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THE DEMAND FOR BANANAS AND THE ECONOMIC EFFECT OF SUPPLY RESTRICTION

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ABSTRACT

The wholesale demand elasticity of bananas was estimated at between -0,52 and -0,66 for the short run and between -0,65 and -0,71 for the long run. Estimates of demand elasticities using Time Varying Parameters varied between -0,62 and -0,93, also indicating that the demand becomes less price elastic during summer months. Retail elasticities were estimated at between -1,42 and -1,52 for the short run and at -1,79 for the long run. The social cost of the banana control programme is estimated at between 7,8 % and 12,68 % of income transfer between producers and consumers in marketing areas. The impact of cut-backs in banana production where entry is free (any farmer can produce bananas) is to increase prices in marketing areas, but depress prices in production areas. It is uncertain whether farm income can be increased significantly through such a scheme even though the demand is inelastic, if the supply of good banana land is not limited.

INTRODUCTION

The most pressing sales problem facing the banana industry is that peak production (2/3 of the total production) occurs during a short period. The demand function is more inelastic during the period of peak production (lower end of the demand function) and the bigger crop leads to a smaller income (Chadwick, 1984).

Supply control in a competitive industry operating at the equilibrium output theoretically raises profits in the industry irrespective of the elasticity of demand (Phillips, 1967, p. 5). The increase in net revenue will continue, if production is reduced, until marginal revenue equals marginal cost.

Du Toit and Döckel (1978, p. 9) estimated demand elasticities in various regions for different seasons in order to determine the optimum allocation of bananas. This study calculates a national demand equation in order to investigate the economic consequences of supply restriction. The first part of the paper presents demand models which are used in the second part to explore theoretical considerations of supply control on profits and in the third part to estimate social costs of intervention.

THE DEMAND FOR BANANAS

Banana demand equations are estimated at both retail and wholesale level. The consumption of bananas is assumed to be dependent upon the price of bananas, the consumption of substitutes and complements, consumers' disposable income and changes in banana quality. Monthly and yearly data were used in order to obtain short and long run functions. A partial adjustment model was also fitted in order to calculate short and long run functions and to compare these with the above functions.

Statistics on total value and total mass sold monthly on five markets (i.e., Pretoria, Johannesburg, Bloemfontein, Port Elizabeth and Cape Town) were obtained from *Statistics on Fresh Produce Markets* for the years 1975 to 1981. Retail figures were obtained from *Crops and Markets*, and yearly data from the *Abstract of Agricultural Statistics* for the period 1958 to 1982. The price was then calculated by dividing total value by total mass produced and consumed.

Personal disposable income information was obtained from the *S.A. Reserve Bank Quarterly Bulletin*. Both price and disposable income were deflated by the monthly consumer price index (CPI) with 1970 = 100, which was obtained from *Agrekon*. Banana consumption and disposable income were converted to per capita figures using population figures obtained from the *Abstract of Agricultural Statistics*. For the years 1977 to 1981 the Black population figure was extrapolated using a 2,8 % growth rate before being added to the other population groups to take into account the independent National States. The following demand functions were estimated:

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Model 1 Short run demand for bananas at the wholesale level

$$\text{LBCON} = 0{,}1281 - \underset{(t=9{,}06^{**})}{0{,}65790\ \text{LBANAP}} + \underset{(t=4{,}30^{**})}{0{,}10554\ \text{LPAC}} + \underset{(t=3{,}64^{**})}{0{,}7765\ \text{DI}}$$

$R^2 = 72\%$ DW $= 1{,}70^+$

Model 2 Long run demand for bananas at the wholesale level with price dependent

$$\text{BANAP} = 72{,}871 - \underset{(t=6{,}61^{**})}{47{,}6829\ \text{BCON}} + \underset{(t=3{,}52^{**})}{0{,}32081\ \text{YD}}$$

$R^2 = 73\%$ DW $= 1{,}29^+$

Model 3 Long run demand for bananas at wholesale level

$$\text{LBCON} = -2{,}08043 - \underset{(t=5{,}92^{**})}{0{,}70720\ \text{LBANAP}} + \underset{(t=2{,}92^{**})}{0{,}38293\ \text{LPIC}} + \underset{(t=2{,}84^{**})}{1{,}12724\ \text{LYD}}$$

$R^2 = 88\%$ DW $1{,}58^+$

Model 4 Short run demand for bananas at retail level

$$\text{LBCON} = 4{,}91484 - \underset{(t=9{,}93^{**})}{1{,}43360\ \text{REP}} + \underset{(t=4{,}08^{**})}{0{,}14459\ \text{PAC}} + \underset{(t=2{,}12^{**})}{0{,}14479\ \text{PIC}}$$

$R^2 = 79\%$ DW $= 2{,}14^+$

Model 5 Short run demand for bananas at wholesale level

$$\text{BCON} = 0{,}02694 - \underset{(t=7{,}02^{**})}{0{,}00080870\ \text{BANAP}} + \underset{(t=8{,}21^{**})}{0{,}000019043\ \text{PAC}} + \underset{(t=6{,}25^{**})}{0{,}0000081837\ \text{PEC}} - \underset{(t=3{,}04^{**})}{0{,}0000065900\ \text{MAC}}$$

$R^2 = 80\%$ DW $= 1{,}42^+$

Model 6 Long run demand for bananas at wholesale level

$$\text{BCON} = 1{,}07527 - \underset{(t=6{,}93^{**})}{0{,}01556\ \text{BANAP}} + \underset{(t=2{,}73^{**})}{0{,}000048166\ \text{PIC}} + \underset{(t=4{,}23^{**})}{0{,}00624\ \text{YD}}$$

$R^2 = 91\%$ DW $= 1{,}86^+$

Model 7 The partial adjustment model at retail level

$$\text{LBCON}_t = 4{,}40596 - \underset{(t=-8{,}31^{**})}{1{,}51514\ \text{LREP}} + \underset{(t=2{,}54^{**})}{0{,}15335\ \text{LBCON}_{t-1}} + \underset{(t=4{,}30^{**})}{0{,}26516\ \text{LPIC}}$$

$R^2 = 72\%$ DW $= 2{,}08^+$

The adjustment coefficient is $\triangle = 1 - 0{,}15335 = 0{,}846\,65$, which means that 85% of the adjustment in banana consumption takes place in one month. The long run equation is therefore LBCON $= 5{,}203\,9 - 1{,}789\,5$ LREP $+ 0{,}288\,62$ LPIC.

The variables used above are as follows: where a variable is prefixed by an L the data associated with that variable have been converted to logs.

BCON	= consumption of bananas in tons per capital per month (subscript t indicates consumption in period t)
BANAP	= wholesale price of bananas in rands per kg
REP	= retail price of bananas in rands per kg
PAC	= pawpaw consumption in tons per capita per month
PEC	= peach consumption in tons per capita per month
PIC	= pineapple consumptions in tons per capita per month
MAC	= mango consumption in tons per capita per month
YD	= real disposable income in rands per capita per month
DI	= a dummy variable for intercept showing that there are significant changes in consumption between the summer months (October, November, December) and other months. This dummy shows the effect of quality changes, quantity changes and changes in tastes and preferences
**	= highly significant
R^2	= the adjusted coefficient of determination
-	= some autocorrelation detected using the Durbin Watson Statistic
+	= no autocorrelation detected using the Durbin Watson Statistic

However, the DW Statistic is not appropriate in lag models and so for Models 5 and 6 the h statistic is determined.

$$h = (1 - 1/2 \times d)\sqrt{N/1 - N(\text{VAR}(\triangle_2))}$$

where d = DW-statistic

where n = number of observation

VAR $(\triangle_2)$ = the variance associated with the lagged variable. For Model 5, h = 3,33, which is fairly high and could mean some autocorrelation present, and for Model 6, h = 0,52, which means the hypothesis that there is no first order autocorrelation can be accepted (Gujarati, 1978, p. 272).

Results indicate that the wholesale demand for bananas is price inelastic in the short run and lies between -0,52 (Model 5) and -0,66 (Model 1). In the long run the wholesale demand is inelastic in the log model (-0,71 in Model 3) and in the linear model (-0,65 in Model 6). These values seem realistic in the light of studies undertaken in Australia by Richardson (1976, p 86), ED = -0,60, Aggrey, Mensah and Guise (1969, p. 198), ED = -0,5 to -1,3 and Stuckey (1974, p. 70), ED = -0,55 to -0,61. Results using a relatively new econometric technique (time varying parameters) estimated by the author indicated that price elasticity of demand varied between -0,93 and -0,62. Monthly variation in the price elasticity of demand is shown in Figure 1. In every year demand becomes less elastic during summer months. Since production is at a peak during this period, if supply restrictions were not imposed the total revenue earned by banana farmers would fall. Model 2 estimates the price flexibility at -1,14 in the long run. This model is used in the calculations in part 2.

The retail price elasticity of demand for bananas is elastic in the short run, varying between -1,43 (Model 4) and -1,52 (Model 7). Since it is expected that retail level demand is more elastic than farm level demand (Foote, 1978, p. 134) results seem realistic. In the long run the retail price elasticity of demand is more elastic having a value of -1,79 (Model 7). Results at retail level agree with studies in South Africa by Du Toit and Döckel (1979, p. 9), ED = -1,04 to -2,50, in the U.S.A. by Arthur, Houk and Beckford (1968, p. 150), ED = -2,50 to -3,30 and in Australia by van der Meulen (1958, p. 166), ED = -1,81 to -3,12. The income elasticity of demand from Model 3 is 1,12 which is marginally greater than unity. Bananas therefore appear to be a luxury type of fruit. The finding that the income elasticity for bananas exceeds its price elasticity is in accordance with Wold and Jureen (1962, p. 115), who state that income elasticities of luxuries exceed their price elasticities. The relationship between bananas and other fruit is not very strong. The availability of pawpaws and pineapples is complementary to consumption of bananas which agrees with earlier studies by Du Toit and Döckel (1978, p. 8). The relationship is not very strong and the availability of other fruit does not influence the consumption of bananas to any significant degree. Nieuwoudt's (1977, p. 22) conclusion that bananas do not have any close substitutes is verified in the above models. The range of elasticities usually resulted from variation owing to seasons. Model 2 is used in part 2 to examine the effect of supply restriction on total revenue and Model 6 is used in the estimation of social costs in part 3.

TABLE 1 - The price elasticity of demand

	Wholesale level		Retail level	
Model No.	Short run ED	Long run ED	Short run ED	Long run ED
1	-0,66			
2		-0,88*		
3		-0,71		
4			-1,43	
5	-0,52			
6		-0,65		
7			-1,52	-1,79

*Estimated as inverse of price flexibility (-1,14)

THE EFFECT OF SUPPLY RESTRICTION ON PROFITS

In order to determine whether supply restriction in the banana industry will raise profits and to determine the most profitable level of production Figure 2 is used. A competitive industry which does not take into account the effect of output on price will produce where marginal cost cuts the demand function. This situation is point P_1Q_1 in Figure 2. At this output marginal revenue is less than marginal cost and a contraction in supply will increase profits until marginal revenue equals marginal cost. Therefore, if a single authority is imposed on a competitive industry, it can raise profits irrespective of the elasticity of demand. The maximum profit position is point P_2Q_2, where

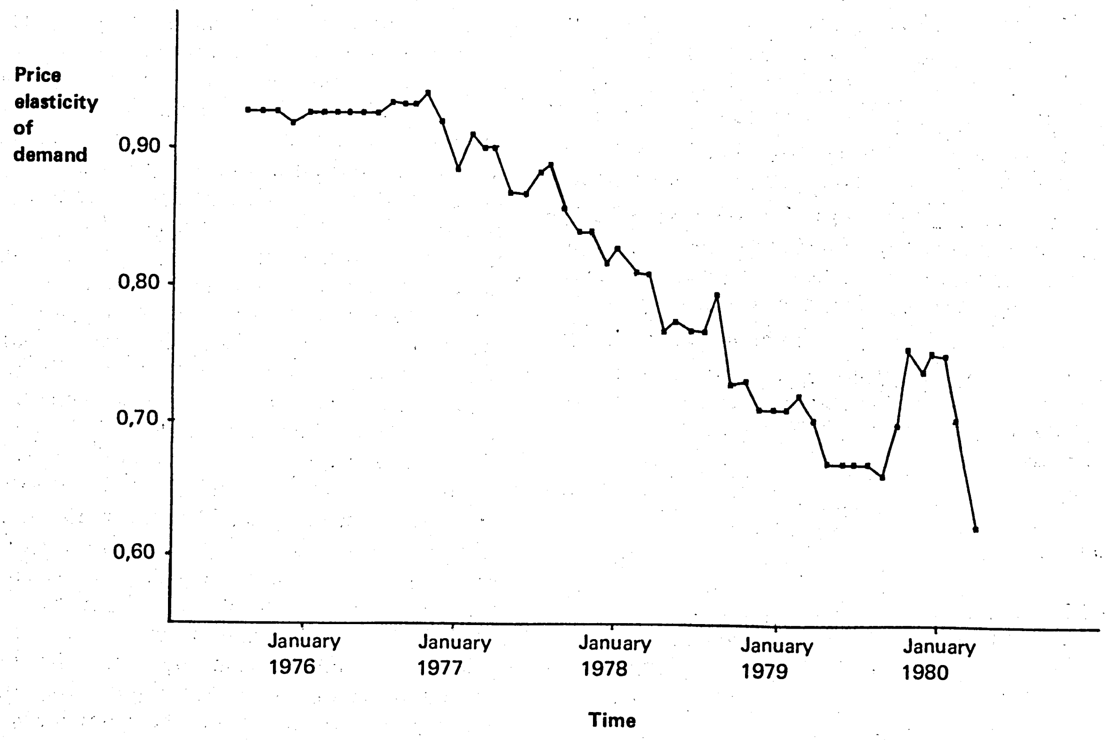

FIGURE 1 - Price elasticity of demand adjusted over time

marginal revenue equals marginal cost. With the present system adopted by the Banana Board, whereby the producers are cut back by a percentage of their estimated bi-weekly production, the position is not so clear. Since most production costs have already been incurred they cannot be saved and only picking, packing and transport costs are reduced.

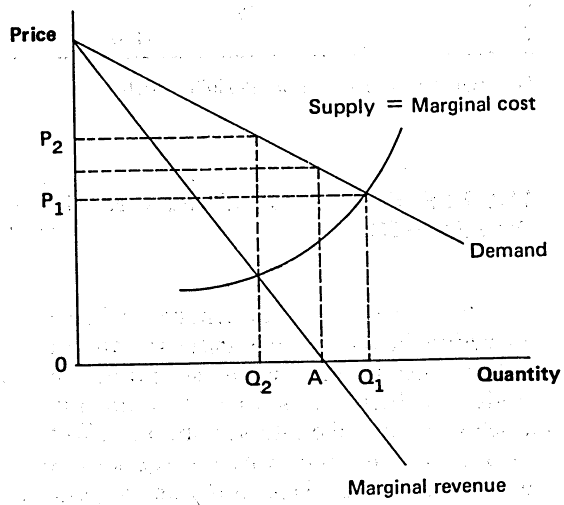

FIGURE 2 - Comparison of monopoly and competitive output

In order to determine point P_2Q_2 the supply and demand curves need to be known. With knowledge of the demand curve alone it is possible to determine at what quantity the marginal revenue is zero (point A). Should the present situation be to the right of point A then marginal revenue is negative and supply restriction at least until point A will increase total revenue. If the present situation is to the left of point A then with no knowledge of the supply curve no recommendations can be made.

Since supply control is implemented at the farm level the demand function is derived at that level. To calculate the consumption at which total revenue is maximum, Model 2 from part 1 is used. The price and consumption variables are isolated by taking other variables at their mean level, thus

$$\text{BANAP} = 72{,}871 - 47{,}6829\ \text{BCON} + 163{,}96$$
$$= 236{,}83 - 47{,}683\ \text{BCON}$$

Total revenue is derived by multiplying price by quantity as follows:

Total revenue $= 236{,}83$ BCON $- 47{,}683$ BCON^2

The point where the marginal revenue curve is zero gives the maximum total revenue, i.e., where $a\,\text{TR}/a\,\text{BCON} = 0$

The optimum consumption is where $0 = 236{,}83 - 95{,}37$ BCON

BCON $= 236{,}83/95{,}37$

$= 2{,}48$

Since the mean level (2,85 kg per capita) lies to the right of the point where marginal revenue is zero the elasticity of demand would be expected to be less than unity. This is verified in Model 3 where the price elasticity of demand is 0,71. Since marginal revenue is zero with a per capita supply of 2,48 kg, which is less than the mean over the past 22 years, it appears that a restriction on banana supplies increases farm income.

By fitting 95% confidence intervals to the estimate of supply at which marginal revenue is zero it is found that the point at which marginal revenue is zero falls within the 95% limit of current production.

THE SOCIAL COST OF SUPPLY RESTRICTION

The present system of supply restriction is applied at the least cost point - on the farm, so no transport, packing or marketing costs are incurred on the surplus production. The distribution of bananas is organised by telephone auctions. The producer puts through an estimate in week one of how much he has available in week two. Once the total quantity for all producers is calculated the Board finds out from its agents the quantity demanded at various prices and the produce is sold to the highest bidders. The sale price is determined on a tram line system, for example, in 1983 the Board found that if the price increased beyond R15 per 20 kg container then there was consumer resistance, whereas if the price dropped below R6 per 20 kg container then the retailer made a higher profit and the volume sold did not increase. The R6 is therefore the lower cut off point and any produce not sold at this price is a surplus. When there is a surplus and producers send in only a percentage of their weekly crops, the same reduction is applied to all producers and therefore no producer is favoured.

Whether producers actually benefit from the scheme or not is debatable. If good banana land is not limited and given that there is free entry into the industry then in the long run abnormal profits cannot be made. Returns from alternative investments will be the same given that information about choices is available. There is no reason to expect that returns per hectare of land would be higher for a given crop if free entry is allowed as presently is the case. Prices received in production areas would be depressed below equilibrium price and prices in marketing areas would be increased above equilibrium price. This situation is shown in Figure 3, restricted quantity Qm is sent to marketing areas and receives price Pm, the remaining quantity (Qe - Qm) is sold within production areas at price Pp, which covers harvesting costs or is greater than the opportunity cost of using bananas for feed or rations. The equilibrium price is Pe, the weighted price of Pp and Pm should equal the equilibrium price and producers would not gain from the system. Transfer of welfare would be from marketing area consumer to production area consumer and the Board. Production area consumers gain from the reduced price (Pp). During summer prices are reduced through temporary cutbacks. During winter net price differentials are due to uncertainty and quality differences. Producers estimate their crops conservatively so as not to risk paying transport costs if estimates are not met.

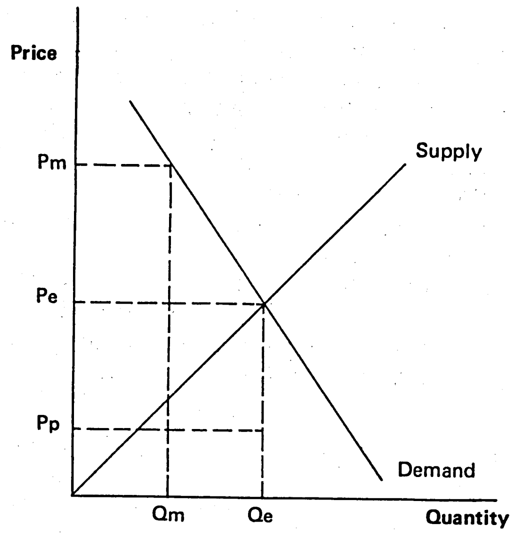

FIGURE 3 - Price distribution between marketing and production areas

If good banana land is limited then weighted prices could be above the equilibrium price. Supply is fairly constant and by restricting the quantity available in marketing areas producers gain through higher weighted prices received, i.e. discrimination can be practised if the supply is limited in the long run. The following analysis is concerned with marketing areas in isolation and assumes welfare transfers from consumers to producers and the Board.

Social costs in this context may be defined as the extent by which the loss in consumer welfare exceeds the gain in producers income. It is assumed that the area under the demand curve is a measure of total value placed on a commodity by consumers and that the area under the supply curve represents the opportunity cost of resources used to produce that commodity. The consumers' surplus is the area under the demand curve above the equilibrium price, and the producers' surplus is the area above the supply curve below the equilibrium price (Beck, 1974, p. 240). The total utility in a free market is then given by area OHDG in Figure 4 and resources to the value of ODG are used to produce output OG.

Supply resriction of quantity FG by a percentage cut-back on all producers causes the total utility to decrease by area BDGF. Area DGFE is variable resources used and it is debatable whether this area should be included or excluded. Since producers are uncertain as to by how much their

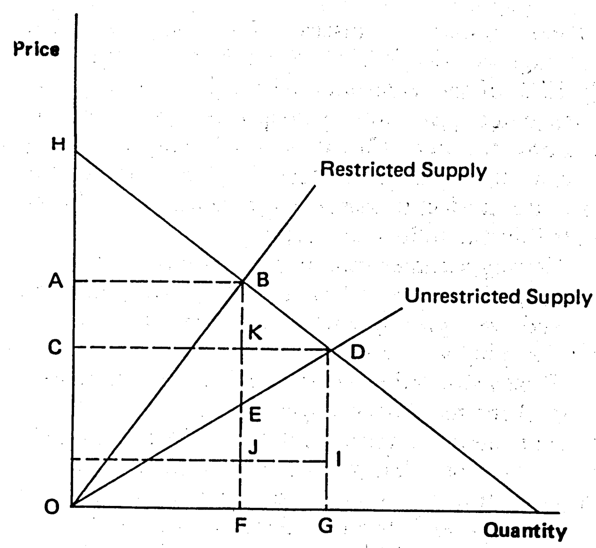

FIGURE 4 - The social cost of supply restriction

production will be cut in any week production beyond point F is expected. This over-production has zero value to the producer. The extent by which production exceeds point F depends on the favourableness of weather and the expectations of farmers and it is therefore reasoned that some percentage of area DGFE should be included as social costs. If producers are completely uncertain then area BDGF is measured as social cost. Since this area is similar to assuming completely inelastic supply Wallace's (1964, p. 585) formula (equation 1) is used: $SC = r\ E_D P_1 Q_1 (1 + 1/2r)$, (1) where $SC =$ social costs, $r =$ percentage increase in price above equilibrium price $P_1 Q_1$ is net income earned from bananas and E_D is the elasticity of demand at retail level.

The lower limit to social costs is area BDE in Figure 3 and is measured as follows:

$SC = 1/2\ E_D P_1 O_1 r^2 (1 + E_D / E_S)$ (2) (Wallace, 1964, p. 585)

where E_S is the elasticity of supply.

The fact that prices in production areas are lower than prices in marketing areas is due to restricted sales of bananas through the Board. Information on this price difference is partly used to calculate by how much prices are being kept above equilibrium. The Natal coastal production area is taken as a proxy for a perfectly competetive market and farm stall prices were obtained. The cost of packing and transporting were added to this price in order to compare it directly with the Durban Municipal Market price. For the 1983/84 season the price during summer on farm stalls was 30c/kg and the Municipal market price was 35c/kg. The percentage increase in price is 17%. During the winter months farm stall prices were 40c/kg and

Municipal market prices were 48c/kg. The percentage in price is 20 %. Since Natal accounts for only 17 % of the total national production the above figures could give only a rough estimate for r in equations (1) and (2). It was decided to vary r between 10 % and 20 %. Assuming that production areas are perfectly competetive markets could be debated on the following issues:

- During summer months any surplus that is not taken by the Board is pushed through the farm stall so production areas could be seen as dumping markets.
- Production areas are usually sparsely populated and the number of buyers is small.

The supply curve for most agricultural goods is assumed to be almost perfectly inelastic. This is especially true for non-storable products were the entire crop is sold during a certain period regardless of price. The elasticity of supply for bananas is expected to fall between 0,0 and 1,0. The social cost is measured at three levels of elasticity of supply: 0,5, 1,0 and 1,5. The elasticity of demand is 0,71 from Model 3 in part 1.

TABLE 2 - Annual social cost* measured as area BDE (Equation 2)

r \ Es	0,5	1,0	1,5
10 %	0,86 %	0,60 %	0,52 %
15 %	1,93 %	1,37 %	1,18 %
20 %	3,44 %	2,43 %	2,09 %

*Social costs measured as a percentage of total revenue

TABLE 3 - Annual social cost* measured as area BDGF (Equation 1)

r \ Es	0,0
10 %	7,46 %
15 %	11,45 %
20 %	15,63 %

Table 2 represents a lower bound and Table 3 an upper bound for social costs. With a mean total revenue over this period of R6 231 600 per annum this means that the social cost with r as 15 % varies between R73 532 and R120 270 per annum. The upper bound would be less since no packing, transporting and levy costs are met for the unharvested production. Over the period studied these costs amounted to 8c/kg at the mean. Figure 3 is used to calculate by how much the upper bound should be reduced. This figure is also used to calculate transfers in welfare from consumers to producers and the Board.

Area JIGF should be deducted from total social cost area BDGF since the former area represents costs saved. R51 260 is deducted leaving the upper bound to social costs as R662 263, which is 10 % of the total revenue. The social costs are expected to be less because:

- Through experience producers would expect a cut-back and therefore produce closer to point F than point G.
- Some of the over-production is sold within production areas at reduced prices.
- Part of the surplus is used as cattle feed and rations.

The central purpose of state intervention is to redistribute income to producers from consumers or taxpayers. Gardner (1983, p. 225) therefore defines social cost as the "deadweight loss per rand transferred". The transfer of welfare from consumer to producer and the Board is area ABKC which is R934 936, which is 15 % of total revenue. This transfer means that there is a welfare loss to consumers of approximately R1 million and a gain for producer/Board of the same amount. Of this 15 % welfare transfer 7 % is taken up by levies and 8 % is received by producers. This transfer measured as a percentage of social cost is given in Table 4.

TABLE 4 - Social costs measured as a percentage of transfer recieved by producers

r \ Es	0,5	10	1,5
10 %	5,73	4,00	3,47
15 %	12,86	9,13	7,87
20 %	22,92	16,20	13,93

Social costs expressed in terms of percentage of transfer are high. The cost of tranferring R1,00 from consumers to producers/Board is between 7c and 13c (taking r as 15 %). Transfer costs in the milk industry are between 7,03 % and 14,02 % of total social costs (McKenzie, 1984), which is not significantly different from the situation in the banana industry.

CONCLUSION

The aim of intervention is to redistribute income from consumers to producers (Gardner, 1983). If good banana land *is limited* then income could be transferred from consumer to producer and the aims would be achieved. Since any banana farmer can produce bananas if he wants to (entry is free) percentage cut-backs cannot increase banana prices or profits to banana farmers if banana land *is unlimited.*

The income transfer would be from marketing area consumers (who pay above equilibrium prices) to production area consumers (who pay below equilibrium prices) and the Board (through levies). The aim of intervention is not achieved if banana land is unlimited and producers (who get the equilibrium price) do not gain from the Banana Board scheme. From a purely monopolistic point of view the producers gain from a reduction in supply by an increase in total revenue. The long run price elasticity of demand for bananas is estimated at -0,71. Social cost exhibits a wide range depending on what area is to be measured. It seems reasonable to take the percentage increase in price over equilibrium price owing to supply restriction as 15 % and price elasticity of supply as 1,00. (Jones, as cited by Askari and Cummings (1976, p. 410) found the supply elasticity of soft fruit in Great Britain in the long run to be 1,03). This would result in a social cost as a result of supply restriction of R85 373 per annum. The supply restriction would result in a redistribution of welfare with consumers losing R1 million which is gained by producers and the Board assuming limited banana land. Land suitable for banana production is not unlimited and the impact of cut-backs would be to increase prices and incomes to farmers. Social costs amount to between 7,87 % and 12,86 % of total transfer.

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