Faculty Working Papers

ALTERNATIVE SWITCHING REGRESSION TECHNIQUES FOR DETECTING STRUCTURAL CHANGES: AN APPLICATION TO THE COMMON STOCK RETURNS OF MERGING FIRMS

C. F. Lee, R. A. Shick and F. C. Jen

#391

College of Commerce and Business Administration
University of Illinois at Urbana-Champaign

FACULTY WORKING PAPERS

College of Commerce and Business Administration

University of Illinois at Urbana-Champaign

March 28, 1977

ALTERNATIVE SWITCHING REGRESSION TECHNIQUES FOR DETECTING STRUCTURAL CHANGES: AN APPLICATION TO THE COMMON STOCK RETURNS OF MERGING FIRMS

C. F. Lee, R. A. Shick and F. C. Jen

#391

Alternative Switching Regression Techniques for Detecting Structural Changes: An Application to the Common Stock Returns of Merging Firms

by

C. F. Lee
Associate Professor of Finance
The University of Illinois at Champaign-Urbana

R. A. Shick
Associate Professor of Finance
Saint Bonaventure University

and

F. C. Jen
M & T Professor of Banking and Finance
SUNY at Buffalo

SUMMARY

The main purpose of this study is to show that several alternative switching regression methods can be used to detect the structural change of financial relationship. Common stock returns of thirty-four merger firms are used as a case study. It is found that there exist some impacts of corporate merger on individual firm's Jensen performance measure and systematic risk.

I. Introduction

The residual analysis technique for detecting structural shifts in a regression relationship produced by financial events has recently been very popular. Using the market model, Fama, Fisher, Jensen and Roll [FFJR] (1969) applied residual analysis to investigate the impacts of stock splits. [illegible]pern (1973) employed the same technique to measure the gains from mergers and Boness, Chen and Jatusipitak (1974) used the approach to test for the impact of a financial structure change on stock.

The main purpose of this paper is to demonstrate and to compare the usefulness of alternative approaches for detecting structural changes using switching regression methods. Common stock returns of thirty-four merging firms will be used as a case study. In the second section, several switching regression methods will be reviewed with emphasis on their basic assumptions and testing techniques. In the third section, the basic hypothesis and procedure for investigating merger premiums will be presented. It will be [illegible] associated with [illegible] [illegible] [illegible] to test [illegible] [illegible] show that the [illegible] more information th[illegible] [illegible] fied [illegible], dummy variable [illegible] sources of structural shi[illegible] sixth section, results [of] this paper will [illegible]

II. Methods of [illegible] with [illegible] Regression

Anscombe (1961) [illegible] [illegible] desirability and the procedures for examining [illegible] regression model to detect

departures from a regression specification. Let ε_t denote the ordinary least-squares (OLS) residual. A natural first step to detect an abrupt and substantial change in regression slope is to plot ε_t as a function of t. Experience shows, however, that this is not a very effective method of detecting changes which are small and gradual. To improve the effectiveness of residual analysis in detecting structural change, Page (1954), Barnard (1959) and others have suggested that cumulative sum (Cusum) technique be substituted for individual residual analysis. Instead of plotting the individual ε_t, the Cusums $\left[\varepsilon_r = \frac{1}{S} \sum_{1}^{T} \varepsilon_t \quad (r = 1, \ldots, T)\right]$ should be plotted, where the cumulative residuals have divided by the estimated standard deviation (S) to eliminate the irrelevant scale factor.[1] Mehr and McFadden (1965) and Brown and Durbin (1968) have pointed out, however, that the cumulative sum techniques does not produce an objective method of assessing structural change since its covariance $E(\varepsilon_r \varepsilon_s)$ does not reduce to a form that is manageable by standard Gaussian-process techniques. To avoid this kind of difficulty, Brown and Durbin (1968) have proposed a recursive residual method. In addition to Brown and Durbin's recursive residual method, three other principal methods, i.e., Quandt's (1958), Farley and Hinich's (1970) and Chow's (1960) methods can also be used to detect shifts in regression parameters.

Since the capital asset pricing model (CAPM) will use to investigate the effects of mergers on regression structure, the shifting regression techniques will be discussed in the context of the simple regression specification.

The CAPM can be defined as

$$R_{jt} = \alpha_j + \beta_j R_{mt} + U_{jt} \tag{1}$$

where

R_j = the excess rate of return on j^{th} security,

---

1) Both FFJR (1969) and Halpern (1973) did not take this factor into account.

R_m = the excess market rate of return,

both α_j and β_j are regression parameters, U_j is the residual term.

Following Quandt (1958), the basic model of switching regression for the CAPM is defined as:

$$\text{(a)}\quad Rj_{t1} = \alpha_1 + \beta_1 Rm_{t1} + U_{1t} \qquad t \in I_1$$

$$\text{(b)}\quad Rj_{t2} = \alpha_2 + \beta_2 Rm_{t2} + U_{2t} \qquad t \in I_2 \tag{2}$$

where I_1 and I_2 are used to identify the two different regimes of a regression, U_{1t} and U_{2t} are error terms to be distributed as $N(0, \sigma_1^2)$ and $N(0, \sigma_2^2)$ and finally α_1, α_2, β_1, and β_2 are regression coefficients. Switching regression methods are designed to test whether $(\beta_1\ \sigma_1^2)$ is significantly different from $(\beta_2\ \sigma_2^2)$.

To test for shifts Quandt (1958, 1960) proposed that two regimes be estimated by first maximizing a likelihood function conditional on the shift date, t*. After the t* is estimated, the likelihood ratio method is used to test whether the shift is statistically significant. Farley and Hinich (1970) and Farley, Hinich and McGuire (1975) [FHM] devised an alternative specification based upon the assumption that the unknown switching point is equally likely to have occurred at each value of t. In addition, Chow's (1960) test and the modified dummy variable approach can also be used to detect whether a structure of [illegible] has significantly changed over time.

Based on finite sample comparisons, FHM have found that the relative power of the likelihood ratio test, the Chow test and the Farley and Hinich test are dependent upon the location of shift. In general, the Chow test and Farley and Hinich tests are more powerful in detecting a shift located near the middle of the series, where the likelihood ratio test is more powerful when the shift is located at the beginning or the end of the series.

Therefore, these three methods are all to be used to detect the structural change associated with the merger. Since FHN have shown that Brown and Durbin's test statistic is inconsistent, this method will not be explored in the empirical section. Finally, a new technique of integrating Quandt's technique with Gujarati (1970) dummy variable technique is used to test the possible shifts of Jensen's performance measure and systematic risk simultaneously.

III. Basic Hypotheses and Procedures for Investigating Merger Premiums

Where a firm is in equilibrium, the Capital Asset Pricing Model says that its returns will be generated according to equation (1). A merger can disturb the equilibrium state, however, in a number of ways. If the merger generates benefits from factors such as economies of scale, then α_j will rise. Alternatively if mergers are regarded by investors as risky events, then β_j will increase.

To express these possible changes, define from equation (1) the average return on the merging firms stock before the merger as

$$\bar{R}_{j1} = \alpha_1 + \beta_1 \bar{R}_{m1} \qquad (3)$$

where $\bar{R}_{j1}$ and $\bar{R}_{m1}$ are average rates of return over a number of months. Similarly define the average return over the post merger period as

$$\bar{R}_{j2} = \alpha_2 + \beta_2 \bar{R}_m \qquad (4)$$

assuming for simplicity that the average market return remains unchanged.

Merger changes can be obtained by subtracting equation (4) from equation (3) producing

$$\bar{R}_{j2} - \bar{R}_{j1} = (\alpha_2 - \alpha_1) + (\beta_2 - \beta_1)\bar{R}_m \qquad (5)$$

Equation (5) implies that merger changes are structural ones. To determine the changes in α and β, we should first test whether a structural change

has occurred as a result of the merger. Furthermore, we should identify the exact date of structural change. As the announcement date of merger is not necessary the date of structural shift, the shifting date will be estimated by Quandt's switching regression method and a modified dummy variable method. In addition to these two methods, Chow's test, FHN's test and the traditional t test will be used to detect structural changes.

IV. Some Empirical Results

A sample of 34 merging firms was selected for the analysis. To be included, each firm had to have acquired another with total assets equal to at least 10% of its assets at the date of acquisition, and must not have had another merger meeting this criteria for a minimum of two years before or after the merger. The purpose of these criteria was to provide a clearer picture by focusing the analysis on a single acquisition and removing any effects of other mergers.

Monthly closing prices and dividend data were collected for each firm. Based on the above criteria the minimum number of prices collected was 54. The maximum number was set at 84 or seven years.

Monthly rates of return were then calculated as

$$r_t = \ln\left(\frac{P_t - P_{t-1} + D_t}{P_{t-1}}\right)$$

where

r_t = continuously compounded rate of return for month t

P_t = closing price for month t

P_{t-1} = closing price for previous month

D_t = amount of dividends per share if the stock went exdividend during the month

Since one observation is lost in calculating monthly returns, the data sets for each firm ranged from 53 to 83 observations. If a firm has less than 83 observations it is because another merger or similar significant financial event limited the data.

Following FFJR average residuals were computed as:[2)]

$$\bar{U}_t = \sum_{j=1}^{34} \frac{U_{jt}}{34} \qquad (6)$$

where 34 is the number of firms. Residuals were first calculated on the basis of one regression fitted to the approximately 81 monthly rates of return spanning the announcement and consummation of the merger. These residuals are plotted in Exhibit I, where time 0 is the month of the merger announcement. Looking at the preannouncement period, an unusual number of positive residuals occurs from either 15 months before announcement or 5 months before announcement. Since the latter was more reasonable, we denoted 5 months before the merger as the beginning of the period of positive residuals. The positive pattern continued with four exceptions until about 15 months after the merger. Therefore, the 21 month span (5 pre, month of announcement and 15 post) was excluded from the data for further analysis. In addition to the pattern of residual analysis, we also looked at the ratio of the number of positive residuals to the total number of residuals. As shown in Exhibit II, this again confirms the 21 month span identified in Exhibit I.

With this information we then reestimated the CAPM on the data excluding the 21 months and calculated FFJR's cumulative average residuals. These cumulative residuals are shown in Exhibit III and follow the pattern which FFJR found for splits. In this case we only plotted 25 months before and

---

2) U_{jt} is the ordinary least squares residual of the CAPM.

after the announcement. Another interesting observation about Exhibit III is the negative residuals occurring from about 1 to 2 years before the announcement. This could be a motive for the merger consistent with Weston and Mansinghka (1971) hypothesis that firms merge because of poor performance.

FFJR's average residual analysis can only show the possible impact of merger activity in the aggregate. To investigate the impact of a merger for an individual firm, some other alternatives should be used. Furthermore, FFJR's method also is subject to the weakness of residual analysis technique as indicated in section II.

To analyze the individual firms for merger activity effects several alternative switching regression techniques are used to estimate the switching point and to test for the existence of structural shift. Quandt's (1958) likelihood ratio method is first used to identify the switching points for thirty-four firms. The number of observations and the switching points for each firm are indicated in Table I. The switching point divides the whole observation horizon into two regimes as indicated in equation (2). If $\hat{\sigma}$, $\hat{\sigma}_1$ and $\hat{\sigma}_2$ represent the standard error of estimates for over-all regression, first regime and second regime respectively, then the significance of shifting point can be tested by:

$$\lambda = -2\left[(t)\ \log \hat{\sigma}_1 + (T-t)\ \log \hat{\sigma}_2^{T-t} - T\ \log \sigma\right] \tag{7}$$

where t and T represent number of observations for first regime and over-all period respectively. The λ's for thirty-four firms are listed in column (a) of Table II. Following Quandt (1958), λ is a Chi-square distribution with four degrees of freedom. The Chi-square tests show significant shifts in four firms, i.e., Hooker Chemical Co., Pacific Power and Light, Kennecott Copper and J. P. Stevens Co., Inc.

FHN have shown that Quandt's likelihood ratio test does not dominate either Chow's test or Farley-Hinich's test. Moreover the likelihood ratio test has moderately more power at the ends of the records, and moderately less in the middle. Consequently, both Chow's test and Farley-Hinich's test also are used to test the structural shift associated with merger activity. For Chow's (1960) test, the data for each firm is divided into two equal regimes. Three regressions are estimated one for the over-all data and two for the sub-group data. The three sets of residuals associated with these regressions are used to perform an F test to determine whether a structure shift exists in the middle of the data. F values for the thirty-four firms are listed in column (b) of Table II. The F test shows that there are only three firms (Celanese Corp., Stauffer Chemical Co. and Wallace-Murray Corp.) with significant shifts.

Farley-Hinich's test can be performed by introducing an additional term to equation (2) as:

$$R_{jt} = \alpha + \beta R_{mt} + \gamma z_t + U_t' \qquad (8)$$

where $z_t = tR_{mt}$ and $t = \frac{1}{n}, \frac{2}{n}, \ldots, 1$. α, β and γ are regression parameters and U_t' is error term.

Student t values for z_t for the thirty-four firms are calculated and listed in column (c) of Table II. The t test shows that four firms (Celanese Corp., Barber-Greene, Koehring Co. and Wallace-Murray Corp.) exhibit significant shifts. From Quandt's test, Chow's test and Farley-Hinich's test, it can be concluded that nine firms have possible structural shifts. This implies that the switching regression methods can be used to detect the impact of mergers on individual firms. This information was not available when the FFJR's average residual analysis was used to measure the aggregated impact of merger activity. Since the micro information is of importance to

financial management, the switching regression techniques should also be used to test for structural changes in financial studies.

Finally to investigate the actual parameter shifts, three regressions (one for the over-all period and two for the subperiods) are estimated for each firm. The subperiods were determined by the switching analysis above. Results of the estimated α and estimated β are listed in Table I. In Table I, T represents the number of over-all observations; t and (T-t) represent the observations for first and second subperiods respectively. Student t statistics are used to test for a significant shift both α and β. The t_α and t_β values listed in column (d) of Table II, show four firms with significant shifts in intercept and four firms with significant shifts in slope. Merger activity can affect α and β and the shift of α and β can be used as indicators of the merger effect. From regression theory, it can be shown that the estimated α and the estimated β is negatively correlated and the relationship between $\hat{\alpha}$ and $\hat{\beta}$ can be defined as:

$$\hat{\alpha} = \bar{R}_{jt} - \hat{\beta}\, \bar{R}_{mt} \tag{9}$$

where $\bar{R}_{jt}$ is the average excess rate of return for j^{th} security and $\bar{R}_{mt}$ is the average excess market rate of return. Equation (9) shows that the shift of $\hat{\alpha}$ can be due to the changes of $\bar{R}_{jt}$, $\hat{\beta}$, and $\bar{R}_{mt}$. As the average market rate of return is constant over time, then the merger difference is defined as equation (5). Equation (5) implies that the merger difference can be decomposed into two components, i.e., the component associated with α and the component associated with β. Hence, the sign of t_α and t_β indicated in Table II are of interest in investigating the impact of merger activity,[3] a point we will discuss more fully in section V. In sum, t_α and t_β have given us information on the sources of shifting associated with merger

[3] Negative sign implies that the estimated α and the estimated β increase over time.

activity. To detect the existence and sources of structural shifts simultaneously, a modified dummy variable method is derived in the following section.

V. A Dummy Variable Method to Test the Structural Shift.

Gujarti (1970) has derived a dummy variable method to substitute for Chow's (1960) test in detecting the shift of a linear regression. He also has shown that the dummy variable method instead of Chow's method tells us whether a structural shift is due to the intercept, the slope, or both.[4] Quandt's (1958) method of searching for the switching point is integrated with Gujarti's dummy variable model to produce a new method to test for the existence and source of a structural shift. The model is defined as:

$$R_{jt} = \alpha_1 + \alpha_2 D + \beta_1 R_{mt} + \beta_2 (D R_{mt}) + U_t \qquad (10)$$

where

$$D \begin{cases} = 1 \text{ if the observation lies in the first set (of t observation).} \\ = 0 \text{ if the observation lies in the second set (of T-t observations).} \end{cases}$$

Since the division point cannot be divided <u>a priori</u>, Quandt's searching method is used to solve this problem. The procedure can be described as follows: order the observations according to time period $(R_{j1}, R_{m1}), \ldots,$ (R_{jT}, R_{mT}) and divide the data into a left hand and a right hand group where the left hand group contains a small number of observations such as five. Dummy variables for first group are one and dummy variables for second group zero. The parameters of equation (10) are then estimated. Then move the point of division between the groups one time unit to the right and recalculate the regression. Move the division line again and estimate the new regression in analogous fashion until the right hand group contains only five observations.

---

4) Francis and Fabozzi (1977) have employed this dummy variable technique to test the stability of Alphas and Betas over Bull and Bear Market Conditions. They concluded that different market conditions will generally not affect the stability of Alphas and Betas.

The coefficients of determination (R^2) are then used to obtain the optimum division point. The relationship between R^2 and the dummy variable method can be found in Skvarcins and Cromer (1971). The new method developed in this section is called "dummy variable switching regression technique" [DVSR].

To test the usefulness of DVSR, the new method is applied to detect the shifts of intercept and slope for thirty-four firms as indicated in Table I. If t_D and t_S are used to represent the estimated t statistics associated with intercept dummy and slope dummy at the optimum switching point. The estimated t_D and t_S for each firm are listed in column (e) of Table II. Nineteen firms exhibit shifts in either intercept or slope, or both. Among them, are the seven firms with structural shifts that were identified in section four. The DVSR method is more sensitive to the structural change associated with merger activity. This is due to the fact that the DVSR can also detect the changes of intercept and slope resulting in no change in over-all residual behavior. Furthermore, the test associated with the DVSR considers the interrelationship between the change of intercept and the change of slope.[5)]

From the results of Quandt's test, Chow's test, Farley-Hinich's test and the DVSR test, it is clear that the merger differences indicated in equation (5) can be essentially due to changes in systematic risk. As the merger difference is produced by systematic risk, it cannot be regarded as a gain unless the Jensen performance measure, $\hat{\alpha}$, has increased significantly. If the $\hat{\alpha}$ for a firm has decreased, it implies that the merger activity for a firm results in a loss.

[5)] The shifting points obtained from the DVSR method is generally different from those obtained from Quandt's method. This may be due to the fact that the DVSR instead of the Quandt's method has taken the shift of intercept into account.

VI. Summary and Concluding Remarks

In this paper, the average residual analysis technique of FFJR is first used to investigate the aggregate merger effect. Secondly, three alternative switching regression techniques - Quandt's test, Chow's test and Farley and Hinich's test are used to show the impact of a merger on the structure of the market model. The definition of a merger gain (and loss) is derived from the structural change of the market model. To test for the existence and the sources of structural shifts simultaneously, a dummy variable switching regression technique is developed. It is shown that the new switching regression technique is superior to other switching regression techniques. From this study, it can be concluded that the switching regression techniques (especially DVSR) should be used in conjunction with FFJR's average residual method to investigate structural shifts in the market model.

Table 1

Switching Points, Jensen Measures and Systematic Risks

I.	Chemical	t	T-t	α_1	β_1	α_2	β_2
1.	Air Products & Chemicals, Inc.	61	19	.0112 (.7932)	.5210 (1.3507)	.0156 (1.0521)	-.3180 (-.4689)
2.	Air Reduction Co.	65	15	.0086 (1.2273)	.0036 (.0188)	.0081 (.7385)	-.5945 (-1.1901)
3.	Atlas Corporation	68	15	-.0028 (-.3153)	.6742 (2.7471)	.0091 (.4647)	-.7571 (-1.4526)
4.	Celanese Corp.	26	54	.01155 (1.4637)	.8649 (4.7240)	.0070 (.7276)	.2345 (7.1582)
5.	Hooker Chemical Co.	60	20	-.0016 (-.2124)	.9653 (4.6573)	-.0049 (-.5418)	1.5153 (1.5153)
6.	Monsanto Co.	57	14	-.0196 (-1.8877)	-.1403 (-.5514)	.0215 (.7395)	-.0263 (-.1102)
7.	Reichhold Chemicals, Inc.	64	16	.0107 (.9430)	-.1060 (-.3179)	-.0097 (-.5846)	.3968 (1.0916)
8.	Stauffer Chemical Co.	65	15	.0076 (.9867)	1.1158 (4.9668)	-.0313 (-2.5956)	1.1389 (3.8604)
II.	Machinery						
9.	American Chain & Cable Co., Inc.	14	46	.0013 (.0922)	.9165 (1.0941)	.0036 (.4062)	.7563 (2.8602)
10.	Barber-Greene	69	14	-.0043 (-.5579)	.5888 (2.5840)	-.0025 (-.0025)	1.2207 (3.5477)
11.	Clark Equipment Co.	30	24	-.0094 (-.6551)	.5870 (1.6298)	.0107 (.9724)	-.4376 (-1.2420)
12.	Dresser Industries, Inc.	35	45	-.0002 (-.0172)	1.0797 (5.0300)	.0167 (1.0987)	1.1060 (2.7929)
13.	Ingersoll-Rand Co.	21	62	-.0139 (-1.0426)	.6028 (1.4258)	.0031 (.3442)	.1428 (.6440)
14.	Koehring Co.	21	38	.0360 (2.2284)	-1.5151 (-2.2907)	.0236 (2.1609)	.3775 (1.0982)
15.	McNeil Corp.	12	48	-.0042 (-.2715)	.3226 (.8450)	.0098 (.6986)	.4352 (1.1390)

Table I Continue

		t	T-t	α_1	β_1	α_2	β_2
16.	Midland Ross Corp.	20	60	.0061 (.6970)	.5065 (1.7207)	.0176 (2.6920)	.2208 (1.2258)
17.	Rex Chainbelt, Inc.	21	59	-.0174 (-1.3743)	.7708 (2.4674)	.0161 (2.1079)	1.0328 (4.3795)
18.	Wallace-Marray Corp.	45	14	.0263 (1.5928)	.7237 (1.3215)	-.0003 (-.0151)	.8148 (1.4960)
III.	Utility						
19.	Commonwealth Edison	16	55	-.0080 (-1.2586)	.6570 (2.6116)	-.0024 (-.4566)	.6129 (3.7271)
20.	Connecticut Light & Power	68	15	.0077 (1.4861)	.4068 (2.8712)	-.0045 (-.6550)	.5418 (1.3778)
21.	Orange & Rockland Utilities	13	58	-.0027 (-.2330)	-.0111 (-.0399)	.0168 (2.5344)	.5290 (1.6077)
22.	Pacific Power and Light	14	69	.0201 (2.5589)	-.0209 (-.0776)	.0081 (1.3322)	.4429 (2.5605)
23.	Public Service Co. of Colorado	12	71	.0087 (.9457)	.1837 (.6310)	.0075 (1.6414)	.1323 (4.1945)
24.	Southern California Edison Co.	14	69	.0140 (1.8894)	-.1242 (-.4984)	.0089 (1.9137)	-.1819 (-1.3258)
IV.	Others						
25.	American Can Co. (Containers)	19	64	.0108 (1.3802)	.8870 (3.5349)	-.0058 (-.9851)	.6192 (4.3707)
26.	Bristol-Myers Co. (Drugs)	12	59	.0224 (1.4838)	.0592 (.0649)	-.0058 (-.0725)	.6192 (-.1279)
27.	Kennecott Copper Corp. (Copper)	13	70	.0131 (1.5003)	1.7156 (4.5478)	-.0128 (-1.3713)	.9861 (4.3882)
28.	Libby-Owens-Ford Corp. (Automobile Part)	19	64	-.0111 (-1.6176)	1.0639 (4.8418)	-.0062 (-.9112)	1.1977 (7.2754)
29.	Ralston Purina Co. (Foods - Animals)	14	69	.0081 (.6963)	.3805 (.7611)	.0029 (.3543)	.0133 (.0685)

Table 1 Continue

	t	T-t	α_1	β_1	α_2	β_2
30. Scott Paper Co. (paper)	18	65	-.0094 (-.8514)	.7104 (1.3242)	-.0045 (-.6898)	.6755 (4.1641)
31. Standard Oil Co. Ohio (oil)	15	68	.0105 (.9635)	.7466 (1.5698)	.0069 (.6429)	.7484 (2.9491)
32. J. P. Stevens Co., Inc. (textiles)	14	69	.0403 (2.7731)	-1.3327 (-2.1211)	-.0221 (-1.9776)	-.3244 (-1.2152)
33. U. S. Gypsum Co. (Concrete, Gypsum & Plaster)	13	70	-.0206 (-1.7677)	1.4427 (1.9685)	-.0069 (-1.0314)	1.2510 (7.3112)
34. Square D. Co.	54	17	-.0099 (-.9266)	,4178 (1.5915)	.0121 (1.3146)	.3827 (1.6128)

REMARKS: (i) t-values appear in parentheses beneath the corresponding coefficients.

(ii) t = observation for second regime.

T-t = observation for second regime.

(iii) α_i = Jensen measure for i^{th} regime (i=1,2).

β_i = systematic risk for i^{th} regime (i=1,2).

Table II

SUMMARY TABLE FOR TESTING STATISTICS

	(a)	(b)	(c)	(d)		(e)	
	λ	F	t_z	$(t_\alpha,$	$t_\beta)$	$(t_D,$	$t_S)$
I. Chemical							
1. Air Products & Chemicals, Inc.	7.4427	-1.5866	1.1160	(-.2143,	1.0762)	(.1118,	2.0591*)
2. Air Reduction Co.	4.6272	1.5870	-1.2688	(.0391,	1.1186)	(2.1173*,	-.1198)
3. Atlas Corporation	4.1850	.8279	-1.3952	(-.5440,	2.4814*)	(1.1605,	1.1461)
4. Celanese Corp.	6.8077	3.8014*	2.0953*	(.6155,	-2.7352*)	(2.8913*,	-2.1915*)
5. Hooker Chemical Co.	12.1836*	.1407	-.1364	(.2587,	-1.1753)	(-.0436,	-1.2128)
6. Monsanto Co.	3.7553	.1338	.9321	(-1.8968,	-.3797)	(-1.5856,	-1.5704)
7. Reichhold Chemicals, Inc.	2.3415	.4675	.5848	(1.0148,	-1.0192)	(-1.9287*,	-1.1218)
8. Stauffer Chemical Co.	5.5941	3.3546*	- .1739	(2.7166*,	.2949)	(2.8071*,	.0002)
II. Machinery							
9. American Chain & Cable Co., Inc.	1.1263	.4223	- .3634	(-.1383,	.1824)	(1.0893,	.0049)
10. Barber-Greene	1.8875	2.4016	2.6529*	(-.1230,	-1.5312)	(-1.5973,	-2.5142*)
11. Clark Equipment Co.	3.1549	.7169	-1.3206	(-1.1126,	2.03358)	(.0055,	1.0827)
12. Dresser Industries, Inc.	6.8656	.2266	.3303	(-1.1463,	-.0584)	(-1.3022,	-.2172)
13. Ingersoll-Rand Co.	.9291	.0592	.6702	(-1.0556,	.9637)	(-.9580,	1.04454)
14. Koehring Co.	4.4672	2.3665	2.2180*	(.6390,	-2.5389*)	(-.0237,	-2.3511*)
15. McNeil Corp.	3.9305	.2365	1.1013	(-.6711,	-.2445)	(1.7171,	-1.9534*)

Table II Continue

		λ	F	t_z	$(t_\alpha,$	$t_\beta)$	$(t_D,$	$t_S)$
16.	Midland Ross Corp.	4.0141	.2088	- .6193	(-1.0465,	.8281)	(-1.0643,	3.0107*)
17.	Rex Chainbelt, Inc.	3.8585	.7403	- .4321	(-2.2664*,	-.6685)	(-2.1345*,	-.5308)
18.	Wallace-Marray Corp.	3.4923	5.0657*	-1.9042*	(1.0709,	-.1178)	(1.7509,	1.0827)
III.	Utility							
19.	Commonwealth Edison	4.8291	.0547	.1003	(-.6859,	.1463)	(.4318,	1.1294)
20.	Connecticut Light & Power	8.3308	1.6876	1.4757	(1.4164,	-.3231)	(1.1889,	-2.7704*)
21.	Orange & Rockland Utilities	1.6224	1.4024	1.7489	(-1.4665,	.9840)	(-1.4343,	1.9403*)
22.	Pacific Power & Light	12.8043*	.1871	.2269	(1.2169,	-1.4520)	(.19775,	1.3553)
23.	Public Service Co. of Colorado	6.9692	.2814	.3488	(.1198,	-1.1607)	(.3233,	2.1421*)
24.	Southern California Edison Co.	.8409	.4943	- .5407	(.5769,	.2027)	(1.4502,	.9831)
IV.	Others							
25.	American Can Co. (Containers)	3.8823	.6687	- .6606	(1.6898,	.9293)	(1.7411,	.0872)
26.	Bristol-Myers Co. (Drugs)	4.5059	1.5350	-1.2733	(1.3114,	.0974)	(1.6913,	-2.1915*)
27.	Kennecott Copper Corp. (Copper)	13.6450*	1.8513	- .9813	(2.0258*,	1.6614)	(1.2527,	2.2697*)
28.	Libby-Owens-Ford Co. (Automobile Parts)	8.1420	.0560	.6541	(-.5073,	-.4876)	(-.2571,	-.4676)
29.	Ralston Purina Co. (Foods-Animals)	2.8247	1.5361	- .9954	(.3678,	.5600)	(1.1455,	2.0280*)
30.	Scott Paper Co. (paper)	4.7775	.4804	.4879	(-.3838,	.0623)	(-.2312,	-1.5240)
31.	Standard Oil Co. Ohio (oil)	8.7018	.8144	.9363	(.2049,	.2537)	(1.1102,	-3.4715*)
32.	J. P. Stevens Co., Inc. (textiles)	10.8918*	1.8798	.5866	(3.4053*,	-1.4770)	(2.4227*,	-.9640)

Table II Continue

	λ	F	t_z	$(t_\alpha,$	$t_\beta)$	$(t_D,$	$t_S)$
33. U. S. Gypsum Co. (Concrete, Gypsum & Plaster)	5.1909	.5210	.3742	(-1.0358,	.2547)	(3.06156*,	-1.90111)
34. Square D Co. (Electrical Industrial Controls)	6.5312	.9321	- .1583	(-1.5996,	-.4296)	(-1.3027,	.9907)

REMARKS:

λ = Quandt's χ^2 value, F = Chow's F value,
t_z = Farley, Hinich and McGuire's t statistics,
t_α = t statistic of testing the change of α for two regimes,
t_β = t statistic of testing the change of β for two regimes,
t_D = t statistics for intercept dummy,
t_S = t statistics for slope dummy,
* = significance at 5% critical level or better for two-tail test.
X = firms are used to do FFJR's average residual test.

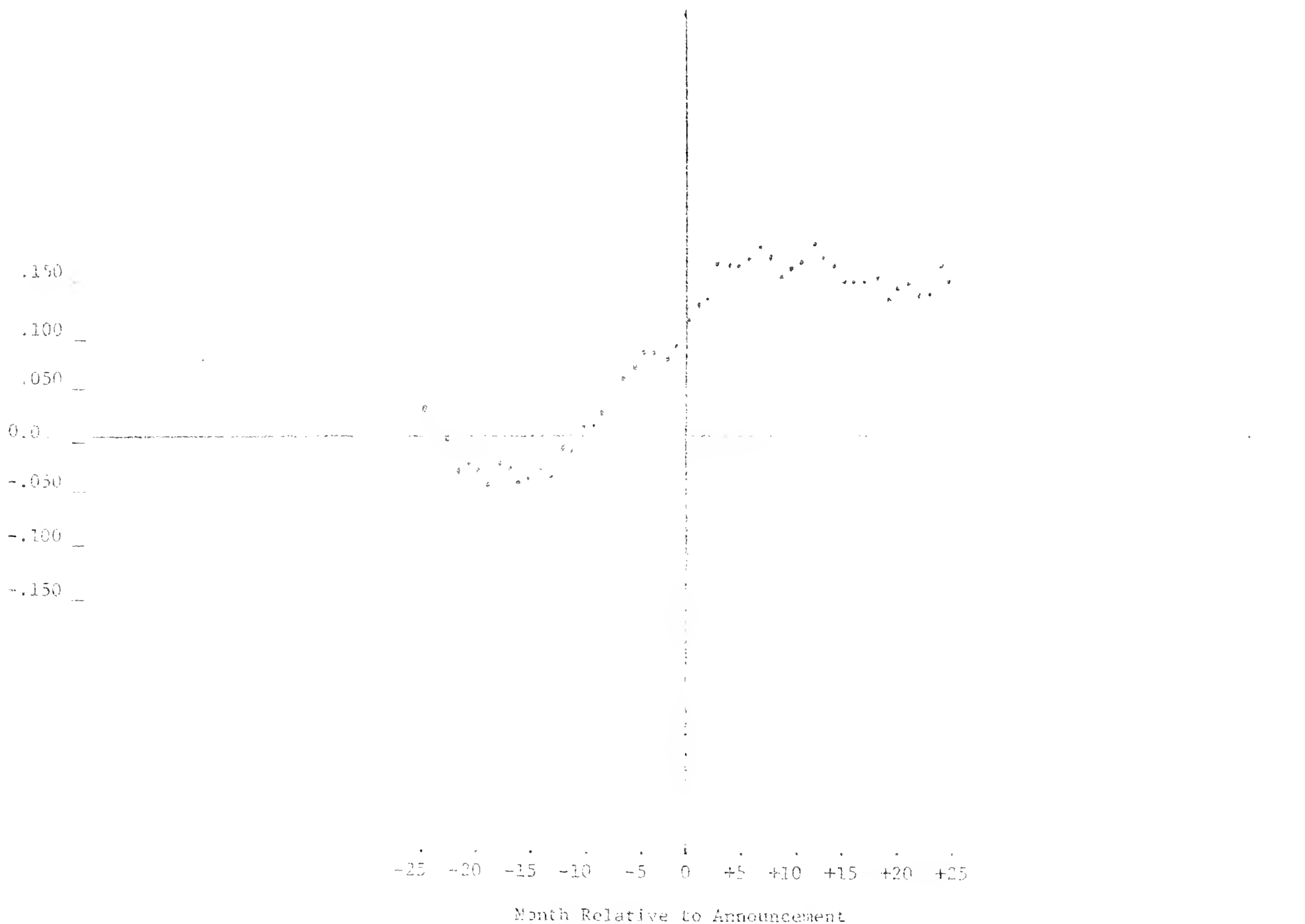
EXHIBIT 1

AVERAGE RESIDUALS

EXHIBIT 11

RATIO OF [illegible] TO [illegible]

CUMULATIVE RESIDUALS WITHOUT SWITCHING



References

1. Anscombe, F. J. (1961), "Examination of Residual," Proc. 4th Berkeley Sump., 1, pp. 1-35.

2. Anscombe, F. J. and Tukey, J. W. (1963), "The Examination and Analysis of Residuals," Techonometrics, 5, pp. 141-160.

3. Barnard, G. A. (1959), "Control Charts and Stochastic Processes," Journal of Royal Statistical Society, B. 21, p. 239.

4. Boness, A. J., A. H. Chen and Soni Jatusipitak (1974), "Investigations of Nonstationarity in Prices," Journal of Business.

5. Brown, R. L. and J. Durbin (1968), "Methods of Investigating Whether Relationship Is Constant Over Time," Math. Center Tracts, 26, pp. 37-45.

6. Chow, G. C. (1960), "Tests of Equality between Subsets of Coefficients in Two Linear Regressions," Econometrica, 28, pp. 591-605.

7. Fama, E. F., M. C. Jensen and R. Roll (1969), "The Adjustment of Stock Price to New Information," International Economic Review, 10, pp. 1-21.

8. Farley, J. U., and Hinich, M. J. (1970), "Testing for a Shifting Slope Coefficient in a Linear Model," Journal of the American Statistical Association, 65, pp. 1320-1329.

9. Farley, J. U., Hinich, M. and McGuire, T. W. (1975), "Some Comparisons of Tests for a Shift in the Slopes of a Multivariate Linear Time Series Model," Journal of Econometric Theory, 3, pp. 297-318.

10. Francis, J. C. and Frank Fabozzi (1977), "Stability Tests for Alphas and Betas over Bull and Bear Market Conditions," Journal of Finance, forth coming.

11. Gujarti, D. (1970), "Use of Dummy Variables in Testing for Equality between Sets of Coefficients in Two Linear Regressions: A Note," The American Statistician, 23, pp. 50-52.

12. Halpern, P. J. (1973), "Empirical Estimates of the Amount and Distribution of Gains to Companies in Mergers," Journal of Business, 46, pp. 554-575.

13. Lintner, J. (1965), "Security Prices, Risk, and Maximal Gains from Diversification," Journal of Finance, 20, pp. 587-616.

14. Mehr, C. B. and McFadden, J. A. (1965), "Certain Properties of Gaussian Processes and Their First-Passage Times," Journal of Royal Statistical Society, B, 27, pp. 505-522.

15. Mossin, J. (1966), "Equilibrium in a Capital Asset Market," Econometrica, 34, pp. 768-783.

16. Page, E. S. (1954), "Continuous Inspection Schemes," Brometrika, 41, pp. 100-114.

17. Quandt, R. E. (1958), "The Estimation of the Parameters of Linear Regression System Obying Two Separate Regimes," Journal of the American Statistical Association, 63, pp. 573-580.

18. Quandt, R. E. (1960), "Tests of the Hypothesis that a Linear Regression System Obys Two Separate Regimes," Journal of American Statistical Association, 55, pp. 324-330.

19. Sharpe, W. F. (1964), "Capital Asset Prices: A Theory of Market Equilibrium Under Condition of Risk." Journal of Finance, 19, pp. 425-442.

20. Skvarcins, R. and F. Cromer (1971), "A Note on the Use of Categorical Vectors in Testing for Equality of Two Regression Equations," The American Statistician, 24, pp. 27-29.

21. Tukey, J. W. (1963), "The Future of Data Analysis," Ann. Math. Statist., 33, pp. 1-67.

22. Weston, J. Fred, and S. K. Mansinghka (1971), "Tests of the Efficiency of Conglomerate Firms," Journal of Finance, 26, pp. 919-936.