AVERAGE COST AND PERFECT COMPETITION PRICING: A STUDY OF THE U.S.A. PETROLEUM REFINERY INDUSTRY

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During the last few decades a great number of price models have been developed, based on both microeconomic and macroeconomic theories of price determination. In 1939 the important work of Hall and Hitch challenged the classical theory of price behavior by suggesting that business models of price determination are based on cost factors only and ignore demand conditions. This theory, known as average cost pricing, has been supported by interview studies and many empirical investigations, mainly on sector and industry level[1]. Yet, many of the above studies have shed little light on the underlying theoretical foundations on which their models were based. In many studies it is not clear whether the estimated equations test the classical competitive meachanism, the average cost theories (target return, and markup) or a model which combines both these theories (hybrid model). Furthermore the level of aggregation plays a key role in studying pricing behavior. Although many economists admit the usefulness of both economy and industry price equations, they agree that the latter in addition to studying the specific industry pricing behavior, are more appropriate in testing two hypotheses : First, the asymmetric prices and cost hypothesis, that is the hypothesis that prices and cost rise in concequence of increased demand, but do not fall when the latter declines, and second, the administered prices hypothesis (or thesis) which holds that pricing decisions are different in concentrated and nonconcentrated industries[2].

1. See Lanzilotti (1958) and Earl (1974).
2. See Earl (1974), McFetridge (1973), and Ripley (1973).

The object of this paper is to contrast the explanatory power of average cost and classical theories of price determination and to construct the most suitable structural model explaining the pricing behavior in the American petroleum refinery industry. The importance of the above industry in the U.S. economy is profound. From the market structure point of view, the main characteristic is the integration with the crude oil, transportation, and marketing of final product industries. The «majors» (about 20 firms) and some of the smaller «independents» are completely vertically integrated.

These firms account for more than 80% of total production. The industry is a loose oligopoly, with the four- and eight-firms concentration rations being 31 and 56 respectively[3]. In 1978 the capital - labor ratio was almost the highest among all the U.S. industries. The crude oil requirements per dollar of final product were almost 48% in 1972[4]. Finally, since the majors set their own prices and the other firms follow, the industry can be described as a Cartel Market[5]. The theoretical models, the specification of the models, the data, the numerical results and the conclusions are given in sections I, II, **III,** and V respectively.

I. THE THEORETICAL MODELS

a. **The** Average **Cost Model**

It is well known that there is no single oligopoly theory to explain the pricing behavior and the output, and other related decisions of large modern firms. Nevertheless, it has been observed that firms often introduce stability into their pricing setting, and that modern management places greater emphasis on long-rum decision than on short-rum adjustments, Given the above observations and the complexity of decision making, many economists have suggested that oligonolistic firms follow simple rules of thumb to bypass the difficulties associated with making their choices and achieving their goals.

Interview and empirical studies have supported the above argument. Most of these studies indicate that among these rules of thumb the average cost pri-

3. U.S. Bureau of the Census, Annual Survey of Manufacturers by Industry, Value-of-Shipment Concentration Ratios, 1972.

4. 1972, Input-Output Tables in *Survey of Current Business*, February 1979, Vol. 59.

5. See Adams (1971).

cing is the most prevalent. The Hall and Hitch (1939) study was the first interview study of actual pricing practice. They found that the majority of the businessmen interviewed stated that their pricing method consisted of adding a margin (mark-up) to standard cost to determine the price. The Lanzilotti (1958) interview study covers a large number of the biggest industrial corporations in the U.S.A. According to this study, the specific objectives of pricing decisions were : (1) pricing to achieve a target return on investment ; (2) stabilization of price and margin ; (3) pricing to realize a target market share ; and (4) pricing to meet or prevent competition. Of these objectives, most of the companies employed, as a long-rum policy, the target return on capital, yet as Lanzilotti6 says : «price making by any firm was not always ruled out by a single policy objective».

Average cost pricing can be expressed as follows [7] :

$$P = \lambda.\ AC = \lambda.\ \frac{TC}{Q} = \lambda.\ \ Q^{-1}\ \ (WL(Q) + P_m M(Q) + RK) \tag{1}$$

where λ = mark-up factor, AC = average cost, TC = total cost, Q= output, W= wages, L= labor, P_m= price of material inputs, M = material inputs, R = cost of capital, and K = capital.

We can distinguish two cases :

Case 1 : Target return on capital pricing.

In this case (1) can be rewritten as :

$$P = ULC + UMC + R^* \frac{K}{Q}$$

where λ = 1 and R = R*. the target rate of return on capital. (2)

6. (1958) p. 992.

7. See Laden (1972), p. 85.

The hypothesis that firms base their price determination on standard (normal) output and cost implies :

$$P = ULCN + UMCN + R^* . \frac{}{QN} \tag{3}$$

where QN, ULCN, UMCN are the standard output, unit labor cost and unit material cost respectively. The implications of the above method are : (1) prices are not related to the short- rum changes in output or productivity (due to changes in demand or supply conditions), (2) prices are related only to cost variables or to technological progress, and (3) the target rate of return (R) depends on market structure and long- run economic conditions of the firm (see Eckstein (1962)).

Case 2: Mark-up pricing.

Under the mark-up pricing $\lambda > 1$, and R is taken as the rental cost on capital (Laden (1972)).

$$P = \lambda. \ (ULCN + UMCN + \frac{RK}{QN} \quad \lambda > 1 \tag{4}$$

In many studies, the last factor in equation (4) is omitted on the grounds that only variable cost at standard (normal) level of operation is relevant[8]. Thus,

$$P = \lambda. \ (ULCN + UMCN), \tag{5}$$

Eckstein and Fromm[9] suggest that mark-up pricing would likely be applied

8. See Challen (1978), Dalton (1973), Eckstein and Fromm (1968) and Schultze (1963). This specification is consistent for the purpose of short-run pricing where the unit capital cost is constant and firms can igronre its changes. However, for the purpose of a longer-run analysis the rental cost of capital should be included in the equation as an explanatory variable.

9. (1968), p. 1166.

to consumer oriented or technology intensive goods or generally in industries which produce a diversity of heterogeneous products. In capital intensive industries or industries producing stadardized products (like petroleum refining and steel) target return is the more appropriate pricing method.

Is average cost pricing consistent with profit maximization ? There is a great dispute about this question[10], but most studies agree that firms do maximize profits, at least in the long- run, by using the average cost pricing method as an aproximation of the profit maximization goal[11].

b. The Classical Model

Assuming a competitive commodity market, the classical model interprets the short-run changes in the price level from the differences between demand and supply. The clearing market mechanism is the crucial assumption on which this theory is based. Excess demand causes price increases, while excess supply causes price decreases. Furthermore, following Eckstein and Wyss (1972), we can expand the above relation to include the effect of the equilibrium price (P^e) itself on the market price, that is :

$$P = f\ (ED,\ Pe) \qquad f_{1,} \qquad f_2 > 0 \qquad (6)$$

where a variable with a dot above it denotes percentage changes and $f_{1,}$ f_2 the partial derivatives with respect to ED and P^e respectively.

The disequilibrium in the market between demand and supply can be estimated by different measures of excess demand such as the deviations of the actual and desired finished goods inventory, where this measure can be taken either in absolute terms or relative to production. On the other hand, the equilibrium price depends on labor (ULC) and material cost (UMC), in other words :

$$Pe = g\ (ULC,\ UMC) \qquad (7)$$

We can then write (6) as :

10. See Adelman (1973), Anthony (1973) and Tarshis (1973).

$$P = f\ (ED,\ g\ (ULC,\ UMC)\ ) \tag{8}$$

II. THE SPECIFICATION OF THE MODEL

On the basis of the models described we have attempted to formulate price equations which can be estimated. The final forms of these equations are given in accordance with the theoretical models already developed. Equation (3) which expresses the target-return-on-capital pricing, can be rewritten as :

$$P = a_0 + \alpha_1 ULCN + a_2 PM + a_3 R + u, \qquad a_{1,} \qquad a_2 > 0, \quad a_3 < 0, \tag{9}$$

where the ULCN depends upon industry wage (W) and time (T), reflecting capital augmented technological progress, and can be estimated by :

$$ULCN = \exp(1nCo + C_1 1nW - C_2 T),$$

PM is the actual price of crude oil representing material cost. R is the ratio of after tax profits to equity[12], corrected for the short-run variations in output, by capacity utilization. The expected sign of the latter is negative since firms raise prices when the rate of return decreases.

The explicit form of equation (5) is given as :

$$P = \beta o + \beta_1 \qquad ULCN + \beta_2 PM + v, \qquad \beta_{1,} \qquad \beta_2 > 0 \tag{10}$$

where the coefficients β_1 and β_2 reflect the effect of unit labor cost and unit material cost on the price level through the mark-up factor. Under the hypothesis that λ is a variable, equation (5) can be reformulated as follows :

$$P^* = \lambda. \qquad (ULCN + PM) + \varepsilon \tag{11}$$

12.In the pure target model, P=f(R*t-Rt-i),f')0and i=1, 2 ..., π Specifically, $\dot{p} \gtreqless 0$ when $(R^*_t - R_{t-1}) \gtreqless 0$. The R*t in unobservable, if however we assume that R* is gererated by the mean of R=E(R), then E(R) will appear in the regression as a constant term and Rt-j will take on a negative sign. In the above model the dependent variable P is expressed in levels. In that sense, equations 3 and 9 are misspecified. See also Eckstein and Wyss (1972), p. 138.

where P^* = the desired price level for period t. Assuming that λ depends upon market conditions (ED), and that P^* is adjusted to its actual level P by a partial adjustment formula, we can then write :

$$\lambda = a_0 + a_1 \quad ED \qquad\qquad a_1 > 0 \qquad (12)$$

$$P - P_{-1} = \Theta(P^* - P_{-1}) \qquad\qquad 0 > \theta > 1 \qquad (13)$$

Substituting (12) and (13) into (11) and solving for P we get :

$$P = \theta a_0 \ ULCN + \theta a_0 PM + \theta a_1 \ ED.ULCN + \theta a_1 \ ED.\ PM + (1 -)\ P_{-1} + \theta\varepsilon \qquad (14)$$

Without imposing any restrictions on the coefficients of equation (14) we get :

$$P = \gamma_1 \ ULCN + \gamma_2 \ PM + \gamma_3 \ (ED.\ ULCN) + \gamma_4 \ (ED.PM) + \gamma_5 \ P_{-1} + e \qquad (15)$$

The above equations describe the price formation in static terms, that is focusing on price levels. The next step is to take percentage rates. Taking the total differential of equation (6) with respect to time we finally obtain :

$$\dot{P} = \delta_1 \ \dot{ULCN} + \delta_2 \dot{PM} + \dot{\lambda} \qquad 16))$$

We allow $\dot{\lambda}$ to be subject to the influence of the market conditions in accordance with[13],

$$\dot{\lambda} = b_1 \, ED + e, \qquad\qquad b_1 > 0 \qquad (17)$$

by substituting (17) in (18) and assuming a partial adjustment scheme for P, we get :

$$P = \delta_1 ULCN + \delta_2 \ PM + \delta_3 \ P_{-1} + \delta_4, \ ED + e \qquad (18)$$

13. We assume here that we adopt such measures of ED that satisfy both (12) and (17).

As a measure of the excess demand variable we used the deviations between the actual and desired finished goods inventory either in absolute terms (I-IN), or relative to production (IQ-IQN)[14]. The justification for preferring these variables is that the refinery industry produces mainly to stock rather than to order. The long-run trend of the actual inventories is used in turn to derive the variable representing the desired inventories (IN or IQN). We also experimented with the capacity utilization ratio.

The asymmetric price hypothesis is tested by saparating the demand variable (I-IN) into excess $(I\text{-}IN)^P$ and deficient $(I\text{-}IN)^N$ demand.

$$(I - IN) = \begin{cases} (I - IN)^P & \text{if } (I\text{-}IN) \geq 0 \\ 0 & \text{otherwise} \end{cases} \qquad (a)$$

$$(I - IN) = \begin{cases} (I - IN)^N & \text{if } (I\text{-}IN) < 0 \\ 0 & \text{otherwise} \end{cases} \qquad \textbf{(b)}$$

The inclusion of excess demand variables in the mark-up equations leads us to model where both cost and excess demand influence the price. Thus in this study and in many others, the mark-up and classical models include the same variables. The question which then arises is whether we can find a possible distinction between these two models, to explain the relationship between prices, and cost and demand factors. A model by Laden (1972) indicates that at high levels of output relative to capacity, an increase in the money income of demanders and in the capital stock, in the mark-up model can lower and raise prices respectively, while in the classical model the same variables give the opposite implications. In the case where capital stock is not included in the price equation, a highly significant long-run variable, like the cost of capital or the standard unit labor and unit material costs, would provide strong evidence in favor of the average cost-oligopolistic model. On the ether hand, estimates of excess demand are the short-rum variables in the latter model. As the industry becomes more competitive, the importance of equilibrium forces, that is actual factor prices, should increase in the regression, (see Eckstein and Wyss (1972)). However,

14. The expected sign of these variables is of course negative.

there is not always a clear-cut distinction between these types of pricing behavior, since market structure (like vertical integration and joint production in the present case) and other conditions influence the relative importance of the above variables in industry price - equations. In our model such a condition is the extensive complex regulation of the crude oil and the oil products markets in the United States during the period under consideration. Refiners were subject to : (1) controls on the crude pil imports, (2) regulations which control their transfer prices when they import oil from their foreign sources, and (3) a system of «entitlements» which ensures : (a) access to supplies of crude, and (b) access to low-priced domestic oil. Certain refined products such as home-heating oil, petrol jet and propane were subject to special regulations aimed at ensuring a non-discriminatory pricing to all-segments of the market. These regulations may be regarded as restoring in some extent competition among the refiners. The question which then arises is whether regulation would bias either the cost data in favored of average cost or the refined products prices in favored of competitive pricing. Two points should be mentioned before ansuering this question. First, under the «entitlements» system the input price of comparable quality is approximately the same for all barrels and all refiners. In effect, industry marginal cost becomes average cost. Second, the main refined product, gasoline which amounts for about half of refinery output was not under control and its price was determined by competition among producers. Hence, refined products price determination was affected by both pricing policies. Furthermore, regulation of crude oil prices didn't contribute appreciably to a decrease in refined products prices relatively to world prices, as someone would expect, enabling producers to preserve their rate of return or even to make windfall profits. Thus, a target rate of return pricing policy should also be expected.

III. THE DATA

All the equations are estimated from quarterly, seasonally adjusted data for the period 1970 (I) to 1978 (IV). All the variables are in the form of indexes (1970 = 100), the only exception being the profit - equity ratio. As a dependent variable we experimented with both the four digit (SIC2911) «Producer Price Index» and the petroleum refined products (according to group classification) «Wholesale Price Index». They are published in the monthly publication «Producer's Prices and Price Indexes» of the Bureau of Labor Statistics (BLS). The reason for this experimentation is that for the period December 1973 to June 1976, there was no published data for the first index. We filled the gap by using the percentage changes of the second index. In order to construct the material price variable, we used two Indexes :

1. The Price Index of the domestically produced crude oil, published in the «Survey of Current Business» (SCB) by the U.S. Department of Commerce, and
2. The export Price Index of Saudi Arabia Crude Oil published in the «U.N. Monthly Bulletin of Statistics», representing the prices of the crude oil imported into the U.S.A.

The material price index, in turn, was derived as a weighted average of the first two indexes ; the rations of domestically produced and imported oil to the total supply of crude oil being the relative weights.

The ULC variable was derived from :

$$ULC = \frac{W.\ HW.\ NE}{Q}$$

Where :

W = hourly wage earnings

HW = hours of work

NE = number of employed workers

Q = industrial production

The four-digit data for W, HW, NE were obtained from the BLS monthly publication «Employment and Earnings.» The Q index is from SCB. From the «Manufacturer's Shipments, Inventories, and Orders» by the U.S. Department of Commerce, Bureau of the Census, but from two digit data we obtained the inventory variable. The net profit after taxes to equity ratio (for two digit industry) is available in the «Financial Reports for Manufacturing Corporations», by the Federal Trade and Security Exchange Commission. Finally, the capacity utilization index was derived by using two different definitions : (1) the Refinery Operating Ratio % of capacity, published in SCB, and (2) the index of industrial production following the «Peak to Peak Interpolation» procedure of the T.S.P. program.

IV. NUMERICAL RESULTS

In this section the best price equations[1s] were selected using the usual criteria, i.e., significant coefficients, correctness of sign, goodness of fit based on the value of R^2, significance of D.W. and statistics, and standard error of the regression (S E). The estimated equations explain : (a) price levels, (b) the rate of change in prices during the year (four quarter interval), and (c) quarter-to-quarter relative change in prices. As independent variable we used the petroleum refined products «Wholesale Price Index», since the performance of most of the equations with this variable proved superior to that of the SIC 2911 «Producer's Price Index». The hypothesis that firms base their pricing decisions on standard unit labor cost was rejected, since in almost every equation, this variable appeared with a wrong sign, insignificant, or with unrealistically large coefficients. As a result, we replaced the ULCN with the ULC (actual). Nevertheless, with only one exception, namely the target return model in price levels, the estimates of this variable appear to be not significant, adding almost nothing to the total variation in prices.[16]. On the contrary, the crude oil prices are always significant and explain most of the variation in prices.[17] Of the several demand variables, the CU variable appeared to be insignificant, sometimes taking on the wrong sign ; therefore results with this variable are not reported. The other demand variables were all highly significant and with the expected sign, explaining almost 50 percent of the remaining variation after the cost variables are included.

Table 1 contains equations in price levels, after examining a number of alternative lag structures[18]. The R^2 is high but autocorrelation is present. The inclusion of the lagged price variable as an argument in the estimated equations when both cost and demand variables are included increased the values of R^2 and DW statistics and have significant estimates varying from 553 to 636, suggesting that

15. All estimations were performed by the Least Squares Method using the Time Series Processor (TSP) program. Whenever autocorrelation was present, the Cochrane-Orcutt technique was used to estimate the parameters of the equations.

16. We are not surprised at theee results since the share of wages in the value of output appears to be very smal (<.100).

17. The adjustment period for this variable is quite short (current value or one quarter lag). In addition, its short-rum coefficient is considerably lower than its full adjustment value, which for the sample period is about .50 (see 1972 Input-Output Tables).

18. The inclusion of an incorrectly lagged variable in an equation is considered as a misspecification error since it is equivalent to the omission of a relevant explanatory variable and the inclusion of one that is irrelevant (see Challen, 1978).

TABLE 1

PRICE EQUATIONS IN LEVELS

Equation Number	Intercept	ULC	PM	I_{-1}	IQ_{-1}	$ULC(I-IN_1)$	$PM(I-IN_1)$	$ULC(IQ-IQN_1)$	$PM(IQ-IQN_1)$	R	P_{-1}	R^2	DW	ρ	SE
1	255.9 (3.209)	.158 (.530)	.182 (3.146)									.989	.856	.972	9.3
2	210.9 (2.292)	.131 (.447)	.177 (3.126)								.130 (1.498)	.990	.917	.975	9.2
3	74.5 (3.429)	.162 (.754)	.121 (2.647)	-.650 (-5.592)							.630 (7.186)	.994	1.430	.669	7.1
4	77.4 (3.461)	.076 (.342)	.123 (2.656)		.027 (-5.390)						.636 (7.088)	.994	1.414	.659	7.2
5	119.8 (1.921)	-.167 (-.0607)	.100 (1.826)			.0130 (3.999)	-.0073 (-3.128)				.544 (4.463)	.993	1.337	.962	7.5
6	83.[illegible] (1.629)	.099 (.387)	.112 (2.319)					.0135 (4.609)	-.0076 (3.593)		.553 (4.803)	.994	1.426	.949	7.2
7	-29.3 (-1.260)	.476 (1.877)	.154 (3.042)							2.671 (4.323)	.458 (5.476)	.984	1.072		11.8
8	.481 (.019)	.281 (.974)	.195 (3.452)							R_{-1} 1.016 (1.746)	.483 (4.377)	.989	1.030	.544	9.7

NOTE : *Figures in parentheses are t-statistics. The hypothesis tested is* H_0:β=0 as against the alternative H_1:β≠0.

The DW statistic is not applicable in equations which include P_{-1} as an explanatory variable. So it serves only as an indication of existence of autocorrelation.

the current price level is affected by earlier adjustments of demand (mainly) and cost variables. The hypothesis that the mark-up factor is a variable is tested by equations (5) and (6). The coefficient of the Crude Oil Prices decreases and the interaction variables are highly significant, but the ULC. $(I-IN_{-1})$, or the ULC. (IQ-IQN-!) appeared with the wrong sign (positive).

In view of the fact that the ULC variable alone is insignificant and with the wrong sign, our main interest lies with the interaction variable PM.$(I - IN_{-1})$. The coefficient of the latter variable suggests rejection of the hypothesis that $a_1 = 0$ in equation (12). Thus a decrease in the difference between actual and desired inventories (or IQ) results in an increase in the mark-up[19], which in turn increases prices.

By testing the hypothesis based on the target return pricing, in a price levels nodel, wo obtain equations (7) and (8). All the regressors are significant, but the target return variable has a positive coefficient[20].

Finally, the inclusion of the demand variable in an additive form gave significant coefficients with the expected sign[21].

The second set of equations (Table 2) explains the rate of change in prices during the year. The overall performance of these equations is slightly better than that of equations in price levels, even though autocorrelation is still present and the lagged dependent variable plays a significant role in explaining price changes. All the demand variables enter with an expected negative sign and are higlysignificant. For example, the sign of the demand variable in equation (6) suggets that an increase in the difference between the actual and the desired inventory- output ratio results in reducing excess demand, which in turn decreases prices. Equations (8) - (10), which include the profit rate give inconclusive results about the sign of this variable. In equation (8) the current value of profit rate has a positive sign, while in equations (9) and (10) the two and four quarters, respectively, lagged values have a negative sign. Although equation (8) is slightly better than (10), we believe that R_{-4} is the relevant long-run explanatory variable in the target return mo-

19. We refer to the short-run effects. Since the lagged dependent variable is included in the equation, the long-run effects are given by the steady-state equilibrium conditions of the model.

20. We should keep in mind, however, that this form of equation is not the adequate representation of the target return pricing behavior (see also footnote 12 of this paper).

21. The reestimation of equations (3) and (4) with I and IQ in a distributed lafg form (using the Almon technique) showed that prices adjust with a lag of about five quarters to changes in demand conditions.

TABLE 2

PRICE EQUATIONS: RATE OF CHANGE DURING THE YEAR

Equation Number	Intercept	$\dot{ULC}$	$\dot{PM}$	I	$I-IN_{-1}$	IQ	IQN_{-1}	$IQ-IQN_{-1}$	R	$\dot{P}_{-1}$	$\bar{R}^2$	D.W	ρ	SE
1	.813 .784	.0769 (.280)	.311 (3.813)								.855	.937	.836	.091
2		.050 (.278)	.283 (5.277)							.581 (6.505)	.939	1.576	.727	.059
3	.708 (2.496)	.113 (.682)	.198 (3.354)	-.010 (-2.645)						.616 (6.828)	.950	1.562	.846	.055
4		.106 (.642)	.199 (3.267)		-.0089 (-2.369)					.591 (6.851)	.948	1.441	.817	.055
5	.703 (3.625)	.266 (4.773)	.205 (4.310)			-.013 (-4.310)				.613 (7.693)	.961	1.757	.888	.049
6	[illegible]	.235 (1.520)	.201 (3.967)					.011 (-3.539)		.576 (7.130)	.957	1.488	.859	.050
7	[illegible]	.262 (1.651)	.202 (3.945)			-.012 (-3.593)	.011 (3.297)			.593 (7.169)	.958	1.513	.843	.051
8	-.262 (-3.780)	-.078 (-.519)	.143 (2.661)						.022 (4.300)	.538 (7.120)	.964	1.805	.758	.047
9	.107 (1.341)	.046 (.254)	.281 (5.328)						R_{-2} -.011 (1.803)	.737 (6.116)	.946	1.450	.710	.058
10	.130 (1.968)	-.032 (-.174)	.277 (5.450)						R_{-4} -.010 (-2.479)	.628 (7.510)	.950	1.500	.617	.056

NOTE : See note to Table 1.

del. Out results are consistent with the findings of Eckstein and Wyss (1970) but disagree with Earl's (1974) study, which accepts the positive sign of this variable.

Table 3 contains equations in quarter-to-quarter changes. A positive feature of these equations is that most of them are free of autocorrelation, the standard error is smaller and the magnitude of the coefficient of the lagged dependent variable has substantially declined relative to that in the first two specifications.

On the contrary, all the variables except the PM, are charactirized by «low signal to noise» effects on price changes, while not all the demand variables are significant[22]. Thus, the $(IQ\text{-}IQN_{-1})$ variable appears to be insignificant in this set of equations. Equation (3), which includes the first difference in actual inventories (I-I-i) as the relevant demand variable, is the best among those equations which include both the cost and demand factors. Of particular interest in Table 3 is the R variable. The results of estimating three alternative target return equations indicate that in the best equation (10) the most significant variable is lagged four periods and takes on a negative sign[23]. Two observations are evident : First, firms raise prices as a result of the long- run rate of return decrease. Second, the target return model is quite relevant in this industry despite the suggestion of Eckstein and Wyss (1972) that this model is applicable to highly concentrated industries only.

These results are consistent with the existing body of evidence which stresses the importance of the target return in explaining long-run price changes. The actual ULC and PM and in some cases demand conditions are the short-rum relevant explanatory variables.

The asymmetric hypothesis is tested by the following equation in quarter-to quarter changes :

$$P = .108\ ULC + .210\ PM - .0004\ (I\text{-}IN_{-1})^{P}\ -.0078\ (I\text{-}IN_{-1})^{N} + .144P_{-1}$$
$$(.090 \qquad (3.455) \quad (-.139) \qquad (-3.066) \qquad (4.563)$$

22. However, when the demand variable is included, te long-run effect of the PM variable on price changes is in general lower in these equations than in changes-during-the gear equation, where the long-run effect is close to the full adjustment value (.500).

23. As we can see in equations (8) and (10) in Tables 2 and 3 respecti vely the constant term is always positive and significant reflecting the presence of the R* variable (see footnote 12).

TABLE 3

PRICE EQUATIONS IN QUARTER-TO-QUARTER CHANGES

Equation Number	Intercept	$\dot{ULC}$	$\dot{PM}$	I	$I-I_{-1}$	IN_{-1}	$I-IN_{-1}$	IQ	IQN_{-1}	$IQ-IQN_{-1}$	R	$\dot{P}_{-1}$	$\bar{R}^2$	D.W	ρ	S.E
1	.024 (1.311)	.017 (.111)	.264 (3.817)										.615	1.562	.586	.041
2	.002 (.244)	-.014 (-.092)	.318 (5.177)									.486 (4.275)	.734	1.873	.235	.039
3	-.001 (-.150)	-.011 (-.082)	.259 (4.708)		-.[illegible]58 (-3.[illegible])							.539 (5.406)	.811	1.918	.266	.039
4		.068 (.346)	.247 (3.930)				-.0037 (-2.064)					.294 (2.205)	.748	1.771	.574	.034
5		.056 (.424)	.244 (3.693)	-.034 (-1.915)		.0035 (1.945)						.284 (1.978)	.750	1.753	.535	.035
6		.064 (.449)	.280 (4.397)							-.0[illegible]1 (-1.[illegible])		.371 (2.825)	.746	1.779	.357	.034
7		.059 (.402)	.278 (4.189)					-.0021 (-1.281)	.0021 (1.300)			.364 (2.583)	.746	1.778	.357	.035
8	-.060 (-1.731)	-.056 (-.391)	.286 (4.807)								.0053 (1.918)	.298 (2.153)	.764	1.797	.377	.034
9	.389 (1.383)	.023 (.147)	.306 (5.008)								R_{-2} -.0029 (-1.393)	.533 (4.597)	.752	1.851	.229	.035
10	.051 (2.008)	-.026 (-.169)	.343 (5.896)								R_{-4} -.0037 (-2.067)	.465 (4.440)	.770	1.846	.159	.033

NOTE: See note to Table 1.

$R2 = .774$ $DW = 1.674$, $S.E. = .033$ $P = 672$

The hypothesis Ho which we test is that there is no statistically significant difference between the coefficients of the positive and negative deviations from the desired inventory. If we accept the above hypothesis as true, then we should reject the asymmetry hypothesis. The t-test[24] which we applied results in the acceptance of the asymmetry demand hypothesis at five percent level of significance.

V. CONCLUSIONS

The general conclusions relating to the models of price determination for the petroleum refinery industry during the period 1970- 1978 are as follows.:

1. Despite the deficiencies in explaining small variations in prices, the quarter-to-quarter percentage change equations seem to be superior to the other two forms of equations.

2. For the particular industry which we studied, our results suggest that in both the short and long- run, pricing decisions are affected by both material cost and demand conditions. If in addition we take into account the fact that our dependent variable represents quoted prices and not transaction prices, we should consider the effects of demand variables on prices as downward biaded.

3. The strong rise of material cost was clearly an important contributing factor to the rise in the wholesale price index. Thus, a 10 per cent in crude oil prices will increase the wholesale prices of the final products by an average 2.5 per cent in the short-run and 5.5 per cent in the long-run.

4. There is strong evidence that the target return model is quite a relevant long-run hypothesis explaining pricing decisions in the petroleum refi-

24. The appropriate t-test is given by:

$$\frac{\delta 4^{P} - \delta 4^{N}}{SE(\delta 4^{P} - \delta 4^{N})}$$

where $\delta 4^{P}$ and $\delta 4^{N}$ are the coefficients of the positive and negative deviations in equation 18.

hery industry, despite the deficiencies associated with thé variable Used. Thus, price movements in this industry can be explained by both the competitive and average cost models, with the latter appearing to have somehow superior explanatory power than the former.

5. In the American petroleum refinery industry there appears to be asymmetry response of price changes to demand conditions.

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