals in week t–2 and 25 per cent of arrivals in week t–3. We adopted this procedure also.

2.2 THE DATA

In this section of the study we use weekly data from January, 1968, to July, 1972, on prices and quantities of both 7-inch grade hand and single bananas on the Sydney wholesale market. Data on grades other than 7's were not available, but 7's make up the greatest proportion of all bananas sold. They also comprise a fairly stable proportion of supplies over the year. These data were made available by the Division of Marketing and Economics of the N.S.W. Department of Agriculture.

2.3 THE HYPOTHESES

Consideration of the information summarized above led to the formulation of several hypotheses regarding the demand relationship to be estimated. A number of other hypotheses were also suggested by unpublished survey information relating to the retailing of bananas in the Sydney area [17], which revealed a number of variables seemingly important in the demand for bananas at retail but not included in the

[1] Phillips [13] used deflated annual prices whereas van der Meulen [19] compared use of deflated and undeflated monthly prices and found the latter superior.

published demand functions. These included the banana characteristics of size, colour, skin-marking and form (of presentation—hands *vs.* singles).

Assuming quantity to be the "dependent" variable, the following null hypotheses were formulated.

Hypothesis (*i*). The proportion of bananas sold as hands does not influence the demand relationship. *Comment*. The unpublished survey results suggested that consumers appear to have quite strong preferences about form when shopping.

Hypothesis (*ii*). The price/quantity relationship does not vary throughout the year.

Hypothesis (*iii*). The incidence of school holidays does not affect the demand for bananas. *Comment*. Housewives apparently like bananas for school lunch packs and accordingly may demand fewer during school holidays [5, p. 12].

Hypothesis (*iv*). The introduction in January, 1972, of three instead of two banana trains per week to the Sydney markets has not affected the demand for bananas. *Comment*. The introduction of three banana trains per week was aimed at overcoming the "mixed-ripe" problem [2] and intended to promote more consistent banana quality which may have affected the demand for bananas.

Hypothesis (*v*). The demand schedule for bananas is not "kinked", in that there is no upper-price region beyond which the demand curve suddenly becomes less inelastic. *Comment*. Schultz [14, p. 187] suggested that above a certain price the aggregate retail demand for food becomes more elastic but that such a price level is seldom, if ever, reached at retail.

Hypothesis (*vi*). The demand curve for bananas is best represented by a variable elasticity functional form. *Comment*. Intuition suggests that models which imply fixed price elasticity of demand at all prices, *ceteris paribus*, may be unduly restrictive. But, if such models do suffice, empirical analysis is considerably simplified.

To test these hypotheses, several models were formulated of which the most useful was a demand function with constant price elasticity, namely:

$$(1)\ QTY = e^{\beta_1} PW^{\beta_2 + \beta_3(H/T) + \beta_4 DWI + \beta_5 DSH + \beta_6 DT + \beta_7 DK} \times e^{\beta_8(H/T) + \beta_9 DWI + \beta_{10} DSH + \beta_{11} DT + \beta_{12} DK}$$

where here, and following, the β_i, $i = 1, \ldots, 12$ are coefficients to be estimated, QTY denotes the estimated mass of bananas marketed according to the formula of Aggrey-Mensah [1], PW denotes the average weekly wholesale banana price in cents per kilogram, (H/T) denotes the proportion of bananas sold as hands, DWI denotes the dummy variable for winter (1 for winter weeks 22 to 34 and 0 for other seasons weeks 1 (i.e. commencing 1st January) to 21 and 35 to 52), DSH denotes the dummy variable for school holidays (1 during state primary school holidays and 0 during school terms), DT denotes the dummy variable for three banana trains per week (1 for three trains per week since week

4, 1971 and 0 for two trains per week prior to week 4, 1971), and *DK* denotes the dummy variable for the "kink" in the demand curve (1 below the "kink" price P^* and 0 above the "kink" price P^*).

This model has been designed in such a way that the hypotheses of irrelevant factors in (i) to (v) can be contradicted in two ways. First, coefficients β_3 to β_7 measure any effects of these factors on price elasticity of demand (otherwise given by β_2) and secondly coefficients β_8 to β_{12} measure any effects on shifts of demand through the logarithmic "intercept" term otherwise β_1.

The presumption that demand is normal implies $\beta_2 < 0$ and, if inelastic as well, $\beta_2 > -1$. If hypotheses (i) to (v) are true then coefficients β_3 to β_{12} all will not differ from zero. On the other hand if they are untrue, we would expect the coefficients to take on other values within certain ranges. The ranges and our reasons for them are as follows.

$\beta_3, \beta_8 < 0$: (Hypothesis (i))	On average, approximately 40 per cent of bananas sold are hands. However, considerably less than 40 per cent of consumers prefer hands to singles [17]. One might, therefore, expect an increase in the proportion of hands to shift the curve to the left ($\beta_8 < 0$). By similar reasoning, the demand for hand bananas may be more elastic than the demand for singles, and hence an increase in the proportion of hands may mean a more elastic demand for bananas in total ($\beta_3 < 0$).
$\beta_4, \beta_9 < 0$: (Hypothesis (ii))	Winter may induce a change in dietary preferences of consumers resulting in the demand curve shifting to the left ($\beta_9 < 0$), and becoming more elastic ($\beta_4 < 0$) than at other times [1, pp. 115–116].
$\beta_5, \beta_{10} < 0$: (Hypothesis (iii))	The speculated school holiday "lunch pack" effect would shift the demand curve to the left ($\beta_{10} < 0$) and may result in more elastic demand during holidays ($\beta_5 < 0$).
$\beta_6\ \beta_{11} > 0$: (Hypothesis (iv))	Three banana trains a week may have meant better quality bananas on the market, which may have shifted the demand curve to the right ($\beta_{11} > 0$). The demand for good quality bananas is probably more inelastic than the demand for poorer quality bananas. If this is the case the overall quality improvement resulting from the three trains would have induced a more inelastic demand ($\beta_6 > 0$).
$\beta_7 > 0$; $\beta_{12} < 0$: (Hypothesis (v))	If the demand curve *is* kinked, the lower-price portion is more inelastic than the higher-price portion ($1 > \beta_7 > 0$). A curve with less inelastic portion above a kink would also have a lower intercept term than the same curve without such a kink ($\beta_{12} < 0$).

A linear (non-constant elasticity) model analogous to the above constant-elasticity model was also formulated to test in part hypothesis (vi) regarding the suitability of a constant elasticity functional form. When

the two models were estimated by least squares regression, overall subjective appraisal, tests of significance on individual coefficients and general explanatory power suggested that the constant elasticity model was superior to this particular non-constant elasticity model. The constant-elasticity form also had the convenient advantage that the conditional estimates of price elasticity could be observed directly. However, it must be noted that conclusions about the other hypotheses are necessarily conditional on the validity of the constant-elasticity form.

2.4 ESTIMATION AND RESULTS

The constant elasticity model (1) was cast in log-linear form for estimation by ordinary least squares regression analysis with the purpose of testing hypotheses (i) to (v). The analysis implicitly assumes that our price/quantity observations trace out a consumer demand curve. Logically, however, our time series observations on wholesale price and retailer purchases represent points of intersection of the retailer demand schedule and the merchants' supply schedule over time. The retailers' demand and the merchants' supply are derived schedules, highly correlated with the consumers' demand and farmers' supply schedules, respectively. So the demand function we are attempting to estimate is actually the retailers' rather than the consumers'. However, we can assume that retailers reflect the preferences of consumers sufficiently closely that the parameters of the retailers' demand function are acceptable indicators of the parameters of the consumers' demand function.

Given this appreciation of our aim, we must question whether the function fitted to points of intersection of the retailers' demand schedule and the merchants' supply schedule represent a statistical retailers' demand curve or a statistical merchants' supply curve, or some hybrid. This is the classical identification problem to which the answer depends on the relative variability of the two curves over time [9, pp. 373–399; 10, pp. 325–329]. It seems reasonable to assume that, over the $4\frac{1}{2}$-year period under study, the supply schedule of merchants would have been subject to much greater random shift elements than the demand schedule of retailers. Van der Meulen claimed that changes in supply are responsible for about 87 per cent of variation in average monthly prices [19, p. 157]. Our weekly price/quantity observations therefore can be presumed to trace out a demand curve [1, pp. 92–93].

The demand function estimated takes price as an independent variable and quantity as the dependent variable. This infers that price "explains" quantity, $Q = f(P)$, and not vice-versa [9, 21]. However, van der Meulen, Phillips, and Aggrey-Mensah used the alternative $P = f(Q)$ approach, possibly because short-term supplies are effectively fixed, and prices are determined in the market so that retailers shift daily supplies off the market.[2] The relationship between estimates of elasticities and

[2] When discussing merchants' control of supplies to the market, Aggrey-Mensah [1, pp. 212–213] observed that merchants are subject to rather restricted technological possibilities in their capacity to regulate supply flows to retailers.

flexibilities derived from these two approaches has been controversial [4, 7, 8, 11] excepting when cross-elasticities are zero. However, Phillips [13, p. 7] found that other fruit prices and income had regression coefficients not significantly different from zero in attempts to explain variation in banana prices and that the collective effect of these variables was also not statistically different from zero. The survey information [17] supported this finding, as other fruit prices and household income did not appear to affect consumption significantly at the micro-level. We chose the $Q = f(P)$ approach for the ease of interpretation of the coefficients as direct elasticity estimates. Waugh [20] might agree with our choice as he suggests that "if, for any reason, the elasticity of demand is wanted, I would prefer to use . . . regression equations, using quantities as the dependent variables . . .". Our curiosity, however, led us also to estimate an equivalent $P = f(Q)$ model. We were impressed by the close reciprocal correspondence of the results.

In estimating the constant elasticity model (1) a number of the variables appeared not significant, as guided by tests of statistical significance on their respective regression coefficients (zero null hypotheses). After such variables were eliminated from the model in a series of alternative specifications, the finally modified estimational form arrived at was:

$$(2)\ \log(QTY) = \beta_1 + \beta_2\log(PW) + \beta_4 DWI\log(PW) + \beta_7 DK\log(PW) + \beta_8(H/T) + \beta_{10}DSH + \beta_{12}DK + u,$$

where β_1 denotes the logarithmic intercept term, u denotes the disturbance term and the variables are as previously defined. The results of estimating model (2) are presented in table 1, including the estimated coefficients and standard errors. Some of the variables in (2) can behave as "demand shifters"—a positive (negative) coefficient indicating a shift to the right (left). In this category in model (2) are the variables (H/T), DSH, and DK. Those variables not behaving as demand shifters behave as "elasticity changers" wherein a positive (negative) coefficient implies that demand will be more (less) inelastic. The elasticity changers are DWI and DK. The null hypothesis (iv) is implicitly accepted because of the elimination of the β_6 and β_{11} coefficients from the final model. That is, the analysis showed that the change from two to three banana trains per week had no detectably significant effect on demand for bananas.

Null hypothesis (v) must be rejected as the evidence for some sort of kink is quite strong and accords with the situation depicted in figure 1. The selection of a high-price kink point was rather arbitrary and in recognition of this several different values of P^* were experimented with in the process of converging on the finally selected model (2). Naturally the estimates of price elasticities for the two segments were quite strongly dependent on the value of P^* but overall the statistical quality of the regression and the coefficients for the other influential factors were quite insensitive to the value of P^*. The presentation of these results for $P^* = 22{\cdot}2$ c/kg ($\log_e P^* = 3{\cdot}1$) is therefore arbitrary.

However, the appearance of some sort of kink in the wholesale demand function for bananas requires some explanation. To begin with, our concept of a kinked demand curve is distinct from, and should not be

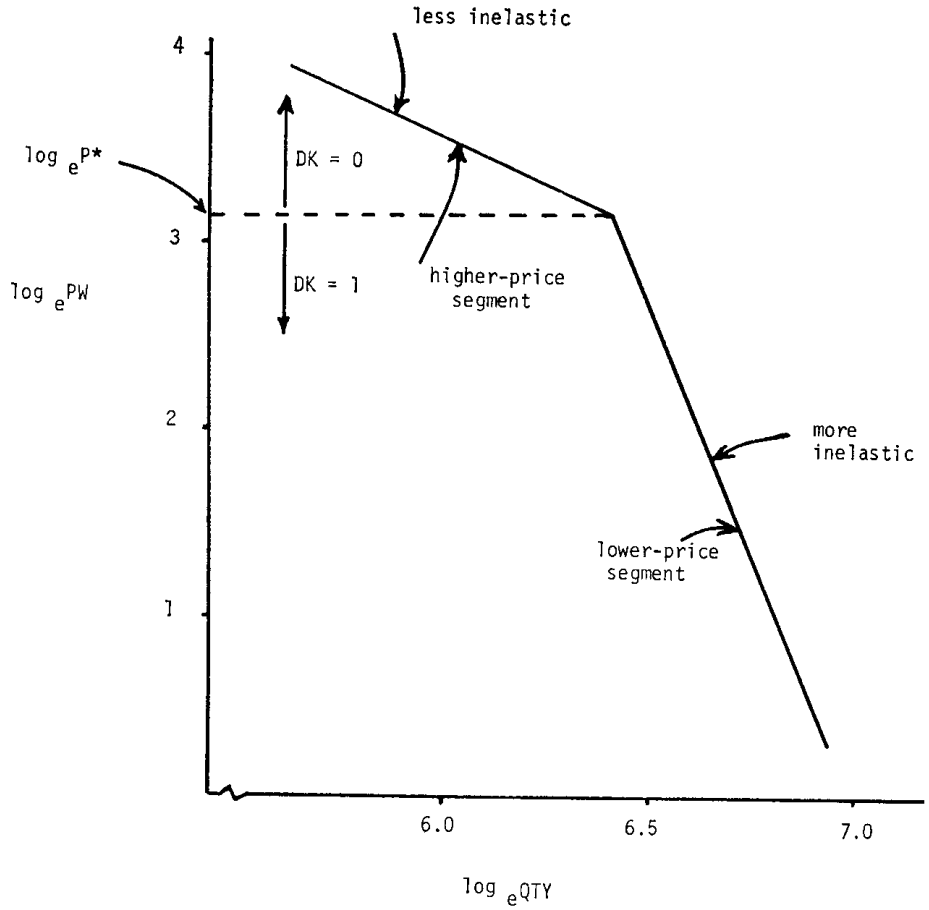

FIGURE 1: *Price segments in the demand curve*

confused with, the kinked demand curve proposed by Sweezy [18] and Hall and Hitch [6], and refuted by Stigler [16].[3] Their kinked demand theory applied only to oligopoly, the arguments for and against revolving around the assumption of selling behaviour and its implications for price movements. However, our kinked demand function relates to the short run (weekly) behaviour of a competitive market with about 30 sellers and over 1,000 buyers. The sellers have no direct ability to influence price, and during any one week they have only a limited ability to influence price through supply adjustment (because of ripening technology and the perishability of bananas). Hence it is a buyers' market. Perhaps our kinked demand function really

[3] Sweezy [18] and Hall and Hitch [6] advanced the theory that there exists a kink in the demand curve for the product of an oligopolist and that this kink goes far to explain the observed price rigidities reported in many statistical studies of prices during the 1930's. Stigler [16] argued that the kinked demand theory was not a valid extension of neoclassical oligopoly theory, and supported his belief with empirical evidence.

reflects the buying policies of retailers. This would support Schultz' [14, p. 187] belief that "there exists an upper segment where the (demand for food) schedule is somewhat more elastic". Alternatively, the kink may indicate an intersection of two demand functions for bananas of different qualities and ripenesses. However, our subsequent conclusions do not dependent crucially upon the kink or the value of P^*, and it will be assumed that the lower segment represents the curve in which we are primarily interested.

Hypotheses (i), (ii), and (iii) are only partly accepted. The proportion of bananas sold as hands does not act as an elasticity changer but, as β_8 is negative, demand shifts to the left as the proportion of hands increases. The dummy variable for the winter season is not a demand shifter, as the intercept term during winter is not significantly different from the intercept term during other times of the year. However, the winter dummy variable is a significant modifier of elasticity. That β_4 is negative implies that elasticity in winter is less inelastic than during the other times of the year. The dummy variable for school holidays does not behave as an elasticity changer but it is a demand changer by moving the demand curve to the left during school holidays (β_{10} negative).

TABLE 1

Regression Statistics for the Modified Model

Variable	Non-zero coefficient	Estimated coefficient	Standard error	Relevant hypothesis	Anticipated sign of coefficient
	1	8·30	0·242		
log PW ..	2	− 0·546	0·072		−
DWI*log PW ..	4	− 0·055	0·006	(ii)	−
DK*log PW	7	0·222	0·077	(v)	+
H/T ..	8	− 0·301	0·077	(i)	−
DSH ..	10	− 0·057	0·019	(iii)	−
DK ..	12	− 0·696	0·250	(v)	−

$n = 227$, $\bar{R}^2 = 0{\cdot}80$, $SEE = 0{\cdot}097$, $d = 1{\cdot}15$

Variance-Covariance Matrix of Estimated Coefficients

(all elements multiplied by 1000)

	1	2	4	7	8	10	12
1 ..	58·5	− 17·3	·52	17·3	− 3·73	− ·17	− 57·2
2 ..		5·22	− ·15	− 5·15	·43	·05	17·0
4 ..			·03	·14	− ·14	·01	− ·46
7 ..				5·96	− ·84	− ·05	− 19·3
8 ..					5·89	− ·10	2·67
10 ..						·35	·13
12 ..							62·5

As table 1 shows, all the coefficients of model (2) were estimated with the anticipated signs and differed from zero at conventional levels of statistical significance.[4] The adjusted R^2 of ·8 seems acceptably large when we recall that the important factor of banana quality has not been accounted for.[5]

The demand model was formulated so that the influences of segment and season on the price elasticity of demand could be estimated. Table 2 presents these elasticities and table 3 shows the effect of school holidays and winter-time on the predicted quantity of bananas consumed at the average price. For example, in table 2 the number − ·39 is the estimate of the elasticity during winter (irrespective of school holidays) when price is below 22·2 c/kg. Estimated elasticity is thus slightly less inelastic during winter than during summer, autumn, and spring. The lower right-hand cell of table 3 gives the predicted mean quantity consumed at the mean price for school-term periods occurring during summer, autumn, or spring, when the price is below the "kink" price and with an average proportion of hands. *Ceteris paribus*, school holidays have the effect of reducing the quantity consumed by approximately 5 per cent, while consumption during winter is approximately 14 per cent below consumption at other times of the year.

TABLE 2

The Influence of Season and Segment on the Price Elasticity of Demand

Season	Kink segment	
	Higher price segment ($DK = 0$)	Lower price segment ($DK = 1$)
Winter ($DWI = 1$)	− 0·61	− 0·39
Rest of the year ($DWI = 0$) ..	− 0·55	− 0·33

[4] The Durbin-Watson statistic (1.15) suggests autocorrelated disturbances but we deemed it not worthwhile in this instance to attempt any of the usual repair operations.

[5] An unsuccessful attempt was made to secure time-series data on the quality of bananas.

TABLE 3

The Influence of School Holidays and Season on Consumption at Average Price and Average Proportion of Hands[a]

(metric tons per week)

Season	School holidays	
	During school holidays ($DSH = 1$)	Rest of the year ($DSH = 0$)
Winter ($DWI = 1$)	555	577
Rest of the year ($DWI = 0$) ..	641	679

[a] Consumption figures relate to the lower segment of the curve ($DK = 1$) as the average price falls in this segment. The grand average quantity is 633 metric tons per week. The average quantity below the kink is 643 metric tons per week.

3 ESTIMATION OF RETAIL DEMAND FOR BANANAS

3.1 INTRODUCTION

The relationship between retail prices and sales of bananas is one seemingly unexplored; at least to the extent that there has been no relevant research published in Australia. This is possibly because time-series data on retail prices have been recorded only in recent years. An analysis of these recent data was carried out in the early stages of this project. It was unfruitful, possibly because of the inaccuracies of the data series.

However, in the field of banana marketing research, knowledge of the retail demand function for bananas is important. An attempt was made to gain at least some idea of the retail demand-retail price relationship by way of cross-sectional data from a banana pricing experiment operated in several Sydney supermarkets during the summer of 1972.

3.2 THE DATA

The pricing experiment used a 4 x 4 latin square design, with four supermarkets for a period of 4 weeks. A set price was charged in each store during each week, and a record was kept of the quantity of bananas sold. Experimental prices were set at one of four prescribed levels ranging either side of the "normal" price for each week. The co-operating supermarket chain had a policy of determining and operating a "normal" price for each week in all its stores. Our experimental prices were related directly to the "normal" price established for each week. The price charged during any one week in any one store was the "normal" price adjusted by one of plus 5 cents, plus 2 cents, minus 1 cent or minus

4 cents.[6] The range of adjustments in defining experimental prices was so restricted on the advice of the supermarket chain. The (appropriately randomized) latin square design was chosen as it allowed the measurement and removal of the effects of different stores and different weeks. The experimental stores came from different socio-economic areas in the Sydney metropolitan area. The latin square does not allow for the measurement of the interaction effects between stores, weeks, and price treatments. This presents no serious problem since such interactions are not of interest in this study beyond the precision they may have added to the estimation of elasticity. A much larger experimental design would have been necessary to measure these interactions and this proved to be impossible due to cost and practical considerations. The results of this experiment are directly applicable only to the particular type of banana sold from Sydney supermarkets during the experimental period.[7]

3.3 THE ANALYSIS

The first step in analysis involved an analysis of variance to determine whether or not the treatments (prices), stores and weeks contributed significantly towards explaining variation in sales of bananas. The analysis revealed significant differences in per capita banana sales among treatments and stores but no significant differences among weeks. This aided the formulation of subsequent regression models.

The data were then subjected to regression analysis, with the aim of isolating and estimating the effect of price on sales, in the form of a demand function. By virtue of the experimental design, there was no potential identification problem as the demand relationship could be presumed stable over the 4 weeks of the experiment, while supply was arranged to be unlimited at the set price. The experimental design also ensured that the necessary conditions for least squares analysis would likely pertain.

The aim is constructing the regression models was to explain the variation in banana sales for the sixteen observations by other (causal) variables. Several different models were tested, again using linear and log-linear functional forms and including different variables analogously to the estimation of the wholesale demand function. Per capita banana sales (total store sales divided by the number of customers passing through the check-outs) was taken as the dependent variable. The explanatory variables used were prices, stores, weeks, the prices and sales of mark-down bananas (bananas falling below the experimental quality level), and average weekly retail banana prices (both for the supermarket chain and for all Sydney fruiterers).[8]

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[6] These prices are in the archaic units of cents per pound.

[7] The estimated elasticities will be biased towards being too elastic to the believed small extent that experimental stores did not enjoy effective spatial monopolies.

[8] In this instance it is clear that price is the independent variable, hence the use once again of the $Q = f(P)$ approach.

The models were of the general form:

$$y_i = \beta_1 + \beta_2 p_i + \sum_{j=2}^{4} \beta_{sj} S_{ji} + \sum_{j=2}^{4} \beta_{wj} W_{ji} + \sum_{j} \beta_{mj} M_{ji}$$

for the i-th observation, where population coefficients are denoted by β's and the variables are defined as y = banana sales per store customer per week, p = price of bananas, $S_j = 1$ for store j, $j = 2, 3, 4$, zero otherwise, $W_j = 1$ for week j, $j = 2, 3, 4$, zero otherwise and M_j denotes the j-th other variable. Thus store 1 and week 1 are here used as base store and week respectively in defining the dummy variables.

The subjective criteria used in appraising alternative models blend considerations of predictive accuracy and specification and were:

(i) the precision of individual regression coefficients;

(ii) the magnitude of the adjusted coefficient of multiple determination ($\bar{R}^2$), (where necessary recomputed with comparable transformations of the variables); and

(iii) the economic implications of the equations: if a model had indicated relationships between variables which did not follow the relationships expected from economic theory, then the models would have been severely discounted. This did not occur.

On the basis of these criteria the model selected as "best" was a linear function.

3.4 ESTIMATION AND RESULTS

The estimated equation for the selected model (with respective standard errors in parentheses) was

$$\underset{(3\cdot6)}{PCS = 105} - \underset{(0\cdot2)}{2\cdot18AP} - \underset{(1\cdot5)}{29\cdot4S_2} - \underset{(1\cdot5)}{19\cdot2S_3}$$

$$\bar{R}^2 = 0\cdot97$$

where PCS = predicted mean sales in pounds per capita per week x 1,000, AP = actual prices in cents per pound, $S_2 = 1$ if store 2 or zero otherwise and $S_3 = 1$ if store 3 or zero otherwise. Other variables such as for store 4 and for weeks were not statistically significant. The linear models were generally better than the log-linear models. This regression rates highly in terms of the criteria listed above. It infers that "uncontrolled" variation in the experiment and the neglect of interactions were of little importance.

The negative signs of the coefficients show that per capita sales decreased with increasing price, and were lower in store 2 and store 3 than for the base store 1. Of principle noteworthiness here is the coefficient of the price variable (− 2·18) because from this coefficient, point estimates can be made of the price elasticity of demand for supermarket bananas. The estimated elasticity at arithmetic mean price and quantity is (dq/dp)

(mean p)/(mean q) = − ·82, which is just inelastic.[9] By means of a t-test we can presume that of a large number of such estimations, in about 98 per cent of such occasions the elasticity will be greater than − 1, i.e. inelastic.[10]

The experimentally determined relationship between sales and price is sketched in figure 2. The line and observation points have been "corrected" for store effects to indicate only the influence of price on sales. The line in figure 2 is an estimate of the weekly demand curve for good-quality, packaged cluster bananas sold from a particular supermarket in March/April, 1972.

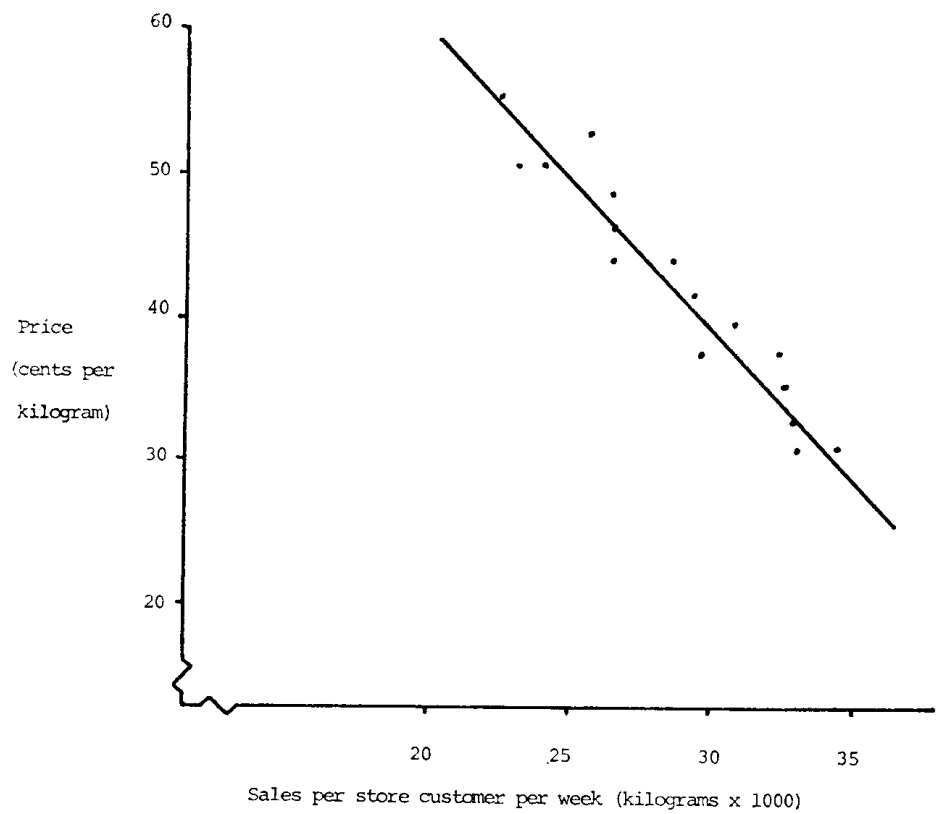

FIGURE 2: *Corrected experimental results and fitted demand curve*

[9] At geometric mean price and quantity, the point estimate of price elasticity of demand is − 0·85.

[10] It is worth noting that our point estimate elasticity of demand should be relevant for large discrete price changes as well as small price changes. Buckwell and Sturgess [3] show that price elasticities evaluated at a point on a linear demand curve can be used to predict accurately the effect on quantity demanded for a large discrete change in price.

4 SUMMARY AND CONCLUSIONS

The principle findings of the study are that the price elasticity of demand for bananas at wholesale (except during winter) is about − 0·3, while at the retail level the elasticity is about − 0·8.[11] The estimate at wholesale is somewhat more inelastic than the average of Aggrey-Mensah's weekly elasticity estimates (− 0·8) for the non-winter period of the year [1, pp. 100–4]. This is only partially reconciled when we consider that Aggrey-Mensah did not account for any possible kink in the demand function at high prices. The relative values of − 0·3 at wholesale and − 0·8 at retail could be anticipated—"the elasticity of the demand at the farm level is usually less than the elasticity at the retail level because middlemen's charges are relatively fixed, so most of a change in price at retail level is passed back to the farmer" [15, p. 34].[12] By the same rationale [14, p. 190] the elasticity at wholesale falls between the elasticities at farm gate and at retail. Our study also revealed that, *ceteris paribus*, the elasticity of demand for bananas is less inelastic during winter (− 0·39) than during other times of the year (− 0·33), and that during school holidays, demand for bananas declines. Demand also tends to decline as the proportion of hand bananas increases.

It can safely be concluded that the (short run) demand for bananas is inelastic. This supports previous research and adds to the belief that some decrease in the supply of bananas would increase industry gross revenue. The supply of bananas to the Sydney market which would maximize gross returns to the industry would be less during school holidays and with increasing proportion of hand bananas, and would be relatively greater during winter. The profit maximizing supply would be similarly constrained. Development of optimal marketing strategies must involve a more thorough understanding of the demand for bananas, particularly at the consumer level.

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[11] The finding of a relatively inelastic demand at wholesale may have a wider applicability than just for the case of bananas. An unpublished study of the Sydney wholesale pineapple market by R. A. Logan and J. R. Anderson indicated that demand for pineapples is generally inelastic (elasticity about − 0·5).

[21] This is especially true if retailers practice "levelling", i.e. marginal cost pricing of their services such that higher margins are charged at lower prices, and vice versa.

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