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A STUDY IN INDIAN STOCK PRICE BEHAVIOUR : JANUARY 1991-MAY 1993

MANJUSRI BANDYOPADHYAY

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A STUDY IN INDIAN STOCK PRICE BEHAVIOUR: JANUARY 1991–May 1993

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Foreword

Amiya Kumar Bagchi

The current study of Indian stock market behaviour is the first of a series which have been planned under the auspices of the RBI Endowment Chair of Industrial Finance, at the Centre for Studies in Social Sciences, Calcutta. As the study makes clear, data regarding Indian stock markets have to be processed carefully in order to test even the simplest of hypotheses. The results reported are only tentative. But they show that stock markets may be efficient and yet display characteristics which may be considered undesirable from certain points of view. Interrelations between stock markets and other financial markets may have to be studied intensively in order to arrive at any notion of causality. It is hoped that the study will be of use to economists interested in finance as well as to financial analysts.

A STUDY IN INDIAN STOCK PRICE BEHAVIOUR : JANUARY 1991 - MAY 1993

Manjusri Bandyopadhyay and Pranab K. Das*

The paper analyses the market efficiency hypothesis in its weak form for the Indian stock market. The price series of four individual scrips and two indices have been chosen for the test of market efficiency hypothesis. The null hypothesis is that the price (or the price index as the case may be) changes follow random walk. The results suggest that the random walk hypothesis is, in general, true for the chosen scrips but there are important exceptions.

This study attempts to investigate the nature of the informational efficiency of the Indian stock market, or to be more specific of the Bombay Stock Exchange (BSE). The paper is divided into three sections. In section I we clarify the meaning of informational efficiency. Section II presents the empirical evidence from the Indian data in the light of the discussion of Section I and Section III contains the conclusions.

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I

There is a substantial literature on the informational efficiency of markets or, alternatively, on the efficient capital market or efficient market hypothesis (EMH). As per Fama (1970, 1976) a market is informationally efficient if prices in such a market reflect all available information instantly and in an unbiased manner. Thus if it is generally known that a firm has favourable earnings prospects, then EMH implies that the price of the firm's stock will be bid to the point where no non-zero capital gain can occur when the high earnings actually materialize. That is to say, if the market is efficient then no one can forecast prices efficiently and cannot enjoy any systematic capital gain. In an efficient capital market no agent has any comparative advantage over others so far as the informational accrual is concerned.

The definition of informational efficiency as per Fama is so general that it has no empirically testable implications. For testing the hypothesis we have to specify the price formation process in greater detail. So depending upon the process of price formation specified several test statistics can be derived. Most of the price formation processes are based on the assumption that the conditions of market equilibrium can be stated in terms of expected returns.

Fama divided these tests broadly into three classes, viz. weak form tests, semi-strong form tests and strong form tests. In case of the weak form tests, informational efficiency is tested on the basis of an information set containing only the past prices. In the case of semi-strong form tests, the information set contains, in addition to past prices, publicly available information such as annual report of the company, dividend declaration, bonus declaration, rights issue, etc. to which everyone has access. In the case of the strong form tests, information set contains in addition to past prices and publicly available information some privately held information to which some people have monopolistic access.

So far as the price formation processes are concerned, two models have widely been used in the empirical literature - random walk and the martingale /‾Kendall, M.G. (1953), West, K.D. (1988), LeRoy, S.F. (1989)_7. We will concentrate on the weak form tests using a random walk model. That is to say we are testing capital market efficiency by testing whether the price series follow a random walk or not. A price series is said to follow a random walk when the following relation holds :

$$P_{j,t} = P_{j,t-1} + U_t$$

where $P_{j,t}$ is the price of the jth scrip in period t, and U_t is a white noise process so that $E(U_t) = 0$, $E(U_t, U_{t-s}) = 0$ for $s > 0$ and $E(U_t^2) = \sigma^2 \; \forall$ t and s. Thus if a price series follows a random walk, then successive price changes are independent. This is what one would expect if the market is efficient with respect to new information. In an idealized market of rational individuals, prices would adjust instantaneously to new information. On the other hand, a pattern of systematic slow adjustment to new information would imply the existence of readily available and profitable trading opportunities. Thus the null hypothesis is

$$H_0 : r_k = 0 \text{ where } r_k = E\,(\Delta P_{j,t}, \Delta P_{j,t-k})$$

It is tested against the alternative $H_1 : r_k \neq 0$. This parametric test is also supplemented with a non parametric test - the 'runs test'.

Though the random walk model is the forerunner in the capital market efficiency literature it has certain interpretation problems (LeRoy, 1989). The hypothesis that a stochastic process is random walk is more restrictive than the requirement that it is a martingale**. The martingale rules out any dependence of the conditional expectation of $P_{j,t+1} - P_{j,t}$ on the information available at t, whereas the random walk rules out this and also the dependence involving the higher conditional moments of $P_{j,t+1}$. Stock prices are known to go through a long period of small fluctuations followed by a long period of high fluctuations. This can be represented with a model in which successive conditional variances of stock prices (but not their levels) are positively autocorrelated. This is consistent with a martingale, but not with random walk. In addition to that Samuelson's (1965, 1973) theoretical formalization of capital market efficiency points towards the martingale rather than the random walk. It was also realized that most of the empirical tests for randomness were in fact tests of the weaker martingale model or for example, the still weaker specification that rates of return are uncorrelated.

** A price series P_t is said to be a martingale with respect to a sequence of information sets ϕ_t, iff P_t has the property

$$E(P_{t+1}/\phi_t) = P_t$$

However, we employed the random walk model for a number of reasons. First, if observations over long intervals like a month or a year are used then it may not reflect the adjustment of prices to new information that takes place within a short interval of time. However, this kind of adjustments involved in the process in fact determines the nature of market efficiency. Due to this consideration we are basically interested in testing market efficiency hypothesis on the basis of weekly data. Second, the test statistics for martingale models [Shiller (1981), LeRoy and Porter (1985), Mankiw, Romer and Shapiro (1985)] are suitable for annual data series. Because these tests somehow or otherwise use dividend series also, we were constrained to use test statistics based only on prices because our time interval is a week. However we could have also used variance-ratio test [Fama and French (1986), Lo and MacKinlay (1988)], but so far as the power of the test is concerned it is not noticeably superior to tests based on random walk hypothesis [see Poterba and Summers (1988)].

II

For our study we have chosen a number of scrips. The two indices viz. SENSEX and BSE National Index have been chosen because their movements on an average reflect the over all market behaviour. However, there are scrips that are traded more frequently than others and thus their movements also provide some additional insight into the over all fluctuations. Hence we have chosen four individual stocks viz. ITC, Reliance, TELCO and TISCO.

We use the weekly prices quoted at the BSE for the period January, 1991 to May, 1993. The weekly prices (or the price indices) have been calculated in the following way : For the whole of the period, first we have identified all the trading weeks from the BSE official directories. There had been no trade for several weeks and we just omitted them. For each of the trading days, there are 4 price quotations viz. opening, high, low and closing. Corresponding to each of the trading weeks, we have chosen the weekly opening price as the price quoted on the first day of the week. The weekly low and high prices are the lowest and highest prices respectively in that particular week. In a similar fashion, the weekly closing price is taken as the closing price of the last trading day of the week. Once we obtain the weekly opening, high, low and closing quotations we calculate the average of these four values and take the average as the weekly average price.

It is to be noted that stock prices being time series observations are likely to have a natural time dependent component. This deterministic time trend may cause significant serial correlation between observations which could have disappeared, had this time trend been removed from the series. To avoid this problem, we have fitted deterministic trend curves to all the six series and finally worked with the detrended series. We checked for fits of linear, quadratic, cubic, semi log, double log, modified exponential, Gompertz and logistic curves. The criteria for best fit is adjusted R^2 - if adjusted R^2 is greater than 0.00001 in a particular fit than any other then that fit is taken as the best fit. The results for the best fits are given below in Table 1 for all the scrips and the two indices.

Table 1 : Best Fit for Time Trends

Scrip	Best fit	R^2	Fitted Equation	SE(dependent variable)
ITC	Quadratic	0.7317852	$\hat{P}_t = -16.53529 + 12.43987\,t - 0.07006465\,t^2$ (7218.96) (1.00123) (0.007822029)	97.80814
Reliance	Double log	0.4931124	$\ln \hat{P}_t = 4.27526 + 0.2533702 \ln t$ (0.88069) (0.0228456)	0.23856
TELCO	Double log	0.816649071	$\ln \hat{P}_t = 5.065829 + 0.1425667 \ln t$ (0.04965586) (0.01290723)	0.1341899
TISCO	Double log	0.834088649	$\ln \hat{P}_t = 4.847935 + 1664248 \ln t$ (0.05808492) (0.01512934)	0.1565959
SENSEX	Quadratic	0.7132595	$\hat{P}_t = 350.424 + 60.53742\,t - 0.3641492\,t^2$ (153548.3) (4.617579) (0.03607)	451.0818
BSE	Quadratic	0.7125868	$\hat{P}_t = 243.0126 + 25.4806t - 0.1546\,t^2$ (26580.26) (1.9212) (.01500922)	187.678

The figures in bracket are SE's.

Table 1 shows that for both SENSEX and National Index the deterministic time trend is quadratic. However for the four individual scrips, double log has been found to be the best for three of them. In all the cases except for the Reliance the R^2 is quite high. Figures 1 to 6 show the actual series and the corresponding fitted trend curves followed by another set of figures (figures 7 to 12) exhibiting the one period changes in the detrended series for each of the selected scrips. For each of the six price series, we have conducted tests of serial correlation on the detrended values. Let U_1, U_2, ... U_n be some time series observations. The serial correlation coefficient r_k of lag k is defined as

$$r_k = \frac{\frac{1}{n-k}\sum_{t=1}^{n-k}\left(U_t - \frac{1}{n-k}\sum_{t=1}^{n-k}U_t\right)\left(U_{t+k} - \frac{1}{n-k}\sum_{t=1}^{n-k}U_{t+k}\right)}{\left[\left(\frac{1}{n-k}\sum_{t=1}^{n-k}\left(U_t - \frac{1}{n-k}\sum_{t=1}^{n-k}U_t\right)^2\right)\left(\frac{1}{n-k}\sum_{t=1}^{n-k}\left(U_{t+k} - \frac{1}{n-k}\sum_{t=1}^{n-k}U_{t+k}\right)^2\right)\right]^{\frac{1}{2}}}$$

If the distribution of U_t has finite variance, then for large samples the standard error of r_k may be written as $\sqrt{1/(n-k)}$ [Kendall (1953)]. Using the above formula, serial correlations between price changes (at the differencing level one) were computed for all the six series, upto lag 52 as the higher lag correlation coefficients may not give meaningful results in a sample size of 123. We also calculated the percentage returns on the detrended series. We find that there is wide variation in the percentage return series. For example, for the sensex series, the maximum (positive) return is 1225% while the minimum (negative) return is - 1405%. The corresponding figures for the National Index, ITC, Reliance, TISCO and TELCO are (1167%, - 2920%), (4526%, - 4494%), (12500%, - 786%), (267%, - 578%) and (1116%, - 384%) respectively.

Results of the tests on serial correlation are given in tables 2 to 7. The tests suggest that coefficients are typically insignificant. It is seen that for the Sensex series, out of 52 coefficients quoted, a mere 8 are more than twice their computed standard error (in absolute value). Out of these 8 coefficients only two are larger than 3 x S.E. (that is, three times the standard error). For the National Index, only 8 correlation coefficients are larger than twice their standard errors and out of 8, only two are greater than 3 x S.E. For the ITC price series, the corresponding figures are 11 and 3 respectively. Similarly for Reliance, 4 are greater than 2 x S.E. and only one is larger than 3 x S.E. The corresponding figures for TISCO and TELCO are 2 and 1 and 4 and 2 respectively. The mean absolute serial correlation coefficients for the Sensex, National Index, ITC, TISCO, TELCO, and Reliance are .0909, .0949, .1147, .0920, .1000 and .0889 respectively. This shows that there is a strong statistical support in favour of the null hypothesis of zero serial correlation coefficients and thus it should be accepted. The statistically insignificant serial correlation coefficients imply that the successive-price changes are independent which confirms the market efficiency hypothesis in its weak form.

Apart from the tests based on correlation coefficients that implicitly assumes an underlying distribution we have employed one non-parametric test viz. the 'runs tests' where we need not make any assumption on the distribution

Table 2

TEST OF EMH : SENSEX

lag	correlation	se	t
1	.3130	.0905	3.4568
2	-.0283	.0909	.3110
3	.2655	.0913	2.9084
4	.2527	.0917	2.7561
5	-.1054	.0921	1.1446
6	-.0783	.0925	.8466
7	.1244	.0928	1.3398
8	-.1095	.0933	1.1741
9	-.2906	.0937	3.1030
10	-.1864	.0941	1.9820
11	-.0555	.0945	.5870
12	-.2518	.0949	2.6533
13	-.2553	.0953	2.6775
14	-.0378	.0958	.3946
15	-.0752	.0962	.7819
16	-.0789	.0967	.8163
17	.0256	.0971	.2638
18	.0824	.0976	.8443
19	.0050	.0981	.0505
20	.0305	.0985	.3092
21	.1987	.0990	2.0070
22	.1992	.0995	2.0016
23	.0529	.1000	.5293
24	.0553	.1005	.5503
25	.0616	.1010	.6095
26	-.0810	.1015	.7979
27	-.1424	.1021	1.3949
28	-.0522	.1026	.5088
29	-.0116	.1031	.1120
30	-.1008	.1037	.9723
31	-.0567	.1043	.5442
32	.0957	.1048	.9128
33	-.0463	.1054	.4394
34	-.1495	.1060	1.4105
35	-.0257	.1066	.2409
36	.0719	.1072	.6706
37	-.0073	.1078	.0673
38	.0273	.1085	.2516
39	.0228	.1091	.2089
40	.0183	.1098	.1665

Contd.. Table 2

lag	correlation	se	t
41	.0038	.1104	.0345
42	-.0761	.1111	.6851
43	-.0217	.1118	.1937
44	-.0079	.1125	.0700
45	-.0947	.1132	.8364
46	-.0083	.1140	.0727
47	.0301	.1147	.2620
48	-.0765	.1155	.6625
49	-.1487	.1162	1.2795
50	-.0945	.1170	.8071
51	-.0282	.1179	.2389
52	.0086	.1187	.0725

Table 3

TEST OF EMH : BSE NATIONAL INDEX

lag	correlation	se	t
1	.3835	.0905	4.2363
2	.0843	.0909	.9274
3	.2952	.0913	3.2336
4	.2546	.0917	2.7779
5	-.0566	.0921	.6145
6	-.0910	.0925	.9843
7	-.0023	.0928	.0243
8	-.1745	.0933	1.8716
9	-.2780	.0937	2.9686
10	-.1657	.0941	1.7614
11	-.1091	.0945	1.1548
12	-.2705	.0949	2.8498
13	-.2561	.0953	2.6864
14	-.0772	.0958	.8060
15	-.1401	.0962	1.4562
16	-.1286	.0967	1.3307
17	.0161	.0971	.1656
18	.0859	.0976	.8805
19	.0442	.0981	.4510
20	.0614	.0985	.6236
21	.2339	.0990	2.3624
22	.2306	.0995	2.3179
23	.0788	.1000	.7880
24	.0454	.1005	.4521
25	.0354	.1010	.3507
26	-.0457	.1015	.4505
27	-.1197	.1021	1.1729
28	-.0273	.1026	.2664
29	-.0492	.1031	.4767
30	-.1229	.1037	1.1851
31	-.0268	.1043	.2574
32	.0647	.1048	.6168
33	-.0189	.1054	.1791
34	-.1224	.1060	1.1543
35	-.0247	.1066	.2317
36	.0529	.1072	.4934
37	.0010	.1078	.0097
38	.0108	.1085	.0992
39	.0005	.1091	.0045
40	-.0047	.1098	.0428

Contd. Table 3

lag	correlation	se	t
41	.0242	.1104	.2192
42	-.0347	.1111	.3124
43	-.0197	.1118	.1758
44	-.0278	.1125	.2475
45	-.0796	.1132	.7033
46	-.0587	.1140	.5151
47	-.0040	.1147	.0352
48	-.1017	.1155	.8809
49	-.1114	.1162	.9583
50	-.1048	.1170	.8950
51	-.0584	.1179	.4953
52	-.0170	.1187	.1430

Table 4

TEST OF EMH : RELIANCE

lag	correlation	se	t
1	.2994	.0898	3.3334
2	-.0284	.0902	.3152
3	.1779	.0905	1.9649
4	.0124	.0909	.1369
5	-.1299	.0913	1.4226
6	.0026	.0917	.0284
7	.1017	.0921	1.1045
8	-.0947	.0925	1.0243
9	-.1504	.0928	1.6203
10	-.0853	.0933	.9148
11	-.0793	.0937	.8468
12	-.2219	.0941	2.3591
13	-.1291	.0945	1.3661
14	-.0290	.0949	.3055
15	-.0846	.0953	.8875
16	-.1153	.0958	1.2035
17	-.1456	.0962	1.5132
18	-.0707	.0967	.7309
19	-.0275	.0971	.2831
20	-.0180	.0976	.1846
21	.1077	.0981	1.0988
22	.1801	.0985	1.8283
23	.0500	.0990	.5051
24	-.0225	.0995	.2264
25	.2054	.1000	2.0541
26	.0334	.1005	.3322
27	-.1762	.1010	1.7446
28	-.0757	.1015	.7451
29	.0096	.1021	.0940
30	-.0684	.1026	.6667
31	.0524	.1031	.5077
32	.2112	.1037	2.0367
33	.0171	.1043	.1636
34	.0755	.1048	.7199
35	.1054	.1054	1.0002
36	-.0328	.1060	.3091
37	-.0624	.1066	.5856
38	.0559	.1072	.5219
39	.0233	.1078	.2164
40	.0264	.1085	.2431

Contd. Table 4

lag	correlation	se	t
41	.1021	.1091	.9358
42	-.0474	.1098	.4322
43	-.0942	.1104	.8530
44	.0266	.1111	.2390
45	-.0449	.1118	.4019
46	-.0401	.1125	.3566
47	.0280	.1132	.2474
48	-.0839	.1140	.7359
49	-.1294	.1147	1.1282
50	-.2168	.1155	1.8775
51	-.1891	.1162	1.6265
52	-.0271	.1170	.2317

Table 5

TEST OF EMH : TISCO :

lag	correlation	se	t
1	.3254	.0905	3.5944
2	.0532	.0909	.5849
3	.0683	.0913	.7486
4	-.0909	.0917	.9918
5	.1301	.0921	1.4134
6	.1410	.0925	1.5255
7	-.0546	.0928	.5878
8	-.0543	.0933	.5821
9	-.2163	.0937	2.3099
10	-.0742	.0941	.7890
11	-.0139	.0945	.1475
12	-.1154	.0949	1.2159
13	-.0209	.0953	.2194
14	.0242	.0958	.2527
15	-.0752	.0962	.7815
16	.0482	.0967	.4991
17	.1384	.0971	1.4247
18	.1377	.0976	1.4110
19	.1341	.0981	1.3671
20	.0568	.0985	.5768
21	.0137	.0990	.1384
22	.0760	.0995	.7641
23	.1138	.1000	1.1383
24	.0566	.1005	.5628
25	-.0976	.1010	.9664
26	-.1984	.1015	1.9541
27	-.1515	.1021	1.4844
28	-.0972	.1026	.9475
29	-.0247	.1031	.2400
30	.0298	.1037	.2878
31	-.0459	.1043	.4405
32	-.0144	.1048	.1376
33	.0130	.1054	.1235
34	.0249	.1060	.2347
35	.1182	.1066	1.1087
36	.0513	.1072	.4786
37	.0256	.1078	.2374
38	.1884	.1085	1.7365
39	-.0364	.1091	.3334
40	-.0558	.1098	.5081

Contd. Table 5

lag	correlation	se	t
41	.0048	.1104	.0432
42	-.1152	.1111	1.0372
43	-.0839	.1118	.7506
44	-.1618	.1125	1.4384
45	-.1232	.1132	1.0877
46	.0158	.1140	.1388
47	-.1747	.1147	1.5229
48	-.1220	.1155	1.0568
49	-.1841	.1162	1.5835
50	-.1958	.1170	1.6728
51	.0838	.1179	.7109
52	.1140	.1187	.9602

Table 6

TEST OF EMH : TELCO

lag	correlation	se	t
1	.4390	.0902	4.8686
2	.0520	.0905	.5748
3	.0390	.0909	.4285
4	.0524	.0913	.5739
5	.0543	.0917	.5927
6	-.0460	.0921	.4995
7	.0147	.0925	.1591
8	.0264	.0928	.2842
9	-.0429	.0933	.4601
10	-.1118	.0937	1.1941
11	-.1564	.0941	1.6622
12	-.2921	.0945	3.0912
13	-.2446	.0949	2.5768
14	-.0671	.0953	.7042
15	.0984	.0958	1.0268
16	.0842	.0962	.8751
17	-.0155	.0967	.1604
18	-.0947	.0971	.9751
19	-.0548	.0976	.5610
20	.0779	.0981	.7939
21	.1089	.0985	1.1057
22	.1947	.0990	1.9669
23	.2357	.0995	2.3683
24	.1760	.1000	1.7601
25	-.0136	.1005	.1350
26	-.0839	.1010	.8308
27	-.0635	.1015	.6257
28	-.1168	.1021	1.1445
29	-.1087	.1026	1.0598
30	-.0662	.1031	.6421
31	.0241	.1037	.2323
32	-.0664	.1043	.6367
33	-.1940	.1048	1.8502
34	-.0807	.1054	.7655
35	.0281	.1060	.2656
36	.0738	.1066	.6926
37	.1003	.1072	.9352
38	.0880	.1078	.8163
39	.0636	.1085	.5860
40	-.0442	.1091	.4051

Contd. Table 6

lag	correlation	se	t
41	-.0089	.1098	.0811
42	.0365	.1104	.3307
43	.0630	.1111	.5671
44	.0823	.1118	.7365
45	.0973	.1125	.8650
46	.2073	.1132	1.8311
47	.1364	.1140	1.1968
48	-.0848	.1147	.7396
49	-.2092	.1155	1.8119
50	-.1988	.1162	1.7099
51	-.0156	.1170	.1329
52	.0672	.1179	.5702

Table 7

TEST OF EMH : ITC

lag	correlation	se	t
1	.2458	.0905	2.7153
2	-.1392	.0909	1.5316
3	.3110	.0913	3.4071
4	.3238	.0917	3.5318
5	-.1487	.0921	1.6149
6	-.1754	.0925	1.8975
7	.1143	.0928	1.2312
8	-.0773	.0933	.8292
9	-.2967	.0937	3.1674
10	-.2612	.0941	2.7765
11	-.1929	.0945	2.0413
12	-.2534	.0949	2.6696
13	-.2438	.0953	2.5572
14	-.1133	.0958	1.1828
15	-.1022	.0962	1.0622
16	-.0241	.0967	.2488
17	.0359	.0971	.3699
18	.0490	.0976	.5025
19	-.0415	.0981	.4234
20	.0771	.0985	.7820
21	.2705	.0990	2.7317
22	.2235	.0995	2.2464
23	.0594	.1000	.5937
24	.1692	.1005	1.6837
25	.2130	.1010	2.1081
26	-.0456	.1015	.4493
27	-.1381	.1021	1.3532
28	.0367	.1026	.3580
29	.1027	.1031	.9959
30	-.1307	.1037	1.2600
31	-.0958	.1043	.9186
32	.0417	.1048	.3980
33	-.0888	.1054	.8423
34	-.1961	.1060	1.8501
35	-.0926	.1066	.8690
36	.0137	.1072	.1274
37	-.0549	.1078	.5092
38	-.0206	.1085	.1895
39	-.0091	.1091	.0832
40	.0271	.1098	.2470

Contd. Table 7

lag	correlation	se	t
41	.0103	.1104	.0931
42	-.0483	.1111	.4345
43	.0543	.1118	.4861
44	.0339	.1125	.3011
45	.0290	.1132	.2560
46	.0651	.1140	.5713
47	.0808	.1147	.7042
48	-.0904	.1155	.7828
49	-.0803	.1162	.6904
50	.0788	.1170	.6733
51	-.0272	.1179	.2310
52	-.1082	.1187	.9113

from which the observations were drawn. Since only signs and not magnitudes are used in runs test, we have worked only with the series on price changes in the original series. This non-parametric test is used to check whether the number of consecutive days of price changes in any particular direction conforms to that expected by pure chance factors. A run is defined as a sequence of consecutive price changes of the same sign. The stock prices can either increase (plus change) or decrease (minus change) or remain the same (zero change). Thus there can be three types of run. Under the assumption of independence, the total expected number of runs of the three kinds for a particular stock is given by,

$$m = \left[N(N+1) - \sum_{i=1}^{3} n_i^2 \right] / N$$

Where N is the total number of price changes and the n_i's are the number of price changes of each type. The standard error of m is given by,

$$\sigma_m = \left(\frac{\sum n_i^2 \left[\sum n_i^2 + N(N+1) \right] - 2N \sum n_i^3 - N^3}{N^2 (N-1)} \right)^{\frac{1}{2}}$$

For large sample, the sampling distribution of m is approximately normal (Wallis and Roberts (1956)). Hence one standardized variable K can be computed as

$$K = (R - m \pm \tfrac{1}{2}) / \sigma_m$$

Where $\pm \frac{1}{2}$ in the numerator is the adjustment factor and the sign of this discontinuity adjustment is plus if $R \leq m$ and minus otherwise.

So for large N, K will be approximately normal with mean zero and variance one. In the present study, runs tests have been applied to all the six series. We also calculated for each of the series, the percentage or the proportional discrepancy between actual number of runs and expected number of runs as given by,

$$D = (R-m)/m$$

The results of runs tests are shown in table 8.

Table 8

Stock	Actual total number of runs (R)	Expected number of runs (m)	Standard error (σ_m)	Standardized variate (K)	Discrepancy (D)
SENSEX	54	61.59	5.46	- 1.2979	- .1232
NATIONAL INDEX	53	61.59	5.46	- 1.48	- .1394
ITC	62	60.55	5.42	0.1752	.0239
TISCO	48	61.19	5.42	- 2.34	- 0.2156
TELCO	48	61.97	5.50	- 2.45	- 0.2254
RELIANCE	54	61.80	5.46	- 1.33	- 0.1262

It is seen that out of 6 standardized values, 5 are negative (i.e. the actual number of runs is less than the expected number). Again for TISCO and TELCO the two standardized values are significantly different from zero. This is also supported by the discrepancy values. While other discrepancy values are quite low, only for this two series, the actual number of runs deviate from the expected numbers by more than 20%. This means that for these two scrips again, the efficient market hypothesis has a week statistical support. Whether this is true for other scrips also has to be tested separately.

III

It is observed that except for a few, the major proportions of correlation coefficients are statistically insignificant indicating thereby that successive price changes in individual scrips are very nearly independent which is consistent with an "efficient" market that adjusts instantaneously to new information. It is to be noted however that for each of the series, coefficient at lag 1 is highly significant while no systematic pattern is visible among the rest.

However the evidence of market efficiency cannot be supported only on the basis of short period data. Unlike the conventional efficiency tests that test the orthogonality of returns over short intervals, the variance-bounds tests [Shiller (1981), LeRoy and Porter (1981) etc.] check for the orthogonality over a long period and observed excess volatility (excess over what is expected from fundamentals) that violates market efficiency hypothesis. In another series of tests [Fama and French (1988) etc.] it was found that the stock price returns have a U shaped pattern which shows the presence of a mean - reverting component in stock prices. This implies the violation of EMH. It has been found that for the span of ten years the correlation reverts to approximately zero. Consequently Shiller (1984) and Lawrence and Summers (1986) proposed that instead of the martingale model, ideally stock prices should be modelled as a random walk plus a fad variable where the latter is treated as a slowly mean-reverting stationery series.

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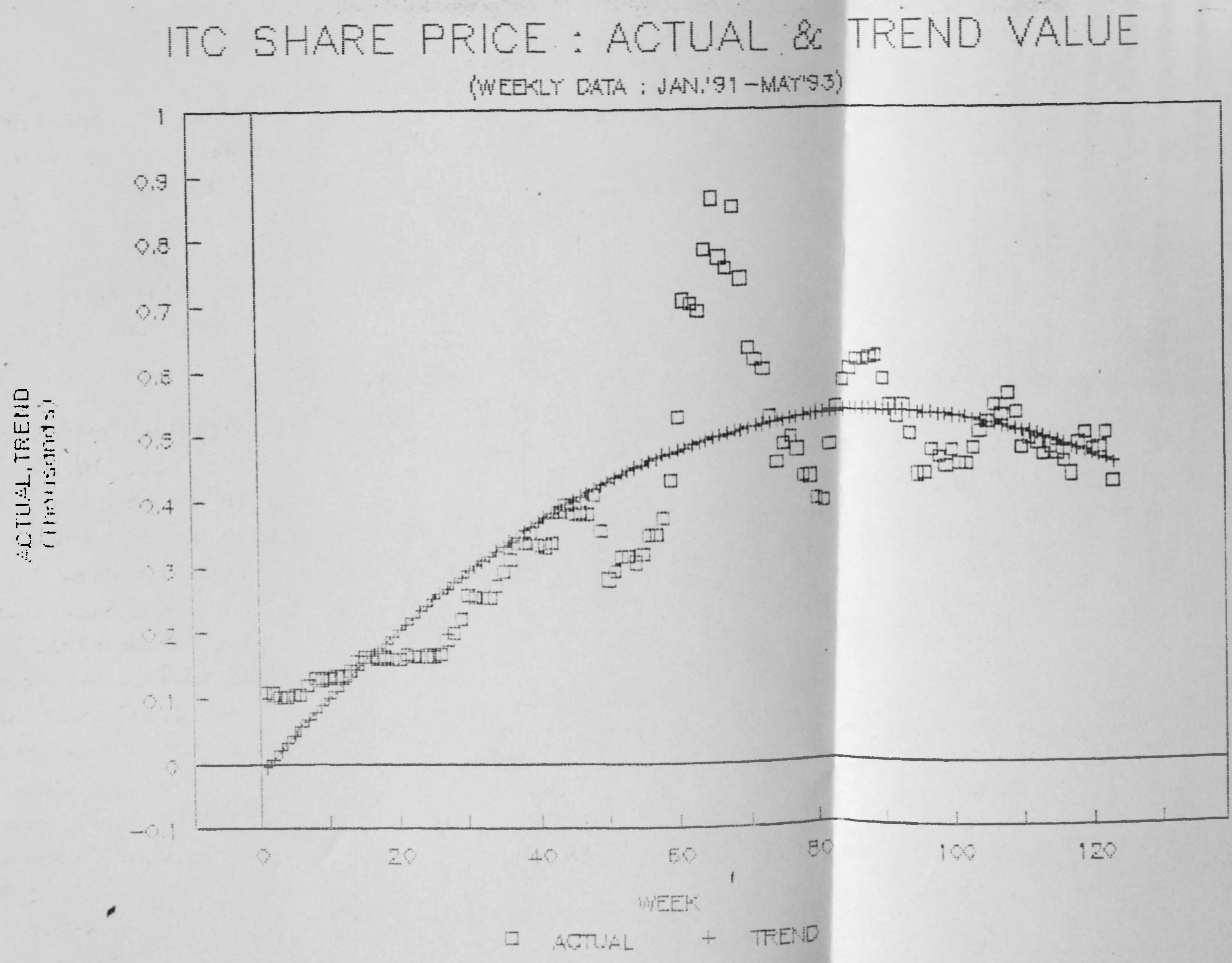


ITC SHARE PRICE : ACTUAL & TREND VALUE
(WEEKLY DATA : JAN.'91 - MAY'93)
ACTUAL, TREND
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
20
40
60
80
100
120
WEEK
□ ACTUAL
+ TREND

Fig. 1

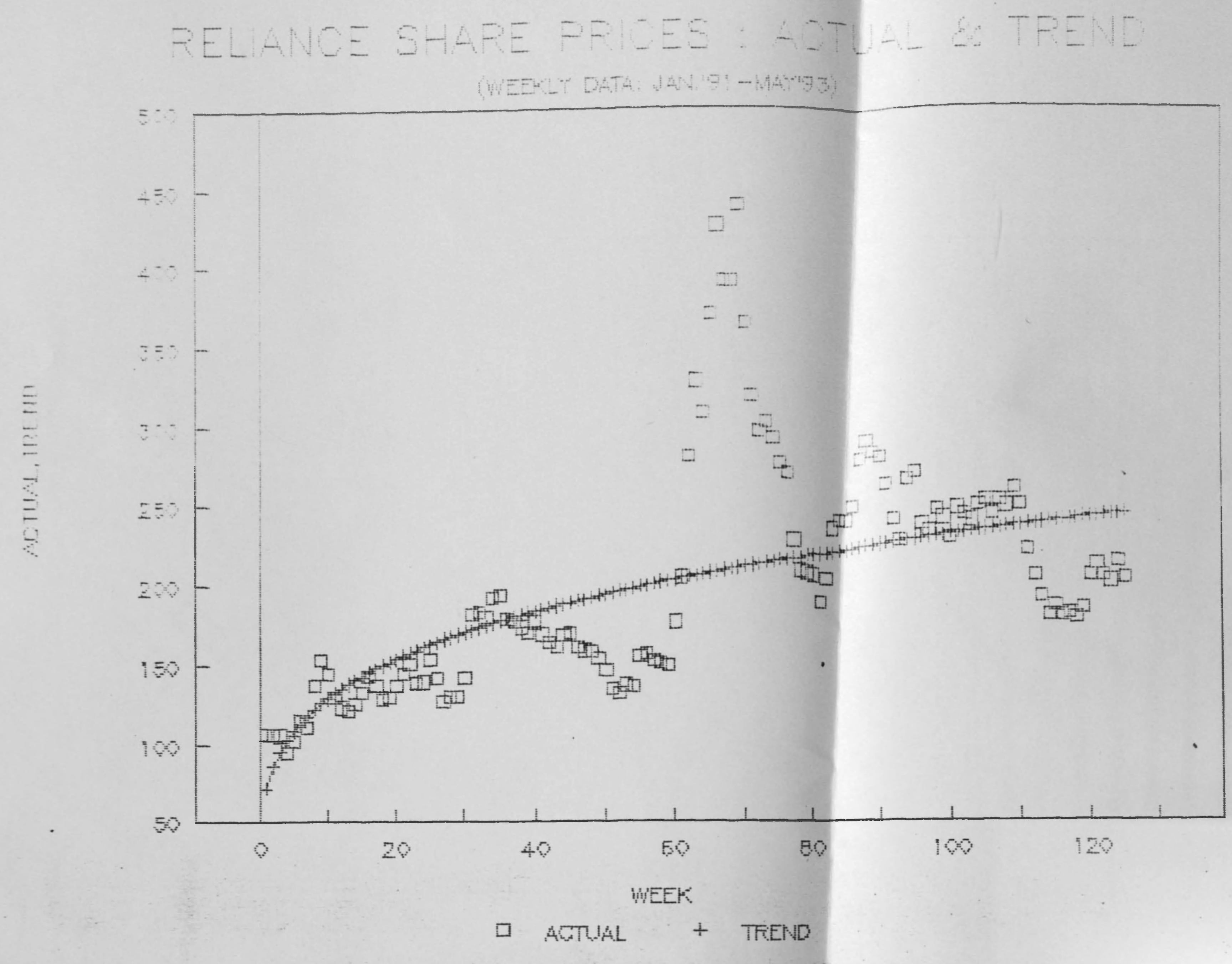
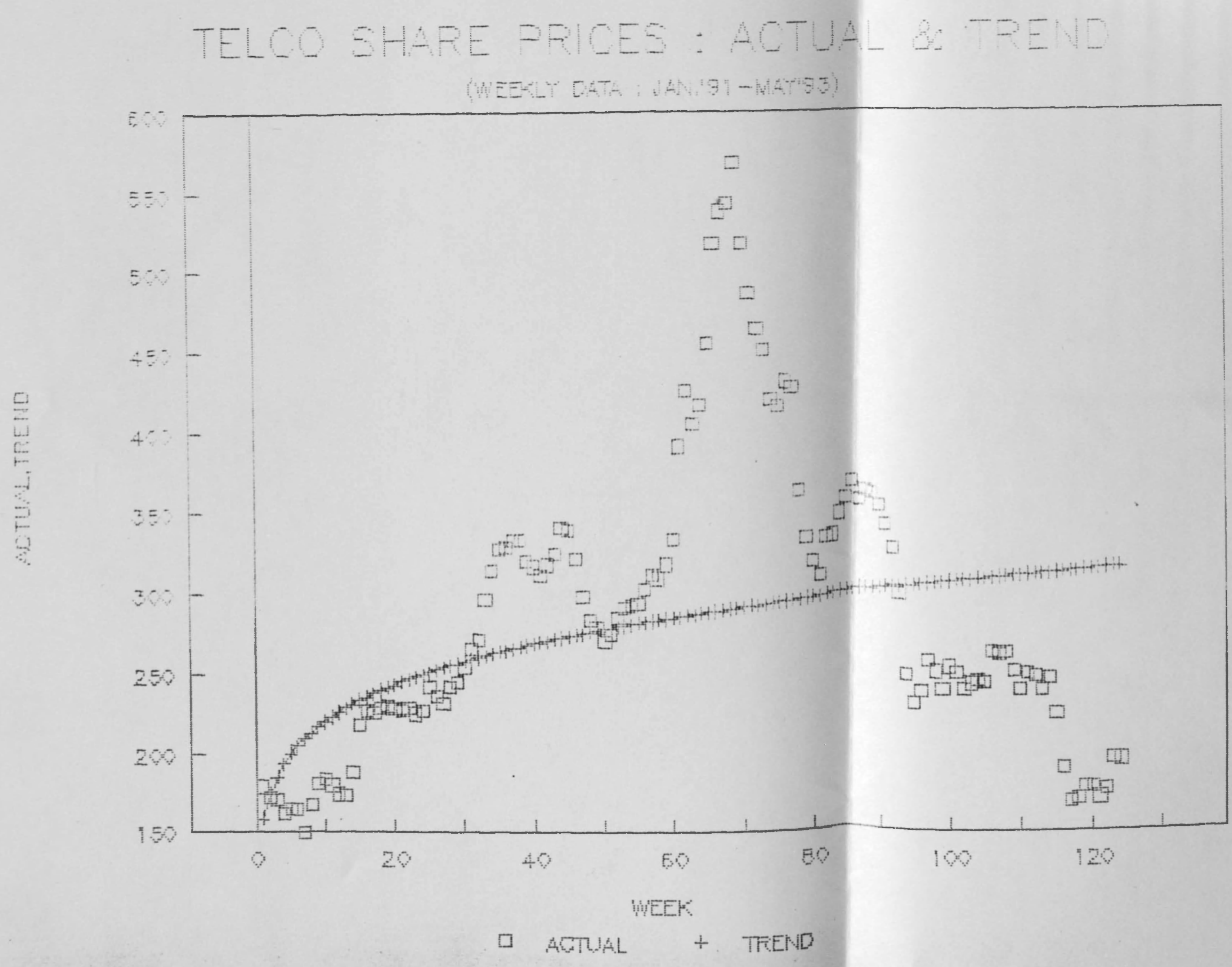

RELIANCE SHARE PRICES : ACTUAL & TREND
(WEEKLY DATA: JAN.'91 – MAY'93)
ACTUAL, TREND
WEEK
□ ACTUAL + TREND

Fig. 2



TELCO SHARE PRICES : ACTUAL & TREND
(WEEKLY DATA : JAN.'91 - MAY'93)
ACTUAL,TREND
600
550
500
450
400
350
300
250
200
150
0
20
40
60
80
100
120
WEEK
□ ACTUAL + TREND

Fig. 3

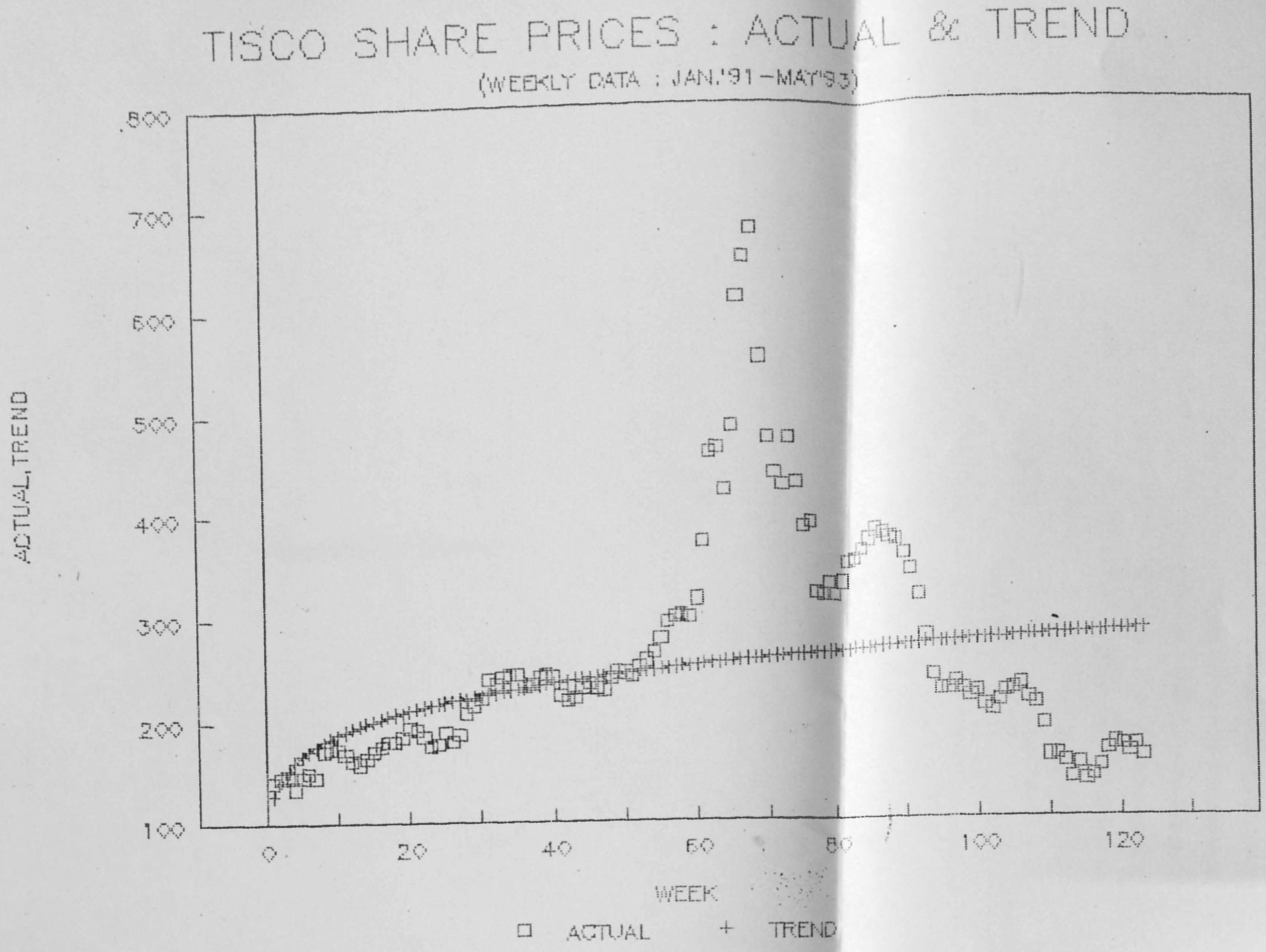

TISCO SHARE PRICES : ACTUAL & TREND
(WEEKLY DATA : JAN.'91 – MAY'93)
ACTUAL, TREND
800
700
600
500
400
300
200
100
0
20
40
60
80
100
120
WEEK
□ ACTUAL
+ TREND

Fig. 4

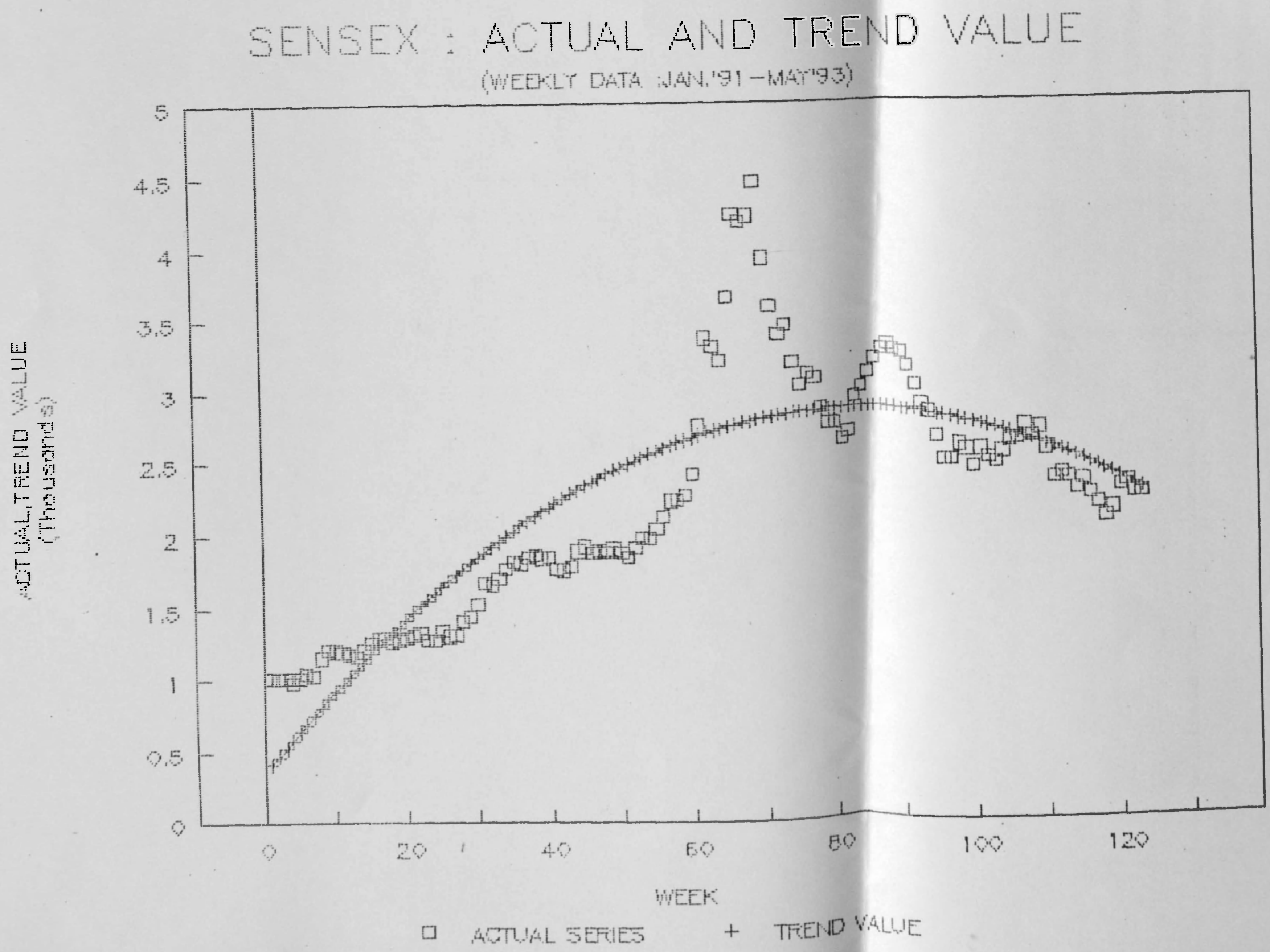
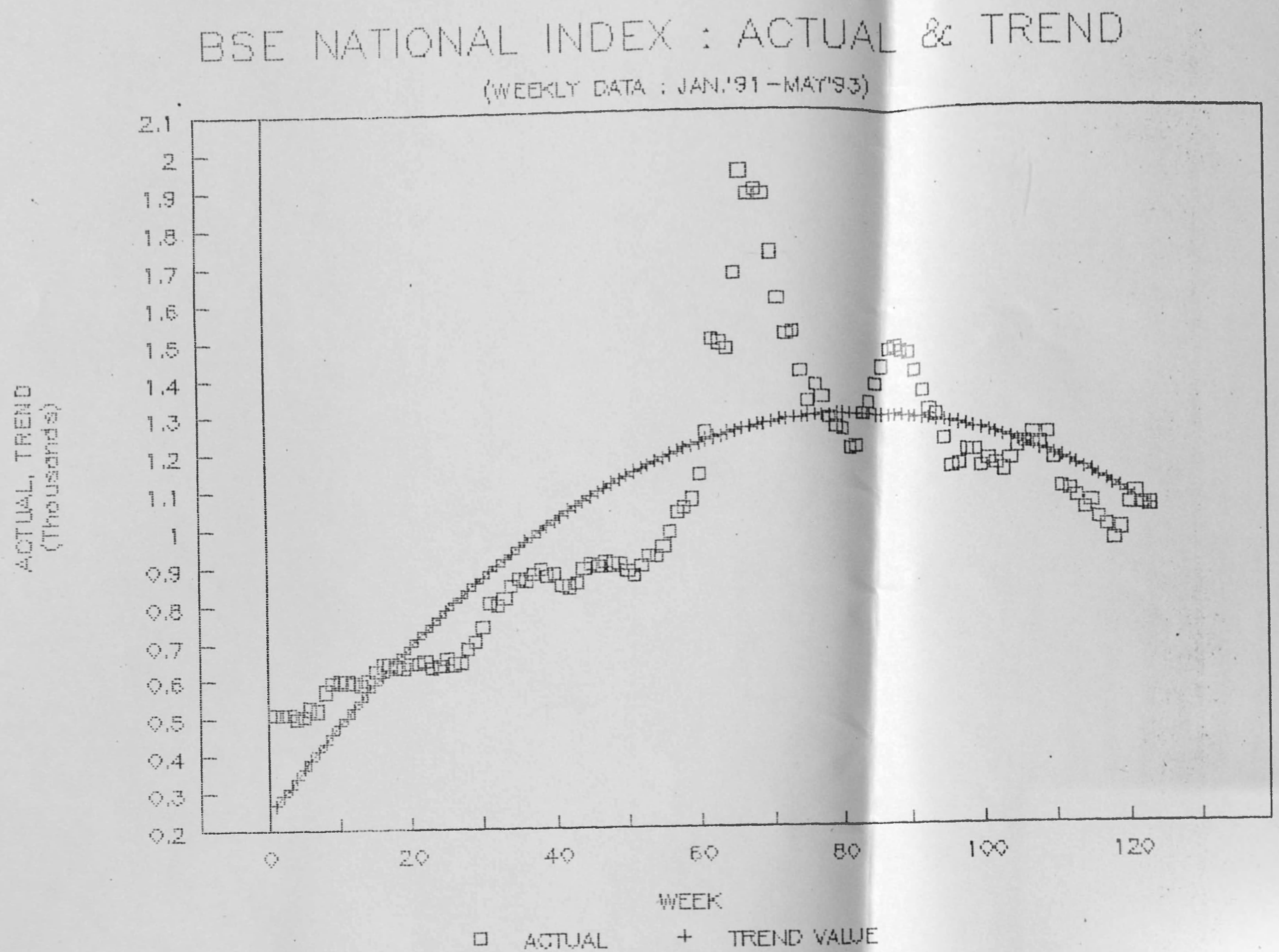
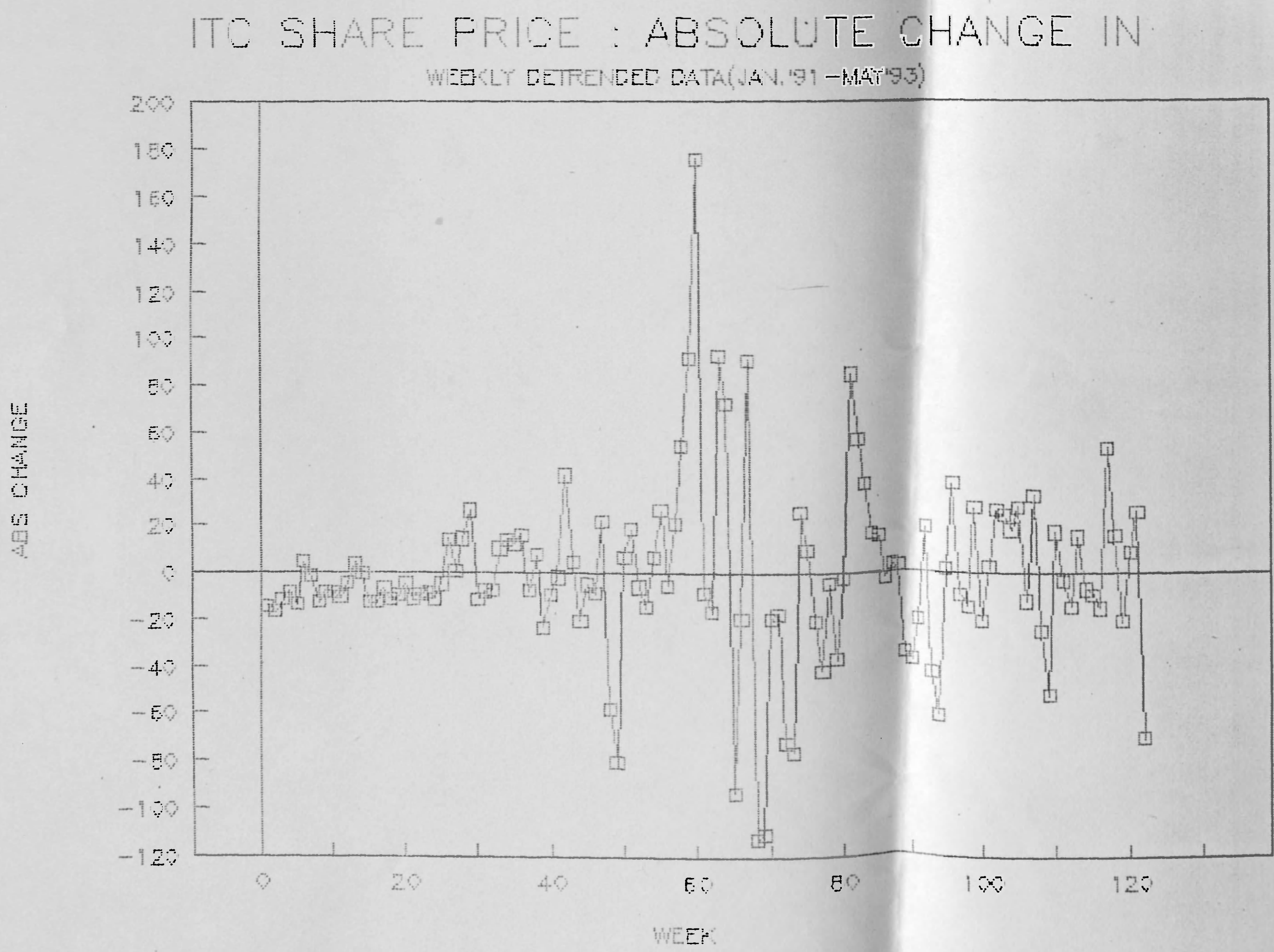

SENSEX : ACTUAL AND TREND VALUE
(WEEKLY DATA :JAN.'91 - MAY'93)
ACTUAL,TREND VALUE
(Thousands)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
20
40
60
80
100
120
WEEK
□ ACTUAL SERIES
+ TREND VALUE

Fig. 5



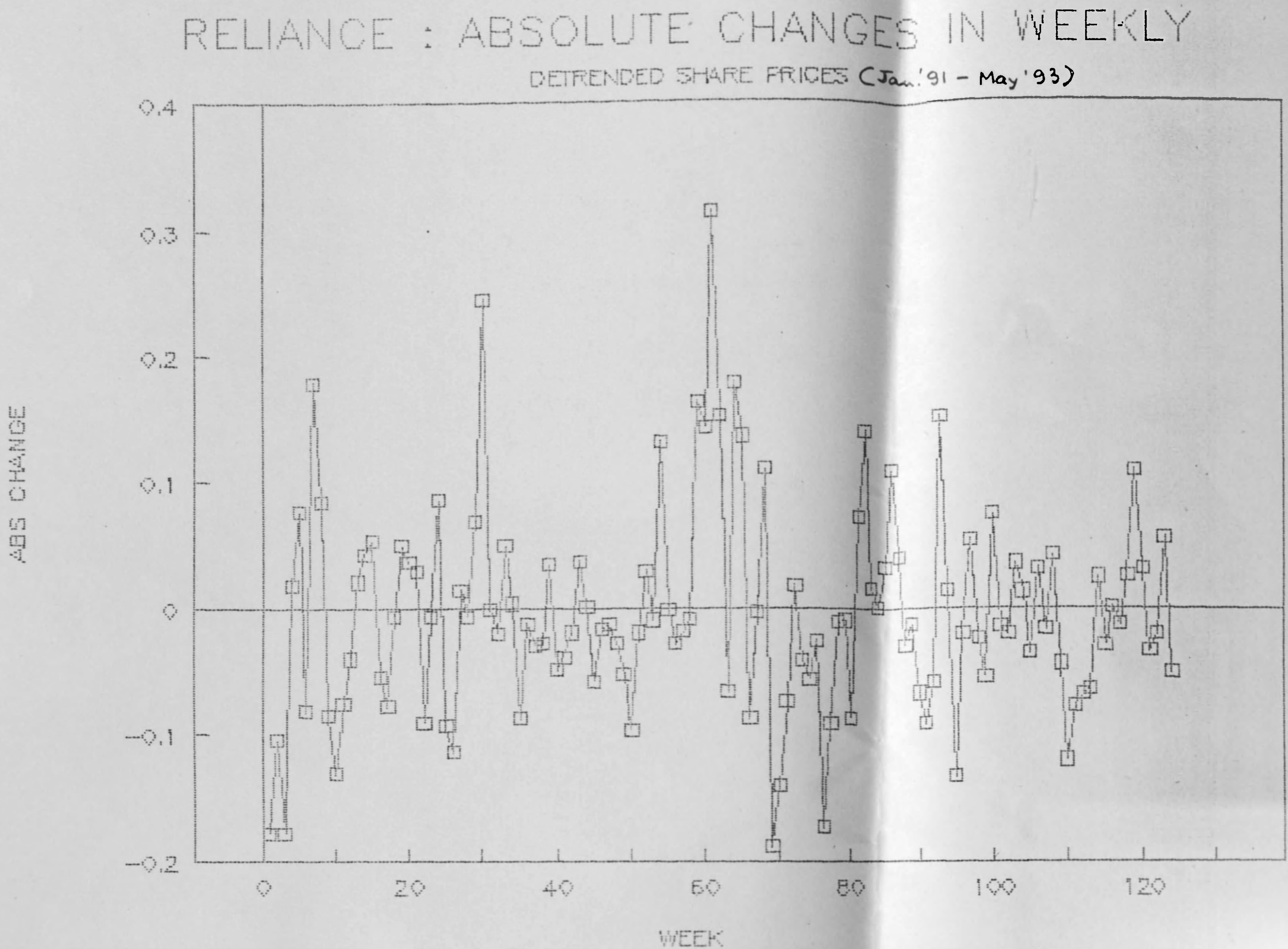
BSE NATIONAL INDEX : ACTUAL & TREND
(WEEKLY DATA : JAN.'91 – MAY'93)
ACTUAL, TREND
(Thousands)
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
20
40
60
80
100
120
WEEK
□ ACTUAL
+ TREND VALUE

Fig. 6



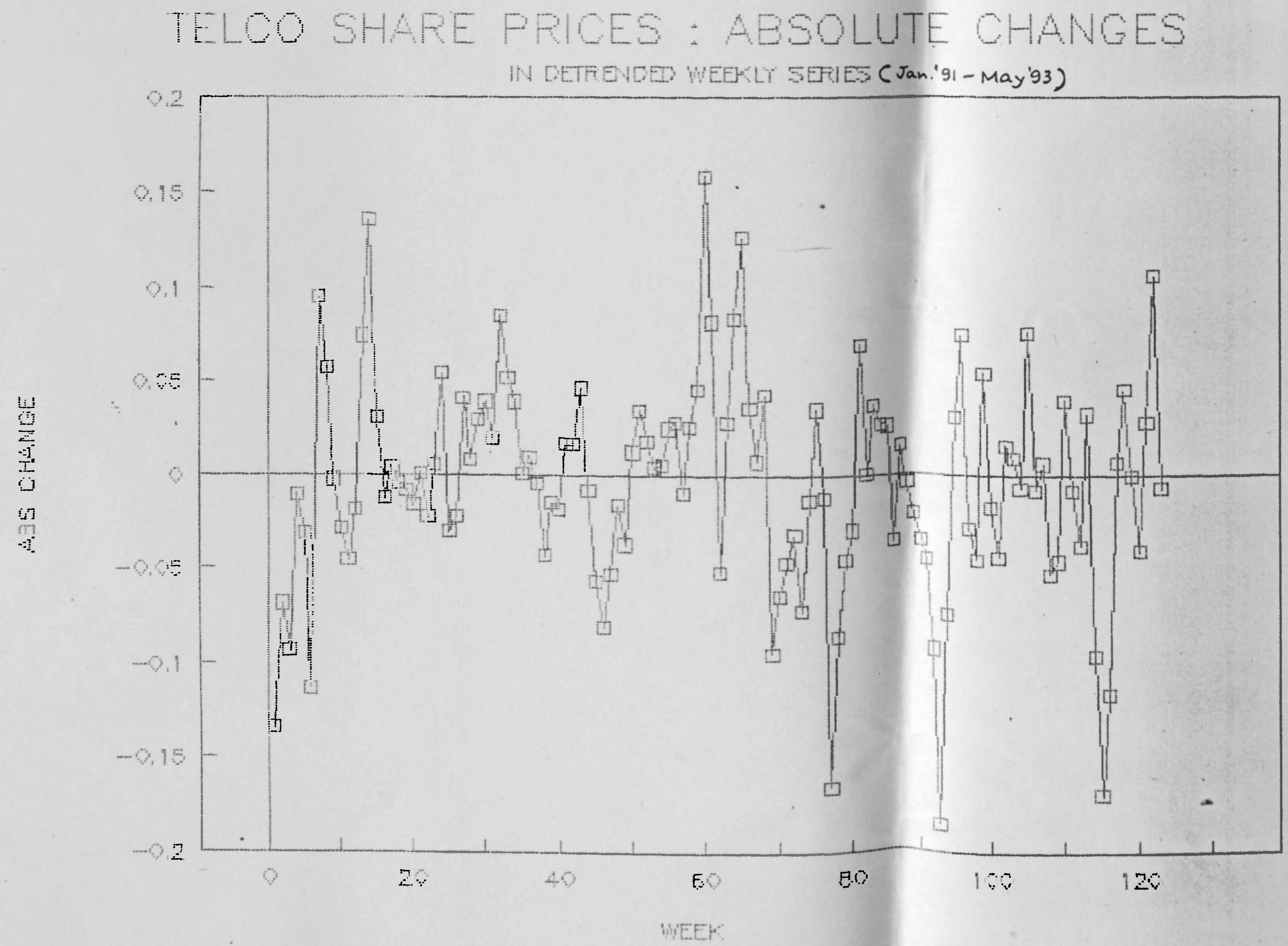
ITC SHARE PRICE : ABSOLUTE CHANGE IN
WEEKLY DETRENDED DATA(JAN.'91 -MAY'93)
ABS CHANGE
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
0
20
40
60
80
100
120
WEEK

Fig. 7



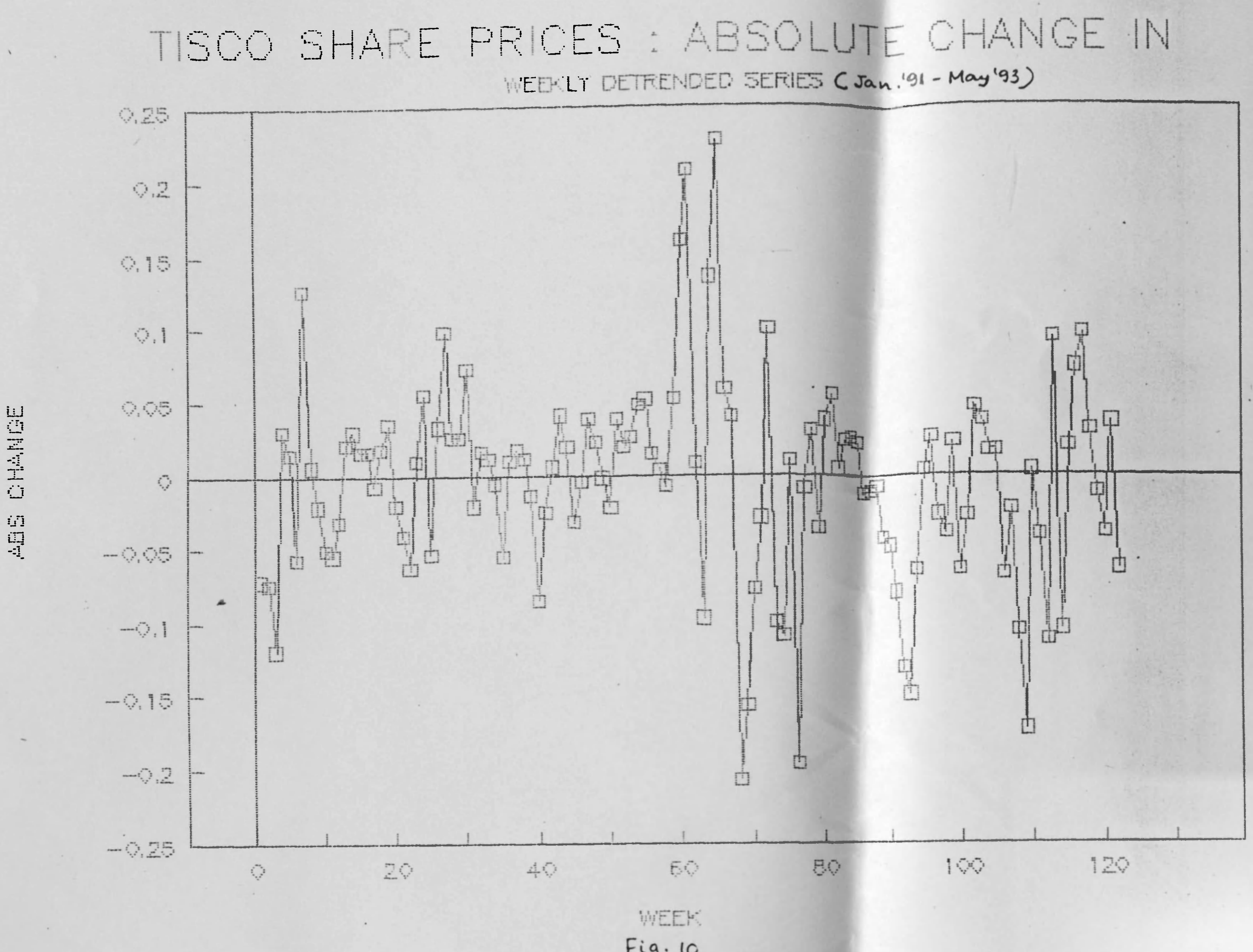
RELIANCE : ABSOLUTE CHANGES IN WEEKLY
DETRENDED SHARE PRICES (Jan.'91 - May'93)
ABS CHANGE
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0
20
40
60
80
100
120
WEEK

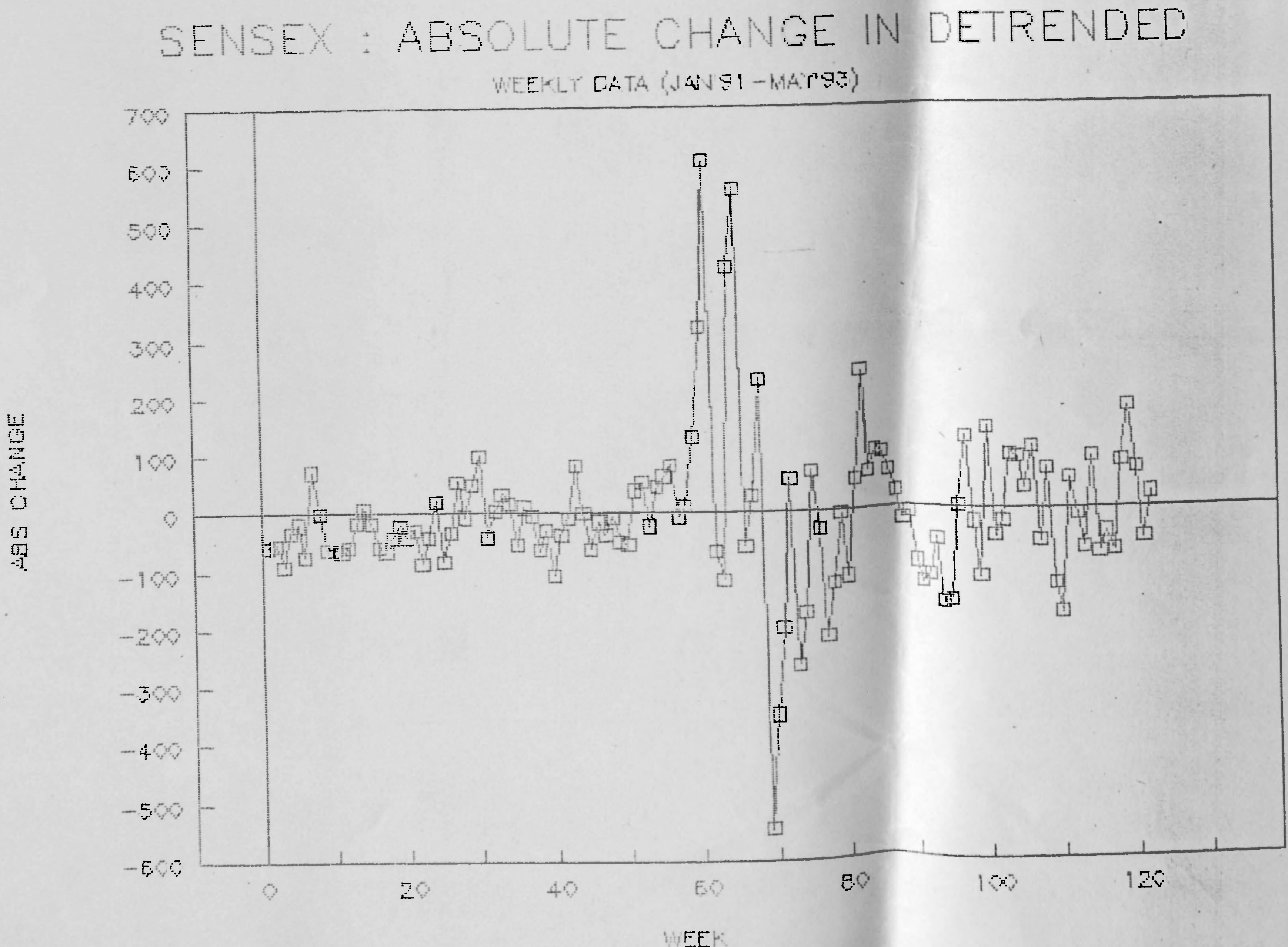
Fig. 8



TELCO SHARE PRICES : ABSOLUTE CHANGES
IN DETRENDED WEEKLY SERIES (Jan.'91 – May'93)
ABS CHANGE
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0
20
40
60
80
100
120
WEEK

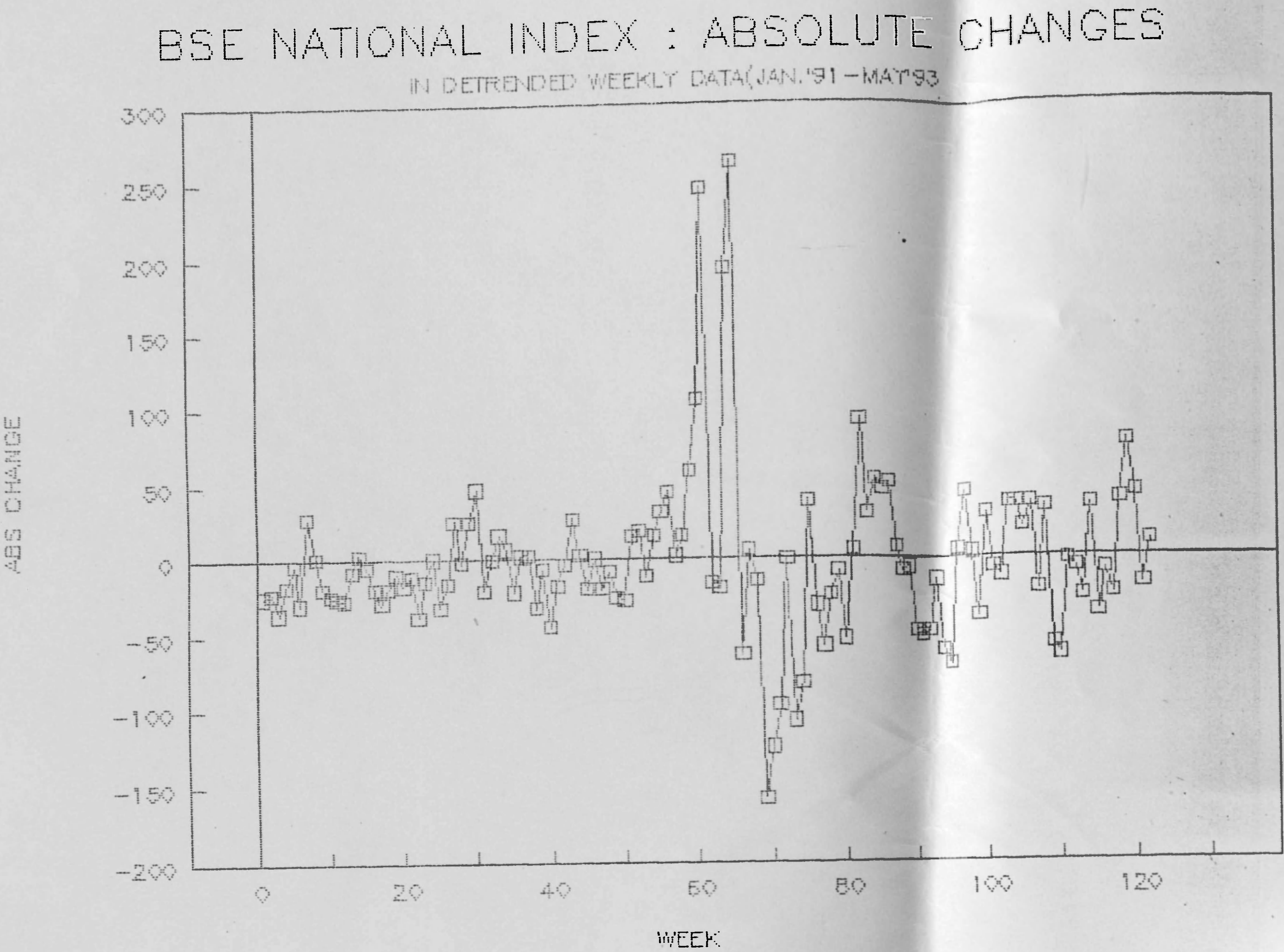
Fig. 9


TISCO SHARE PRICES : ABSOLUTE CHANGE IN
WEEKLY DETRENDED SERIES (Jan.'91 - May'93)
ABS CHANGE
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
20
40
60
80
100
120
WEEK
Fig. 10



SENSEX : ABSOLUTE CHANGE IN DETRENDED
WEEKLY DATA (JAN'91 - MAY'93)
ABS CHANGE
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
0
20
40
60
80
100
120
WEEK

Fig. 11


BSE NATIONAL INDEX : ABSOLUTE CHANGES
IN DETRENDED WEEKLY DATA(JAN.'91 – MAY'93
ABS CHANGE
300
250
200
150
100
50
0
−50
−100
−150
−200
0
20
40
60
80
100
120
WEEK
Fig. 12

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