

MODELLING THE EFFECT OF
BUYER AND SELLER POWER ON THE MARGINS
OF COMMODITY PLASTICS.

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SUMMARY

In the last decade, large sectors of the chemical and plastics industries in the USA and West Europe have suffered drastic declines in price and gross margin during periods of low utilisation of industry capacity. This paper shows that the major changes in gross margin observed for some commodity plastics can be modelled successfully in terms of the balance between buyer power and seller power. These industries have visibility of prices and industry occupancy and comparable concentrations of sellers and important buyers. The modelling follows Burgess (this Journal 1981) in expressing buyer and seller power as simple functions of buyer and seller concentrations, industry occupancy and 'cohesion' between sellers. This work provides a first practical test of this new approach. It is shown that the model fits the observed data best if the 'cohesion' declines as occupancy declines. The explanatory power using only three variables is extraordinarily good. It is suggested that the approach would be useful in understanding the behaviour of other 'near-commodity', capital-intensive businesses, and in helping to distinguish between those businesses where margins are likely to remain relatively stable and those which might face drastically declining margins if the industry occupancy declines or new entrants change the balance between sellers and buyers.

MODELLING PROFITABILITY

Managers of capital-intensive businesses often find that actual prices are below those forecast in the last capital expenditure proposal, particularly if new competition has appeared or industry occupancy has declined. For some observations on polyethylene price movements with occupancy see Simmonds 1973.

The numerous studies exploring relations between industry profitability and structure across groups of industries (see Scherer 1980 Chapters 9 and 10) give no practical guidance to managers of individual businesses on how much price or profit might be affected by changes in occupancy or of concentrations of buyers and sellers. The PIMS Programme has disclosed some important relations between profitability, market share and capital intensity (Schoeffler 1974) and is capable of giving some pointers on the effect of new competition, but the PIMS data base does not record industry occupancy and to date it has published little on the effect of buyers (Buzzell 1975, 103). Many econometric studies on profit and structure have ignored the fact that price must result from a balance between buyer and seller powers. However, Brooks 1973 demonstrated that across 20 broadly defined industry groups, buyer concentration had a negative effect on profitability nearly equal in size to the positive effect of seller concentrations. A number of related studies have appeared since which are discussed later. Burgess 1982 introduced a new modelling approach which explicitly models gross margin changes in terms of the balance between buyer power and seller power. This paper is largely concerned with testing variants of the Burgess model against data for some near-commodity Bulk plastics businesses in the USA and West European markets.

The Burgess model defined a target gross margin (GMT) which would produce an adequate return on inflation adjusted capital (if operating at full capacity) and postulated that the proportion of this which is bargained away (Y) under competitive pressure is determined by the ratio of buyer power to the total buyer and seller power in the market :

$$Y = B / (B+S)$$

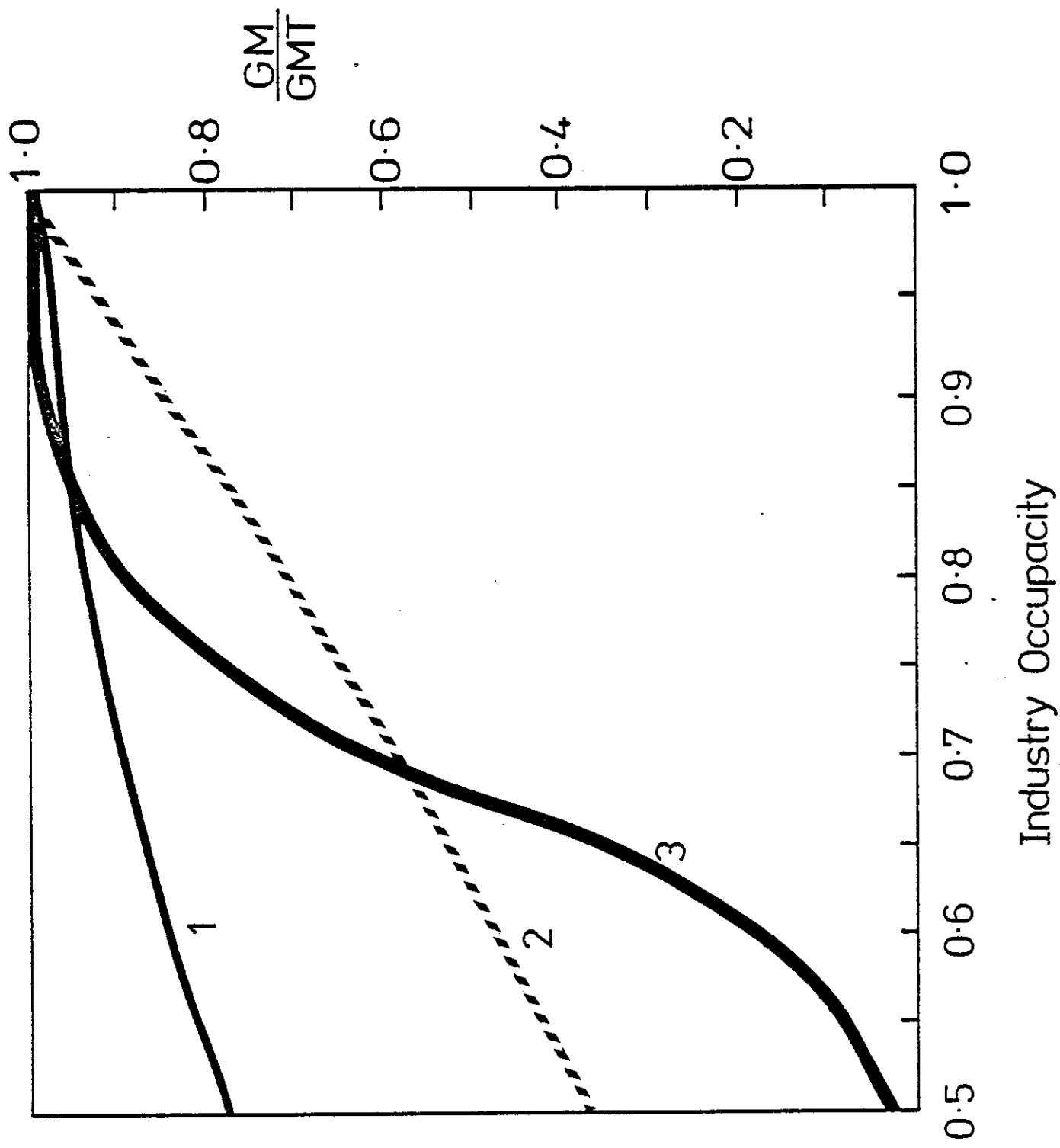
Alternatively, the actual gross margin retained (GM) would be :

$$\frac{GM}{GMT} = \frac{S}{B+S}$$

Buyer power B and seller power S are expressed as functions of four variables recognisable as important by practising managers :

1. Seller concentration, $s = 1/\sum m_i^2 = 1/H$

Figure 1



H is the Herfindahl index (= the sum of squares of the fractional market shares of all the sellers).

2.
- Buyer concentration, b = number of buyers taking 50% of sales value. This was chosen as it is a more accessible measure than the corresponding Herfindahl index for buyers. b is recorded in the PIMS data base.
3.
- Fractional Industry occupancy, ϕ = total demand /total nameplate capacity.
4.
- 'Cohesion' between sellers, a . Burgess suggested this might be a constant for a particular group of producers, and he arrived at an empirically determined value for a of about 0.7 for a group of chemical businesses.

This led to the expression :

Proportion of target gross margin retained by seller

$$\frac{GM}{GMT} = \frac{\phi a^{s-1}}{(1-\phi)/b + \phi a^{s-1}} \qquad \text{-----(1)}$$

If GM/GMT is plotted against occupancy, ϕ , this expression shows little decline in margin for many buyers and few sellers (line 1 in Figure 1) and a very rapid decline in margin for many sellers and few buyers (dashed line 2). However, line 2 shows a rather drastic decline in margin even at high occupancies in the range 0.85 to 0.95. It seems inherently more reasonable to expect more price stability than this at high occupancy and that a more typical behaviour would be shown by the sigmoid curve 3 in Figure 1. This shape of curve is obtained if model 1 is modified so that a is not a constant (0.7) but is allowed to vary with occupancy. If a is put numerically equal to ϕ , model 1 becomes :

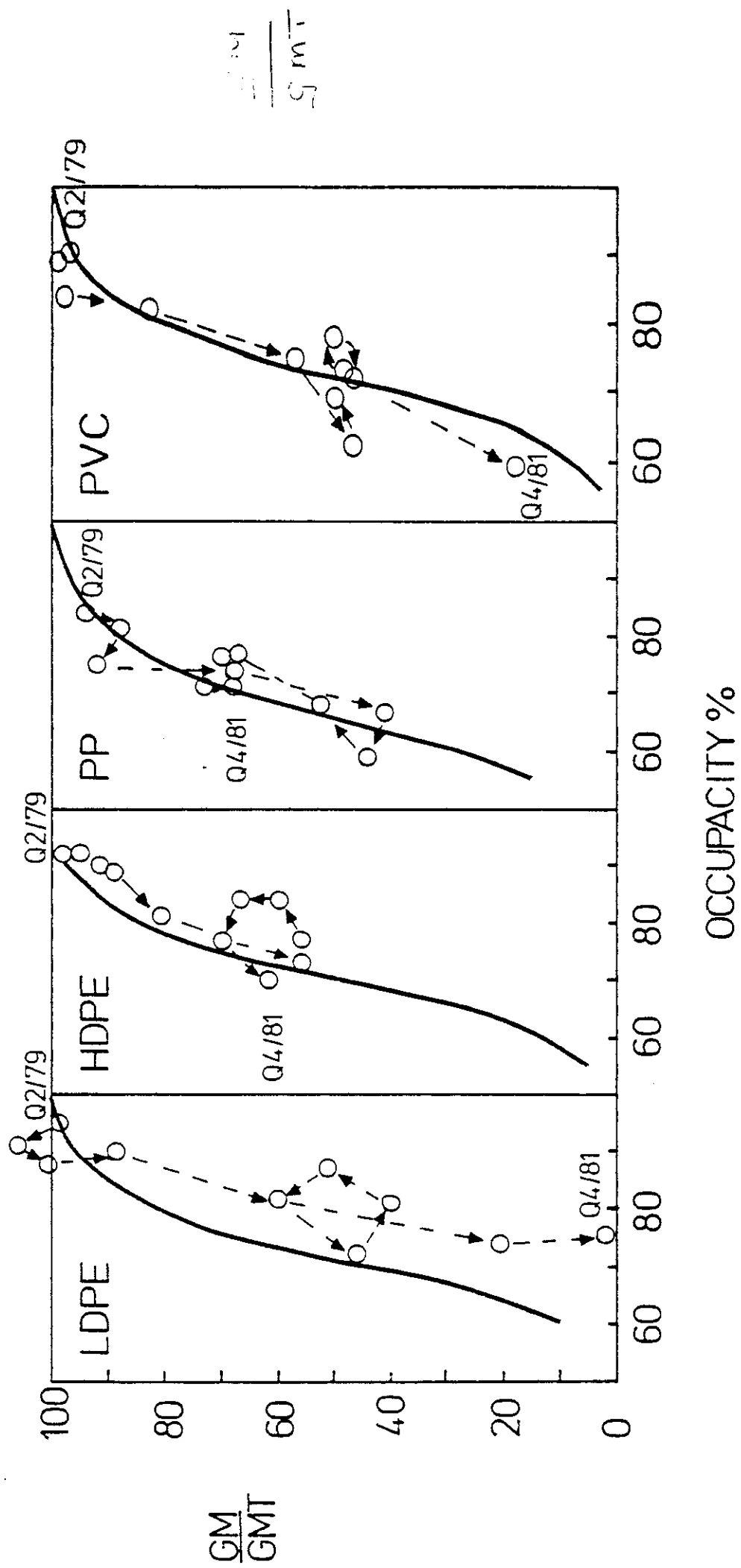
$$\frac{GM}{GMT} = \frac{\phi^s}{(1-\phi)/b + \phi^s} \qquad \text{-----(2)}$$

This model 2 reproduces the shape of the curve 3 in Figure 1. The values of s and b are used for plotting the curves in Figure 1 were :

	<u>s</u>	<u>b</u>	<u>a</u>
Line 1	5	15	0.7
2	10	15	0.7
3	10	15	$a = \phi$

Model 2 would assume that 'cohesion' is high ($a = 1$) at high occupancy, but progressively decreases under competitive pressure as industry occupancy falls. Qualitatively, this model fits with common experience. If buyers are weak compared with sellers little gross margin is bargained away in periods of low occupancy (line 1). This is expected of a stable oligopoly, or a 'sound' business. If sellers are weak compared with buyers, much of the gross margin may be bargained away in periods of low occupancy, i.e., a high risk business. In extreme cases, we may have 'sick' industry unless growth rates are high enough for the overcapacity to be eliminated rapidly.

Models 1 and 2 cannot be readily distinguished for 'sound' businesses because the margin changes are small. To distinguish between the models it is necessary to examine businesses which do display large changes in margin with occupancy.



THE DATA

The data used refers to price and industry occupacity for some near-commodity bulk plastics in the USA (1979-81) and West Europe (1974-81). Each bulk plastic (polymer) is manufactured from a major raw material (monomer), the cost of which usually represents some 50-60% of the selling price of the polymers :

	<u>Polymers</u>	<u>Monomers</u>
LDPE	Low density polyethylene	Ethylene
HDPE	High density polyethylene	Ethylene
PP	Polypropylene	Propylene
PVC	Polyvinylchloride	Vinylchloride (VCM)

Each polymer has its own distinctive technology and separate manufacturing plants. The total turnover of these products in 1981 was about £4,000m in each market (USA and W. Europe). Each polymer is sold to a range of processors who specialise in converting it for particular end use applications. Thus PVC processors include businesses (usually separate) specialising in rigid pipe extrusion, manufacturing of flooring materials, cable and wire coating, pressing of gramophone records, bottle manufacture, film and sheet manufacture, etc.

To test the alternative models it is necessary to evaluate GM/GMT actual and to compare this with GM/GMT calculated from the model equations 1 or 2. This requires a time series of actual gross margins corrected to real gross margins by an appropriate index of inflation. Consumer Price Index has been used in this paper. The real gross margins are expressed as a fraction of the target gross margin (estimated to give 8% return on total capital employed at current replacement value with occupacity full up).

Two sets of data have been examined. One refers to quarterly data for four bulk polymers in the USA in 1979-81. For these products the target gross margin full-up was assumed to be the actual in Quarter 2, 1979 with minor upward adjustments applied to each polymer to correct from the actual occupacity in Quarter 2 to full up occupacity. These small corrections of 1-6% were equivalent to fitting the first point of the data series onto the model Curve 2. It is considered that the Quarter 2 figures (corrected) are a reasonable approximation to the target gross margin, because 1978 and 1979 were periods of high industry occupacity and price stability, when it was likely that most producers were earning a modest return. The

actual quarterly gross margins were calculated from actual prices for the main grade of each polymer by subtracting the published merchant price of the monomers and the variable conversion costs (industry estimates of the costs of utilities, maintenance, packages and freight for modern plants). All salaries and plant labour costs were counted as fixed costs. It was clear that prices fell quickly as occupancy decreased and the best correlation was when occupancy was taken as the mean occupancy of the current and preceding quarter. This mean occupancy was used in testing equations 1 and 2.

The second data set consisted of annual data on 3 of the same bulk polymers in Western Europe for the years 1974-81. For these, a target gross margin was calculated for 8% return full-up in 1974 in DM/te using the W. German consumer price index. The actuals were tested against the models using the mean occupancy in the given year and also with the occupancy lagged by 1 quarter (i.e., mean occupancy was expressed as the mean of Q4 of preceding year + quarters 1, 2 3 of current year).

For both sets of data, s was calculated from known annual capacity shares of the competitors in each market. b was put equal to 10 customers taking 50% of sales in the USA and 15 customers taking 50% of sales in Western Europe for all polymers. The significance of this is discussed below. $\emptyset$ the industry occupancy was taken as total demand/total nameplate capacity.

Both sets of data started from a period of high occupancy and acceptable margins. By 1981, occupancy was low and margins had fallen to 'distress' levels often below 50% of the starting levels. This reflects the widely publicised views in the chemical trade press in 1981 that all polymer producers were sustaining operating losses. These were reported as being of the order £1,000m per annum in Western Europe¹ for all Bulk polymers (e.g., European Chemical News 28 September, 1981).

TABLE 1

Bulk Polymers USA 1979-81.

Summary of combined results for HDPE, PP, PVC.

30 observations. Mean Gross Margin = 66.37% of target gross margin

MODEL	2	1	1	1
	a = occupancy	a = 0.7	a = 0.75	a = 0.8
Mean value	68.82	58.92	71.67	81.36
R ²	0.69	0.57	0.64	0.68
Best fit line:				
Constant	-1.1	23.8	41.8	59.2
Slope	1.05	0.53	0.45	0.33

TABLE 2

Bulk Polymers West Europe 1974-81

Summary of combined results LDPE, PP, PVC

24 observations. Mean Gross Margin = 65.92% of target gross margin

MODEL	2	2	1	1	1	1
a =	occupancy of year	occupancy lagged 1 qtr	0.6	0.7	0.75	0.8
Mean value	63.3	67.0	25.2	51.9	67.9	80.8
R ²	0.56	0.67	0.39	0.46	0.53	0.61
Best fit line:						
Constant	-4.2	0.5	-28.7	6.0	32.6	57.1
Slope	1.03	1.01	.82	.70	.54	.36

RESULTS

Figure 2 shows plots of real gross margin/target gross margin versus occupancy for 4 polymers in the USA 1979-81. The heavy lines drawn are for model 2 ($a = \text{occupancy}$). It is apparent that the model equation is giving a fair representation of the quarterly movements. For LDPE, the decline in gross margin with decreasing occupancy was even steeper than predicted by the model. This might be due to the fact that in this period a new product and process was being introduced (linear low density polyethylene, LLDPE) and this may have further unsettled an already unstable market. By end-1981, LLDPE capacity was about 12% of conventional LDPE capacity in the USA. For the other three polymers, linear regressions were run on the total of 30 observations of GM actual v GM Model for Model 2 ($a = \text{occupancy}$) and repeated for Model 1 with $a = 0.7, 0.75, 0.8$ (see Table 1). All the models had R^2 in the range 0.5 - 0.7, but Model 2 had the highest R^2 0.69 and the best fit regression line was nearer the predicted slope and passed nearer the origin. Model 2 reproduced the mean of all observations to within 3%, the slope to within 5% and the intercept was only 1% from the origin. This is an extraordinarily good result for an equation with only 3 variables.

Table 2 summarises the results on the 24 observations combined for the three polymers in West Europe 1974-81. In this case also model 3 had the highest R^2 (0.67) and the best fit line had a slope of practically unity and passed through the origin.

The results for the USA and West Europe were very similar; in both cases Model 2 gave a satisfactory fit.

In calculating the gross margins for HD polyethylene in the USA, 3 of the 30 observations used above were adjusted because it appeared that the reported ethylene prices had moved out of trend in the first 3 quarters of 1981. The regressions were rerun using the ethylene values as reported for these 3 quarters and this reduced the R^2 from 0.69 to 0.50 and altered the best fit lines from slope 1.05 to slope 0.84 with an intercept 15% instead of 1.0%. On either set of data model 2 is showing a tolerably good fit.

Table 3

Seller Structures.

N = Number of Producers

	<u>LDPE</u>	<u>HDPE</u>	<u>PP</u>	<u>PVC</u>
<u>U.S.A. 1979-81</u>				
N	13	14	12	21
s	10.7	10.1	8.1	11.1
CR4 (approx)	48	50	59	44
<u>West Europe 1974-81</u>				
N	22	-	9 (1975) 18 (1980)	28
s	12.2	-	7.6- 12.7	13.7- 15.0

DISCUSSION

This section comments on some details of the parameters used in the modelling.

Occupacity. It is clear where buyer power and seller power are approximately in balance a high level of occupacity is crucial for maintaining margins at a reasonable level. Industry occupacity is difficult to establish with much precision and is often not recorded in conjunction with comparable cost and price data. In the case of the products discussed here, the general levels of occupacity and prices are well known to buyers who read the chemical trade press.

Seller Concentration s. These mature products typically have 10-30 producers in each market (W. Europe, USA) and the s values of 8-15 reflect the fact that no producers are really dominant (Table 3). In most cases, the value of s was stable to 1 unit over the time span examined. However, for polypropylene (PP) in W. Europe, the number of producers increased by 8 between 1976 and 1979 increasing s from 7.6 to 12.7. During this period margins for PP declined drastically, even though the industry occupacity was about constant at 76% and the volume was growing rapidly, about 15-20% per annum. Note that in Table 3 the West European sellers were less concentrated (higher s values) than the corresponding sellers in the USA.

Concentration of Buyers, b. From the results presented it is clear that Model 2 fits the actual results if b is taken as $b_{50} = 10$ customers taking 50% of sales value in the USA, and $b_{50} = 15$ in West Europe.

At this stage there is some uncertainty as to how b_{50} should be defined. In the PIMS data bank, b_{50} is recorded as the number of customers taking 50% of total sales for the particular business in the data base. Since the PIMS data base is biased towards businesses which have leading positions in their markets, this measure is not necessarily representative for other competitors in the same market or of the market as a whole. Alternatively b_{50} might be defined for the total market, i.e., as number of firms whose total offtake add up to 50% of total industry offtake. How would this measure relate to b_{50} as seen by a small producer? In general we can expect the largest producer to have the longest experience of manufacture, the widest range of grades and the widest spectrum of customers. His view of b_{50} may well approximate to b_{50} measured for the market as a whole. A small producer will usually have a narrower grade range and smaller customer base. His measure of b_{50} will usually be small, often substantially smaller than that of the leader. Also he is under more pressure to reduce price, because his leading customers account for a bigger percentage of his sales. The writer is

TABLE 4. Structure studies including buyer concentration - selected results

Columns	1	2	3	4	5	6	7	8
Reference		Independent Variable	Constant	Dependent Variables (Coefficients)			Model	Data
				CR ₄	BC	Other*		
Brooks, 1973		Return on Assets	5.3	0.14	-0.1	BE	Linear	20 Industry Groups, 1963
Lustgarten, 1975		PCM - $\frac{\text{Advertising}}{\text{Sales}}$	0.205	0.12	-0.111	K,D	Linear	327 Industries, 1963
McGuckin and Chen, 1976		PCM	0.2391	0.1259	-0.2634	G,K	Linear, also multiple-active examined	94 Industries 1967 selected by Shepherd
Clevinger & Campbell, 1977		Return on Assets	10.86	0.03	-0.09	BE, I/S	Linear	Brooks 1963 data updated to 1967
La France, 1980		PCM	0.141	0.179	+0.0961 -0.378 (CR ₄ x BC)	K	Linear and CR ₄ x BC	As used by Lustgarten 1975

*Other terms were BE = Barrier to entry (Advertising/Sales)

G = Growth 1958-67

K = Gross Book Value/Sales value

D = Sector dispersion of buyers

I/S = % change in year-end inventories/% change in shipments

inclined to the view that the most appropriate measure of b_{50} is one typical of the smaller producers in the industry. What are typical figures in this sort of industry? A leading producer may well have $10^2 - 10^3$ regular customers, but the real buyer power is much more concentrated. b_{50} for the leading producer appears to be in the region 25-75, while for smaller producers direct experience in the West European businesses considered here suggests that $b_{50} = 15$ is certainly a credible figure.

For the USA it has been possible to check the buyer concentration from industry sources for 1 of the 4 products and a value of $b_{50} = 10$ seems quite reasonable for most producers excluding the leaders. Hence, the values arrived at in the modelling process appear quite reasonable if b_{50} is interpreted as a rough measure for the smaller producers.

Cohesion a. The close agreement between Model 2 and Actual gross margin indicates that cohesion between sellers progressively breaks down as industry occupacity declines. The data is adequately interpreted if a is set equal to fractional industry occupacity as is Model 2. This does not imply that the industry has a rigid price setting mechanism at high occupacity - merely that producers recognise that they have broadly similar costs (albeit varying with scale/local inflation rates/local wages, etc), and are striving for comparable rewards on their investment. Where the number of producers is small it is possible for businesses to operate without drastic price cutting in periods of low occupacity, but the combination of many sellers, prolonged low occupacity and strong buyers appears likely to lead to distress margins. If the market is slow growing or has other adverse features, the industry is then likely to face a most difficult restructuring situation.

Relating this work to previous econometric studies

A number of papers have appeared since Brooks 1973 in which either Return on Assets or Price-Cost Margin has been examined across groups of industries in terms of seller concentration, buyer concentration and other variables. In all of these, seller concentration has been measured as CR4 (the combined shares of the four largest firms) and a corresponding measure for buyers (BC) arrived at by summing the CR4's of the industries supplied by the seller, weighted by the offtakes of the buying industries.

Table 4 summarises some results from these papers. There is general agreement that the effect of buyer concentration (Column 5) is of the same order of size but opposite in sign to that of seller concentration (Column 4). This much is in broad agreement with the results of this paper. Unfortunately, the econometric studies have referred only to results for single years and have not examined industry occupacity. There is little point in relating the model to the econometric studies further, because although s and b_{50} can be converted roughly to equivalent values of CR4 and of weighted

buyer concentration ratio, the econometric measures all refer to broad industry classifications, not individual businesses. While CR4 and the weighted buyer concentration ratio may approximate the actual business situation in a few cases (probably when a concentrated homogeneous industry is selling to one or two concentrated buying industries) the measure becomes more suspect when the industry classification contains several distinct sub-industries. An example is the plastics and resin classification which contains five major bulk tonnage thermoplastics and numerous speciality resins, all with their own distinct patterns of buyers, sellers and profitability behaviour.

Further Development

More complete validation of the model will require testing businesses showing a wider range of seller and buyer structures than the small group of businesses reported here. The majority of capital intensive manufacturing businesses probably have considerably fewer sellers, and unless their buyers are unusually concentrated, most businesses would be expected to approximate in behaviour to line 1 of Figure 1. Only a small proportion of businesses would be expected to show the drastic declines in margin indicated by line 3. Qualitatively, this fits common business experience. The modelling approach captures, at least for a few important businesses, the broad features of price bargaining over time as a few important structural factors change in the market-place. It could be extended in time to trace margins through the life-cycle of a business, or in position, e.g., to capture the effect of suppliers as well as buyers. b_{50} is clearly a simplistic measure which may prove inadequate over a wider range of businesses, but one can envisage adding other measures such as the importance of purchases to the customer. One interesting line of development is to use the model to ask for a given level of loss of margin ($GM / GMT =$ say 95%), and a given average level of occupancy, what are the allowed combinations of buyers and sellers. On a plot of s versus b_{50} this locates a frontier separating those businesses which have fairly stable margins from those which are or may become unstable. It will be of interest to build up the distribution of businesses as located on such a plot, and to examine their actual performance.

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Footnotes.

- 1 This refers to the 4 polymers cited above plus polystyrene. The products described in this paper would have accounted for a large proportion of these losses.
- 2 Note that b_{50} is related to the inverse Herfindahl index for buyers ($1/HB$). If $1/HB$ is measured for n equal sized buyers, then b_{50} is simply $0.5 (1/HB)$. In practice, the distribution of customer size is about geometric and b_{50} will usually be about $0.3 (1/HB)$. c.f. Buzzell 1981, page 139, finds that market shares are commonly distributed so that in size order, each value is about 0.63 times the next highest.