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Investment, Taxation and Econometric Policy Evaluation : Some Evidence on the Lucas Critique*

by

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ABSTRACT

The aggregate investment schedule is a relationship for which the issue of stability over time is of special importance for macroeconomic policy. In particular, one may wish to use this schedule to study the impact of various policy measures such as changes in the nominal corporate tax rate, changes in depreciation allowances, investment tax credits, etc. An ingenious formulation of an investment function making possible such studies is due to Hall and Jorgenson (1967). The importance of using, for such policy simulations, a model which exhibits a good stability over time is easy to understand. In particular, the parameters should be invariant with respect to the policy changes themselves. This point has been forcefully stressed by Lucas (1976). This author argues the since parameters in econometric relationships reflect economic agent's decision rules and these integrate knowledge about policies, changes in policies are likely to induce shifts in the parameters. Lucas describes three cases where such phenomena could be observed, one of which involves the Hall-Jorgenson (1967) model of investment demand (and taxation). In particular, as regards the impact of investment tax credits with this model, Lucas makes two kinds of prediction: first, if the model is implemented under an assumption of static expectations (vs rational expectations) and estimated from a period during which policy rules changes appreciably, it is likely to exhibit parameter instability related to these policy changes; second, the impact of tax credits is likely to be heavily under-estimated.

The paper presents empirical evidence on both these effects on the basis of a version of this model estimated from U.S. data (1956-1972) by Gordon and Jorgenson (1976) and extensively used in policy simulations; fluctuations of investment tax credits over the period considered suggest the Lucas effects are likely to be observable in this case. For this purpose, we use recursive stability analysis, an exploratory methodology introduced by Brown, Durbin and Evans (1975) and extended by Dufour (1979, 1982). This method is based on a process of recursive estimation of the model considered with, among other things, an analysis of associated prediction errors; it has the advantage of making very weak assumptions concerning the type of instability to be detected and indicates the direction of the prediction errors induced. The main finding is a discontinuity associated with the first imposition of the tax credit (1964-66); furthermore, the observed shift induced a strong phenomenon of unprediction of investment, thus bringing support for Lucas' hypothesis.

RESUME

La fonction d'investissement est une relation dont la stabilité temporelle a une importance considérable pour les politiques macroéconomiques. En particulier, on peut se servir d'une telle relation afin d'étudier l'impact de diverses mesures telles des changements dans les taux de taxation du revenu des compagnies ou dans les taux de dépréciation, les crédits d'impôt à l'investissement, etc. Une formulation particulièrement ingénieuse de cette relation et permettant de telles études a été proposée notamment par Hall et Jorgenson (1967).

Il est facile de comprendre l'importance, pour de telles simulations, d'utiliser un modèle dont les coefficients peuvent être considérés comme stables dans le temps. Lucas (1976) a spécialement insisté sur ce problème. Cet auteur suggère que des changements dans les politiques peuvent induire des changements dans les coefficients: ceci provient du fait que les coefficients des modèles économétriques reflètent des règles de décision optimales qui tiennent compte des politiques gouvernementales. Lucas décrit trois cas où on est susceptible d'observer de tels phénomènes: l'un de ces cas est le modèle de demande d'investissement de Hall et Jorgenson (1967). Considérant le cas particulier des crédits d'investissement, Lucas fait deux types de prévision: premièrement, si le modèle est estimé sous une hypothèse d'attentes statiques et à partir de données d'une période au cours de laquelle la règle de politique pertinente a changé, on peut s'attendre à ce que le modèle démontre une instabilité reliée à ces changements; deuxièmement, l'impact d'un crédit d'investissement temporaire sera sous-estimé.

Dans ce contexte, nous présentons des réusltats sur ces deux effets à partir d'une version du modèle originalement estimée avec des données américaines (1956-72) par Gordon et Jorgenson (1976) et qui a été utilisée pour faire des simulations de politiques. Comme on peut observer plusieurs fluctuations dans la politique touchant les crédits d'investissement, nous anticipons d'observer les effets suggérés par Lucas dans ce cas. Pour cette fin, nous utilisons "l'analyse récursive de la stabilité" telle qu'introduite par Brown, Durbin et Evans (1975) et généralisée par Dufour (1979, 1982). Cette méthode est basée sur un processus récursif d'estimation et l'analyse de diverses statistiques résultantes: les avantages de l'approche sont qu'aucune hypothèse n'est faite sur le type d'instabilité à détecter et qu'elle fournit des indications sur la direction des erreurs de prévision. A l'aide de cette méthode, nous avons détecté une discontinuité qu'on peut associer très précisément avec la première imposition du crédit d'investissement (1964-66); de plus, le changement observé produit un phénomène important de sous-prévision de l'investissement. Ces deux observations semblent donc supporter l'hypothèse de Lucas.

1. Introduction

The aggregate investment schedule is a relationship for which the issue of stability over time is of special importance for macroeconomic policy. In particular, one may wish to use this schedule to study the impact of various policy measures such as changes in the nominal corporate tax rate, changes in depreciation allowances, investment tax credits, etc. An ingenious formulation of an investment function making possible such studies is due to Hall and Jorgenson (1967). Also, a particularly extensive simulation based on this model, aimed at studying the impact of investment tax credits in the United States over the period 1960-1985 was made by Gordon and Jorgenson (1976).

The importance of using, for such policy simulations, a model which exhibits a good stability over time is easy to understand. In particular, the parameters should be invariant with respect to the policy changes themselves. This point has been forcefully stressed by Lucas (1976). This author argues that since parameters in econometric relationships reflect economic agents' decision rules and these integrate knowledge about policies, changes in policies are likely to induce shifts in the parameters. Lucas describes three cases where such phenomena could be observed : the first one is linked to the aggregate consumption function, the second to the Hall-Jorgenson (1967) model of investment demand (and taxation) and the third to the Phillips curve. We will concentrate here on the second case in order to obtain some empirical evidence on the instability issue involved.

The argument of Lucas is that the effect of a change in the rate of an investment tax credit depends crucially on expectations concerning future changes in this rate. The impact of a given change in the rate of the tax credit will differ depending on expectations about future changes in the rate. Or, in other words, the response coefficient to a change in the rate of the tax credit depends on expectations about future changes in this rate. In particular, after developing a simple investment model, Lucas shows that the impact of a given change may be substantially bigger if it is thought to be transitory rather than permanent (once-and-for all)[1]. Thus, assuming the changes in the investment tax credit were considered permanent by the relevant economic agents while they were in fact thought transitory, may lead to appreciably underestimate the impact of the tax credit.

At the empirical level, if one wants to forecast accurately the effect of a proposed change in the tax credit, it is necessary that:

(1) the correct assumptions concerning expectations about future changes in the tax credit (following the proposed change) be used;

(2) the model be specified and estimated using the correct expectational assumptions over the historical period used for estimation.

Hall and Jorgenson (1967) as well as Gordon and Jorgenson (1976) assumed changes in tax rates were viewed as permanent. We will devote our attention here primarily to the second study. During the sampling period used for the estimation of the investment function of Gordon and Jorgenson (1956-72), five major changes in the tax credit took place. The tax credit was originally introduced to stimulate investment in 1962. Then "the effectiveness of the tax credit was increased substantially in 1964

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[1]More precisely, assuming the tax credit follows a Markovian scheme (which includes as special cases a permanent credit and a frequently imposed but always transitory credit), Lucas (1976) shows that the impact of the tax credit on investment can be much bigger if it is thought transitory rather than permanent. Indeed, under reasonable values of the parameters, the ratio of effects may be in the range of 4 to 7.

with the repeal of the Long Amendment[1]. The investment tax credit was suspended in 1966-67 and repealed in 1969 in order to reduce the level of investment. The tax credit was re-enacted in 1971 to stimulate investment expenditures"[2]. Thus, given this apparent instability of policy, it would not be surprising (if we follow Lucas' argument) to observe parameter instability in the Gordon-Jorgenson model (unless expectations effectively obeyed the scheme implicity assumed by Hall and Jorgenson). Also, if we estimate the model recursively (adding observations gradually), as suggested by Brown, Durbin and Evans (1975) and Dufour (1979,1982), we would expect the introduction of the investment tax credit to be associated with under-predictions of investment expenditures, since it is argued that the assumption of static expectations is likely to lead to underestimate the impact of the tax credit.

The precise model considered by Gordon and Jorgenson (1976) is of the form (for quarterly data) :

$$\text{(1.1)} \qquad IPDE58_t = \alpha + \delta K_t + \sum_{i=0}^{6} \beta_i V_{t-i} + u_t \quad .$$

$IPDE58_t$ is real investment (1958 dollars) in producer's durable equipment (during period t), K_t is gross, beginning of period, real capital stock of producer's durable equipment, V_t is a proxy for desired capital stock

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[1]The Long Amendment forbade to use for depreciation purposes that part of the cost of a capital asset financed by the tax credit.

[2]From Gordon and Jorgenson (1971, p. 278). We list the "effective tax credits" (1961-72), as measured by these authors, in Table 7. The "effective tax credit" could be non-zero for periods longer than the nominal credit because, once the credit was suspended or repealed, firms could still use a credit to which they were entitled but did not use when it was in force.

given by

$$V_t = (PGNP_{t-2})(GNP58_{t-1})/C_{t-2} \quad , \tag{1.2}$$

where $GNP58_t$ is real gross national product (1958 dollars)[1], $PGNP_t$ is the GNP price deflator and C_t is the rental cost of capital; u_t is a random disturbance. The cost of capital C_t is defined as

$$C_t = PIPDE_t\left[0.138 + R_t(1-U_t)\right]\left[1-U_tZ_t - TC_t + Y_tZ_tTC_tU_t\right]/(1-U_t) \quad , \tag{1.3}$$

where $PIPDE_t$ is the price deflator for investment in producer's durable equipment, 0.138 is the depreciation rate on producer's durable equipment as calculated by Christensen and Jorgenson (1969), U_t is the nominal corporate tax rate, R_t is the interest rate on new issues of High-Grade corporate bonds, Z_t is the present discounted value of depreciation allowances, TC_t is the effective tax credit and Y_t equals one during those years in which the Long Amendment applied and zero otherwise .

In order to estimate this model, Gordon and Jorgenson (1976) used a second degree Almon polynomial lag structure constrained to pass through zero after seven periods, i.e. it was assumed that

$$\beta_i = a_o - a_1 i - a_2 i^2 \quad , \quad i = 0,1,\ldots,7 \tag{1.4}$$

with $\beta_7 = a_o - 7a_1 - 49a_2 = 0$, so that there are effectively only two free parameters in the distributed lag over V_t. Under these conditions, the relation to be estimated takes the form :

$$IPDE58_t = \alpha + \delta K_t + a_1 W_{1t} + a_2 W_{2t} + u_t \quad , \tag{1.5}$$

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[1] $IPDE58_t$ and $GNP58_t$ are seasonally adjusted and measured at annual rates

where

$$(1.6) \qquad W_{1t} = \sum_{i=0}^{6} (7-i)V_{t-i} \quad , \qquad W_{2t} = \sum_{i=0}^{6} (49-i^2)V_{t-i}$$

Furthermore, since the original Durbin-Watson statistic was 0.7554, a first-order autoregressive transform was used ($\hat{\rho}$ = .6223) and the following result was obtained (based on the period 1956-72[1]) :

$$(1.7) \qquad \underset{}{IPDE58_t} = \underset{(1.522)}{-9.656} + \underset{(0.0163)}{0.0572}\, K_t + \underset{(0.00071)}{0.00181}\, V_t + \underset{(0.00033)}{0.00218}\, V_{t-1}$$

$$+ \underset{(0.00019)}{0.00233}\, V_{t-2} + \underset{(0.00031)}{0.00228}\, V_{t-3} + \underset{(0.00038)}{0.00202}\, V_{t-4}$$

$$+ \underset{(0.00036)}{0.00156}\, V_{t-5} + \underset{(0.00023)}{0.00088}\, V_{t-6}$$

$$R^2 = 0.9577 \quad , \qquad DW = 1.9788$$

In this paper, the stability over time of the above model is analyzed. For this purpose, an "exploratory" methodology aimed at being sensitive to a wide variety of instability patterns is used; it is based on estimating recursively the model under study and considering associated paths of coefficient estimates and prediction errors. An especially interesting aspect of this approach for our problem is that it can give us

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[1]Effective observations, not including those observations which are "lost" via the lagging process and the autoregressive transformation. The standard errors are given in parenthesis. R^2 is the multiple correlation coefficient and D.W. the Durbin-Watson statistic (both for the transformed model).

information on the timings of parameter shifts and the directions of resulting prediction errors, one of the implications of Lucas' conjecture for this model. For a detailed description of the methodology followed and its statistical bases, the reader is referred to Dufour (1982). Another purpose of the study is precisely to illustrate the working and usefulness of the recursive approach to the analysis of the stability of econometric models.[2]

Along these lines thus, we present, in Section 2, the results of three different recursive estimation experiments relating to model (1.5) over the period 1956-1972 (and using the data of Gordon and Jorgenson, 1976). First, we estimate (1.5) recursively by ordinary least squares. Second, since Gordon and Jorgenson (1976) corrected the model for autocorrelation (which, in some cases, may be a rather ad hoc correction for a problem of parameter instability), it is important that we look how the conclusions may be affected after making such a correction; thus we do a similar experiment on the correspondingly transformed model (using $\hat{\rho} = .6223$, the same estimate of ρ as Gordon and Jorgenson) :

$$(1.8) \qquad IPDE58_t(\hat{\rho}) = \alpha(1-\hat{\rho}) + \delta K_t(\hat{\rho}) + a_1 W_{1t}(\hat{\rho}) + a_2 W_{2t}(\hat{\rho}) + \varepsilon_t^*$$

where $IPDE58_t(\hat{\rho}) = IPDE58_t - \hat{\rho}\, IPDE58_{t-1}$, $K_t(\hat{\rho}) = K_t - \hat{\rho}\, K_{t-1}$, etc.[1] Finally, we must deal with an extra problem : the capital stock K_t cannot rigorously be considered as being non-stochastic and independent of the full set of the disturbances u_t for it is a function of past investment. Thus the

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[1]See Dufour (1982, Section 2.5) for a discussion of this procedure.

[2]Another illustration, which concerns the stability of the demand for money during the German hyperinflation, may be found in Dufour (1981b).

regressor K_t may be viewed as a form of lagged dependent variable and the tests performed in the two first experiments cannot be considered exact. As suggested in Dufour (1982, Section 2.5), what can be done in such a case is to get rid of the troublesome regressor $K_t(\hat{\rho})$ by subtracting $\hat{\delta}K_t(\hat{\rho})$ on both sides of (1.6) where $\hat{\delta}$ is the estimate of δ based on the full sample; we thus consider the regression :

$$\text{(1.9)} \qquad IPDE58_t(\hat{\rho}) - \hat{\delta}K_t(\hat{\rho}) = \alpha(1-\hat{\rho}) + a_1 W_{1t}(\hat{\rho}) + a_2 W_{2t}(\hat{\rho}) + \varepsilon_t^*$$

where $\hat{\delta} = 0.0572$ and $\hat{\rho} = .6223$, and we perform the recursive estimation experiment on the remaining coefficients [1].

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[1] Of course, this third experiment involves losing some of the advantages of "recursivity" (we cease to estimate δ recursively), hence quite probably a loss of power. But it appears necessary in the present circumstances as a cross-check of the results obtained without taking into account the presence of the lagged dependent variable.

2. Recursive Stability Analysis

We first estimate equation (1.5) recursively without any transformation (1956/I-1972/IV)[1]. The recursive estimates obtained are listed in Table 1 and graphed in Figures 1A-1D; the recursive residuals (one to four and eight-steps ahead) are listed in Table 2A, with a number of test statistics in Table 2B[2], and they are graphed in Figures 2A-2E.

If we look first at the recursive estimates, we can distinguish at least four phases (for all coefficients): the first phase (say, up to 1961/I) is characterized by wide fluctuations (and somewhat "weird" values, especially at the very beginning[3]) and a rough trend (upward for α and a_1, downward for δ and a_2); then we can observe a period of relative stability showing no trend (1961/II-1963/III), except for δ which trends upward from 1962/IV; third (1963/IV-1966/IV), we notice a very definite period of trend (downward for α and a_2, upward for δ and a_1), during which all coefficients change sign[4] and fourth, over the rest of the sample period (1967/I-1972/IV), a_1 and a_2 move in the direction opposite to the one followed before while α and δ seem to stabilize. The fourth quarter of 1963 and the last quarter of 1966 clearly appear to be breaking points. Let us now look at the (one-step ahead) recursi residuals. Although there is no systematic tendency to over or underpredict over the full period (as indicated by the global location tests in Table 2B), we can observe a run of 13 consecutive underpredictions from 1963/IV to 1966/I a very surprising outcome if the assumed model is correct (the probability of

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[1]Of course, given that K_t is a form of lagged dependent variable and if disturbances are autocorrelated, least squares coefficient estimates will be inconsistent. Nevertheless, the appearance of "autocorrelation" may be a sympt of an instability problem and thus an experiment without such a correction seem indicated. In any case, it will allow us to illustrate how a misspecification may lead to the observation of parameter instability in a recursive estimation experiment.

[2]The test statistics in Table 2B, as well as those in Tables 4B and 6 are based on the (one-step ahead) recursive residuals. We report systematicall three categories of tests (general tests, run tests and serial dependence tests which can be compared and cross-checked [see Dufour (1982, Section 4)].

[3]This is not too surprising since, at the beginning, few observations are used for estimation.

[4]This is, by itself, a somewhat preoccupying behaviour.

obtaining at least one run of this length or more is .0065, under the null hypothesis). The total number of runs (of over- or under-predictions) is extremely small (16) in relation to the sample size and there is strong evidence of serial dependence (at least up to a distance of 3 quarters).

Indeed the striking features of the trajectory of the recursive residuals consist in a first period exhibiting a tendency to overpredict (negative residuals) up to 1963/III[1] followed by a long run of 13 consecutive under-predictions (1963/IV-1966/IV), a "breaking point" between 1966/IV and 1967/I, another run of 9 under-predictions (1967/IV-1969/IV), while the sequel looks relatively "random". We can also observe that the two, three and four-steps ahead recursive residuals show basically the same pattern, in fact a substantially more definite (or "cleaner") pattern. It is quite interesting to compare the observed trajectory of the recursive residuals with the movement in the effective investment tax credit[2]. The long run of under-predictions starts (1963/IV) roughly with the repeal of the Long Amendment (1964/I) and extends as long as the effective tax credit is non-zero (till 1966/IV); then we can note a discontinuity in the series (1967/I) which takes place with the suspension of the tax credit, while the following run of under-predictions (1967/IV-1969/IV) can be associated (although more weakly than in the previous case) with the reimposition of the tax credit (1967/II-1969/I)[3]. With respect to the same issue it is also instructive to compute t-statistics to test the null hypothesis of a zero mean (from the one-step ahead recursive residuals) over the separate subperiods corresponding to the different

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[1] This phenomenon is also indicated by the CUSUM test (see Figure 2F). Note also that the CUSUM of Squares test is not significant (at level .05).

[2] See Table 7 for a listing of variables TC_t (effective tax credit rate) and U_t (dummy for Long Amendment) from 1961/I to 1972/IV.

phases of the tax credit (as given in Table 7)[1]. We have the following set of results:

Period[2]	t	p-value[3]
1962/I -1966/III	2.553	.0200
1964/I -1966/III	8.834	.00000251
1967/II-1969/I	1.724	.128
1971/II-1972/IV	1.127	.303
Remainder[4]	-3.790	.000705

It is remarkable that each period where the effective tax credit is non-zero corresponds to a positive t-value (indicating a tendency to under-predict) while the period in which it does not apply produces a negative t-value. The indication is particularly strong (significant) for the first application of the tax credit (especially after the repeal of the Long Amendment). Thus, estimating recursively equation (1.5) by ordinary least squares (and making abstraction of the fact that the capital stock K_t may be viewed as a form of lagged dependent variable), we find several signs of instability. These, in particular, point to the presence of a substantial shift contemporaneous with the first imposition of the investment tax credit, especially after the repeal of the Long Amendment. Furthermore, the instability involved induced systematic under-prediction of

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[1]This is justified by the fact that the (one-step ahead) recursive residuals are i.i.d. $N[0,\sigma^2]$ under the null hypothesis [see Dufour (1982, Section 4.3)].

[2]1962/I-1966/III corresponds to the first application of the tax credit; 1964/I-1966/III is the same period after the repeal of the Long Amendment; 1967/II-1969/I corresponds to the second application and 1971/II-1972/IV to the third.

[3]Marginal significance level.

[4]1957/I-1961/IV, 1966/IV-1967/I, 1969/II-1971/I.

the level of investment expenditures over this period. In other respects, the two other applications of the tax credit do not seem to have induced a significant effect (although still loosely in the same direction).

Let us now consider the results of a similar experiment applied to equation (1.8), i.e. to model (1.5) after correction for autocorrelation (using $\hat{\rho} = .6223$). The recursive estimates are listed in Table 3 and graphed in Figures 3A-3D; the recursive residuals (one to four and eight-steps ahead) are listed in Table 4A, with a number of test statistics in Table 4B, and they are graphed in Figures 4A-4E.[1] With respect to the recursive estimates, we still distinguish four phases corresponding basically to the same subperiods: first (1957/I-1961/I) wide fluctuations with rough trends (upward for α and a_2, downward for and a_1); second (1961/II-1963/III), a period of relative stability showing no trend (except in the case of δ which starts to go up near 1961/IV; thirdly (1963/IV-1966/IV), a very neat trend for all coefficients (downward for α and a_2, upward for δ and a_1) during which all coefficients change sign; fourth (1967/I-1972/IV), a period where all coefficients seem to stabilize. If we then consider the (one-step ahead) recursive residuals (Figure 4A), the pattern appears more "random" than without the transformation (compare with Figure 2A). Global location tests and serial correlation tests are not significant at standard levels (say .10). Nevertheless, a tendency to overpredict is still visible in the earlier period (up to 1963/II) and, especially, a run of 14 consecutive under-predictions from 1963/III to 1966/IV, followed by a sudden drop (1967/I), as observed in the preceding case.[2] The 1967/IV-1969/IV run (of under-predictions) disappears. These observations are very eloquently confirmed when considering the several-

[1]The recursive residuals obtained in this way are not, of course, exact (for the true value of ρ is unknown). Nevertheless, since $\hat{\rho}$ is a consistent estimate of ρ, their use is justified in large samples. See Dufour (1982, Section 2.5).

[2]By the way, it is interesting to compare the residuals in Figure 4A (recursive) with the corresponding generalized least squares residuals in

steps ahead recursive residuals (Figures 4B-4E). There are thus continuing signs of instability, in association particularly with the first application of the tax credit (especially after the repeal of the Long Amendment). If we compute, as we did previously, t-statistics over the separate subperiods corresponding to the different phases of the tax credit, we obtain :

Period	t	p-value
1962/I -1966/III	2.178	.0429
1964/I -1966/III	6.066	.0000812
1967/II-1969/I	1.130	.256
1971/II-1972/IV	.194	.853
Remainder[1]	-1.839	.0762

As in the first experiment, we can see that the t-values over each period of application of the tax credit are positive, while, for the rest, we get a negative t-value. Moreover, the t-value for the first period of application is significant (at level .04) and very strongly significant (at level .00008) if the period where the Long Amendment applied is excluded.

Finally, we consider the results of a recursive estimation experiment on equation (1.9), in order to take into account the fact that K_t is truly a form of lagged dependent variable. The recursive estimates are listed in Table 5 and graphed in Figures 5A-5C; the

[1] 1957/I-1961/IV, 1966/IV-1967/I, 1969/II-1971/I.

recursive residuals (one to four and eight-steps ahead) are listed in Table 6A, with a number of test statistics in Table 6B, and they are graphed in Figures 6A-6E. With respect to the recursive estimates, we can still observe more or less the same four phases: first (1956/IV-1961/I) wide fluctuations with rough trends (upward for α and a_2, downward for a_1); second (1961/II-1963/II), a period of relative stability; third (1963/III-1966/IV), a clear trend (downward for α and a_2, upward for a_1); fourth (1967/I-1972/IV), a period where all coefficients seem to stabilize. With respect to the (one-step ahead) recursive residuals (see Figure 6A), we note now that none of the test statistics in Table 6B nor the CUSUM and CUSUM of Squares test (Figures 6F and 6G) are significant (at level .05). In particular, the longest run test is not conclusive[1]. Nevertheless, the several-steps ahead recursive residuals (Figures 6B-6E) do not seem to be affected in the same way and still exhibit basically the same pattern as in the previous experiment; in particular, the two and three-steps ahead recursive residuals show continous runs of under-predictions covering the period 1963/III-1966/IV. Indeed, the similitude between Figure 4A and Figure 6A (showing one-step ahead recursive residuals) is itself striking: we note a tendency to over-predict up to 1963/II and a tendency to underpredict over the period 1963/III-1966/IV, while the rest looks relatively "random". If we compute t-values over the separate subperiods coresponding to the separate phases of the tax credit, we find results basically similar to the ones obtained before:

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[1]Two residuals, in the middle of the longest run previously observed (1963/III-1966/IV) were lowered hence "cutting" the run.

Period	t	p-value
1962/I -1966/III	2.197	.0414
1964/I -1966/III	4.697	.000653
1967/II-1969/I	.957	.370
1971/II-1972/IV	.105	.920
Remainder[1]	-1.944	.0613

The t-value attached to 1962/I-1966/III (first application of the tax credit) is positive and significant at level .04 while, for the period 1964/I-1966/III (after the repeal of the Long Amendment), it is significant at level .00065. The contrast between the periods of applications of the tax credit (which produce positive t-values) and the remainder of the period (which produces a negative t-value) is again to be noted.

Thus, although in a less conclusive form than with the two previous experiments, we can still observe a phenomenon of under-prediction associated with the first imposition of the tax credit (especially after the repeal of the Long Amendment). For the two other applications of the tax credit, we do not observe significant effects (although the corresponding t-values are positive and thus also indicate a tendency to over-predict).

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[1]1956/IV-1961/IV, 1966/IV-1967/I, 1969/II-1971/I.

3. Conclusions

The results obtained in this recursive stability analysis are not as clear and definite as those obtained, for example, for the German demand for money (Dufour, 1982). They are confused, in particular, by the presence of a regressor (the capital stock) which contains lagged values of the dependent variable. Nevertheless, one feature remains constant throughout the three experiments performed : there appears to be a discontinuity associated with the introduction of the first investment tax credit (1962/I-1966/III), especially after the repeal of the Long Amendment (1964/I); furthermore, the discontinuity is of a type that induces under-prediction of investment, a behaviour in contrast with the performance of the model before 1962 (which rather runs in the direction of over-prediction). This phenomenon of underprediction appears quite in line with Lucas' forecast. There is also some indication of a tendency to overpredict investment for the two other periods where the tax credit was in force (1967/II-1969/I and 1971/II-1972/IV), as suggested by the corresponding t-values, but these are too small to be considered significant. Indeed, the latter part of the sample (1967/II-1972/IV) exhibits few signs of instability.

Thus, on the whole, we find some evidence of the type of instability suggested by Lucas (1976), although it appears difficult to qualify this evidence as being very "strong" or "neat". Of course, one could try to explain the instability observed by a misspecification other than the one pointed out by Lucas (e.g. the Almon lag scheme used may be wrong) : in any event, whatever the "true" problem may be, it certainly appears desirable to know about its existence.

TABLE 1

Gordon-Jorgenson Model: Recursive Estimates (OLSQ)

1956/I-1972/IV

Quarter[1]	α	δ	a_1	a_2
5604.00	-326.103	1.60907	-.183925E-01	.188617E-02
5701.00	-355.784	1.79364	-.199596E-01	.206323E-02
5702.00	-200.381	.932479	-.113596E-01	.112599E-02
5703.00	-258.436	1.19964	-.145160E-01	.145229E-02
5704.00	103.822	-.271887	.447562E-02	-.442390E-03
5801.00	51.1300	-.300592	.380831E-02	-.478510E-03
5802.00	-201.516	.523348	-.787180E-02	.603300E-03
5803.00	-213.330	.522995	-.769193E-02	.560510E-03
5804.00	-133.619	.189926	-.283355E-02	.649800E-04
5901.00	-121.607	.144214	-.219748E-02	.244000E-05
5902.00	-127.728	.165565	-.246805E-02	.277200E-04
5903.00	-86.0046	.338894E-01	-.105992E-02	-.915900E-04
5904.00	-57.8165	-.476400E-01	-.553050E-03	-.120360E-03
6001.00	-40.0100	-.949120E-01	-.464830E-03	-.111350E-03
6002.00	-39.3876	-.964764E-01	-.462950E-03	-.110880E-03
6003.00	-27.3596	-.126249	-.452580E-03	-.986500E-04
6004.00	-12.9099	-.160771	-.541270E-03	-.723200E-04
6101.00	7.84770	-.207378	-.792980E-03	-.197200E-04
6102.00	20.9628	-.232534	-.115271E-02	.372500E-04
6103.00	27.2526	-.239741	-.114895E-02	.465700E-04
6104.00	29.2462	-.240695	-.113877E-02	.489700E-04
6201.00	29.3131	-.240695	-.113832E-02	.490500E-04
6202.00	28.3852	-.241252	-.114867E-02	.482300E-04
6203.00	28.2689	-.241966	-.119889E-02	.533600E-04
6204.00	28.8155	-.231895	-.796810E-03	.130000E-04
6301.00	30.0117	-.212312	-.755780E-03	.171900E-04
6302.00	31.4756	-.194131	-.113955E-02	.686900E-04
6303.00	31.8001	-.191389	-.125712E-02	.833000E-04
6304.00	31.2270	-.194311	-.104893E-02	.580800E-04
6401.00	30.2549	-.196535	-.734860E-03	.205500E-04
6402.00	28.9430	-.196112	-.410030E-03	-.179400E-04
6403.00	27.4055	-.194510	-.186340E-03	-.451800E-04
6404.00	26.2529	-.191088	-.748500E-04	-.586200E-04
6501.00	23.7241	-.180714	.202190E-03	-.907600E-04
6502.00	21.4365	-.169362	.458480E-03	-.119830E-03
6503.00	17.2606	-.146380	.891050E-03	-.168220E-03
6504.00	12.7149	-.118630	.130624E-02	-.213810E-03
6601.00	7.46455	-.836871E-01	.168839E-02	-.254660E-03
6602.00	2.23885	-.460996E-01	.195926E-02	-.282220E-03
6603.00	-2.75181	-.904949E-02	.224798E-02	-.311510E-03
6604.00	-6.22412	.171677E-01	.250586E-02	-.338100E-03
6701.00	-3.04297	-.738840E-02	.223000E-02	-.309490E-03
6702.00	-2.27927	-.127493E-01	.205964E-02	-.290840E-03
6703.00	-1.59584	-.183420E-01	.197673E-02	-.282160E-03
6704.00	-2.54202	-.929898E-02	.191798E-02	-.274420E-03
6801.00	-5.92124	.243956E-01	.152845E-02	-.226280E-03
6802.00	-6.34494	.287144E-01	.146892E-02	-.219020E-03
6803.00	-7.19575	.374653E-01	.134443E-02	-.203870E-03
6804.00	-7.58745	.414820E-01	.129306E-02	-.197560E-03
6901.00	-8.73867	.530791E-01	.118089E-02	-.183410E-03
6902.00	-8.96801	.553892E-01	.116397E-02	-.181200E-03
6903.00	-9.19697	.577508E-01	.114571E-02	-.178820E-03
6904.00	-9.34596	.592068E-01	.117170E-02	-.181520E-03
7001.00	-8.95453	.553149E-01	.104239E-02	-.167640E-03
7002.00	-8.79821	.536169E-01	.994000E-03	-.162500E-03
7003.00	-9.12312	.575655E-01	.997320E-03	-.162200E-03
7004.00	-7.91518	.420551E-01	.121271E-02	-.188980E-03
7101.00	-7.83756	.410342E-01	.123473E-02	-.191620E-03
7102.00	-8.27800	.468744E-01	.107112E-02	-.172310E-03
7103.00	-8.47859	.494901E-01	.975180E-03	-.161130E-03
7104.00	-9.08786	.571609E-01	.622520E-03	-.120450E-03
7201.00	-9.42687	.611671E-01	.405930E-03	-.956200E-04
7202.00	-9.40500	.609374E-01	.420800E-03	-.973100E-04
7203.00	-9.21286	.593377E-01	.541450E-03	-.110950E-03
7204.00	-9.20364	.592869E-01	.545400E-03	-.111390E-03

[1]End of sample (1956/I-   )

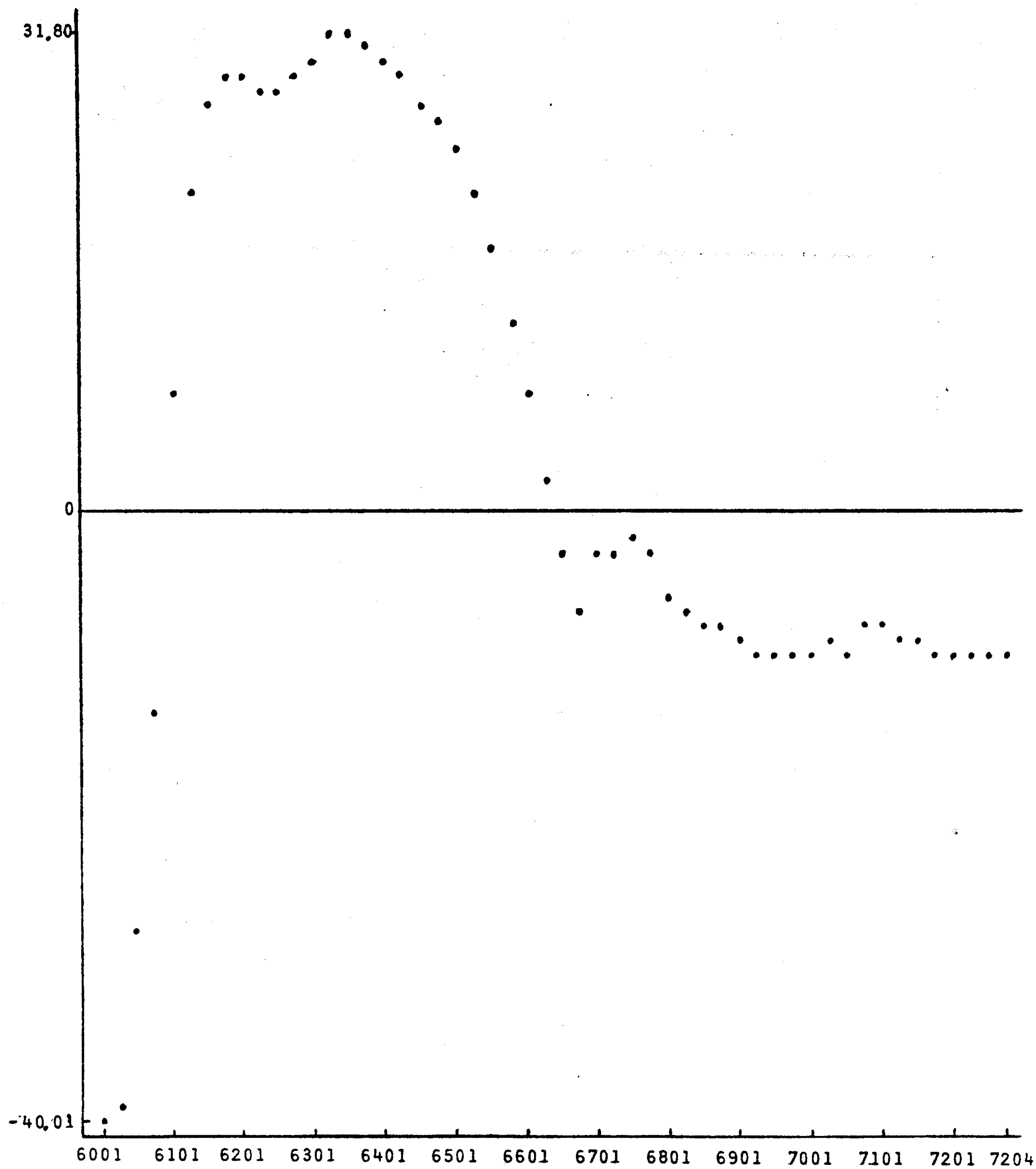

FIGURE 1A - Gordon-Jorgenson Model: Recursive Estimates of α (OLSQ)[1]

[1]The values up to 1959/IV are excluded from the graph because most of them are "too big". Similar remark for Figures 1B-D, 3A-D, 5A-C.

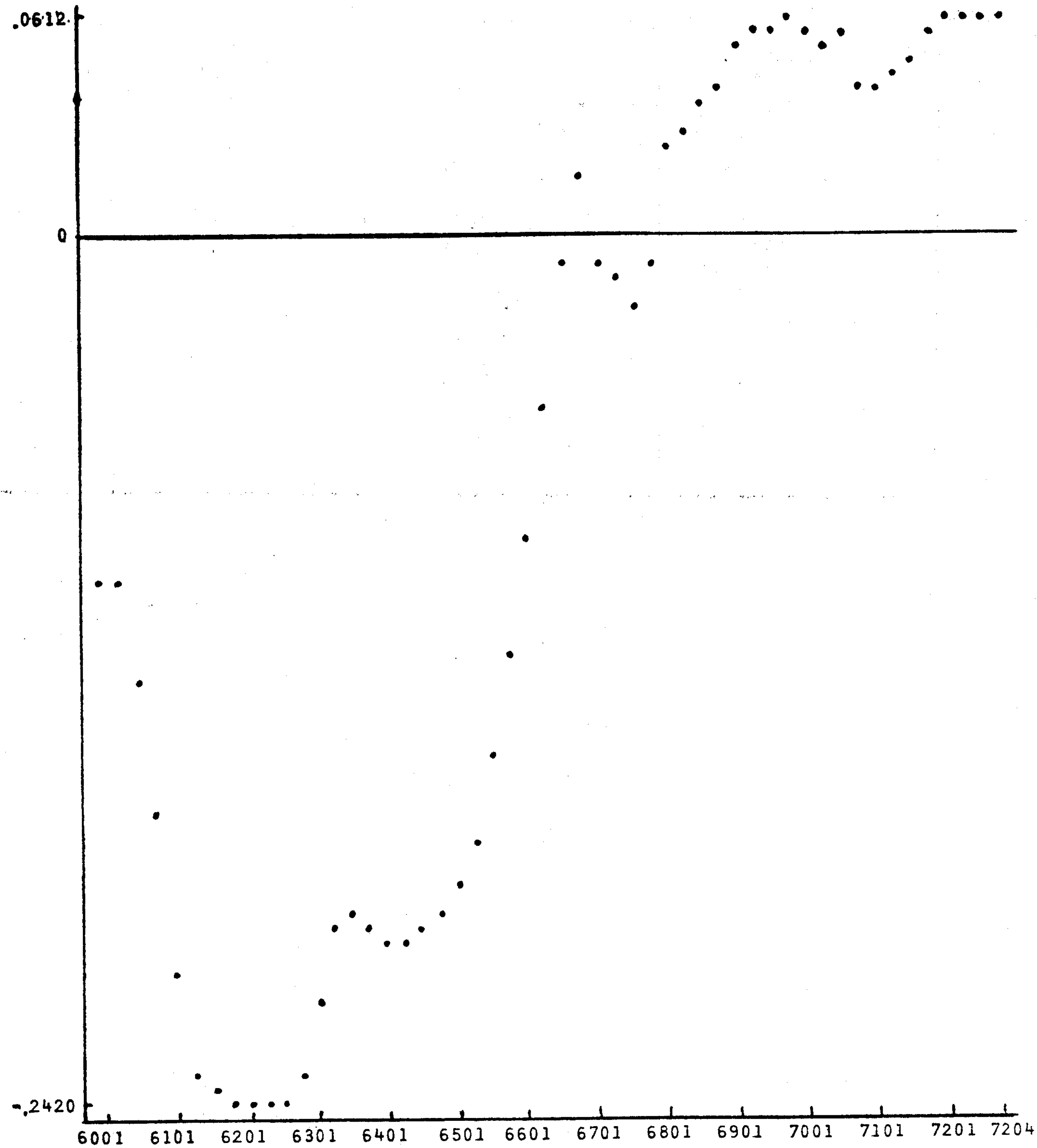

FIGURE 1B - Gordon-Jorgenson Model: Recursive Estimates of δ (OLSQ)

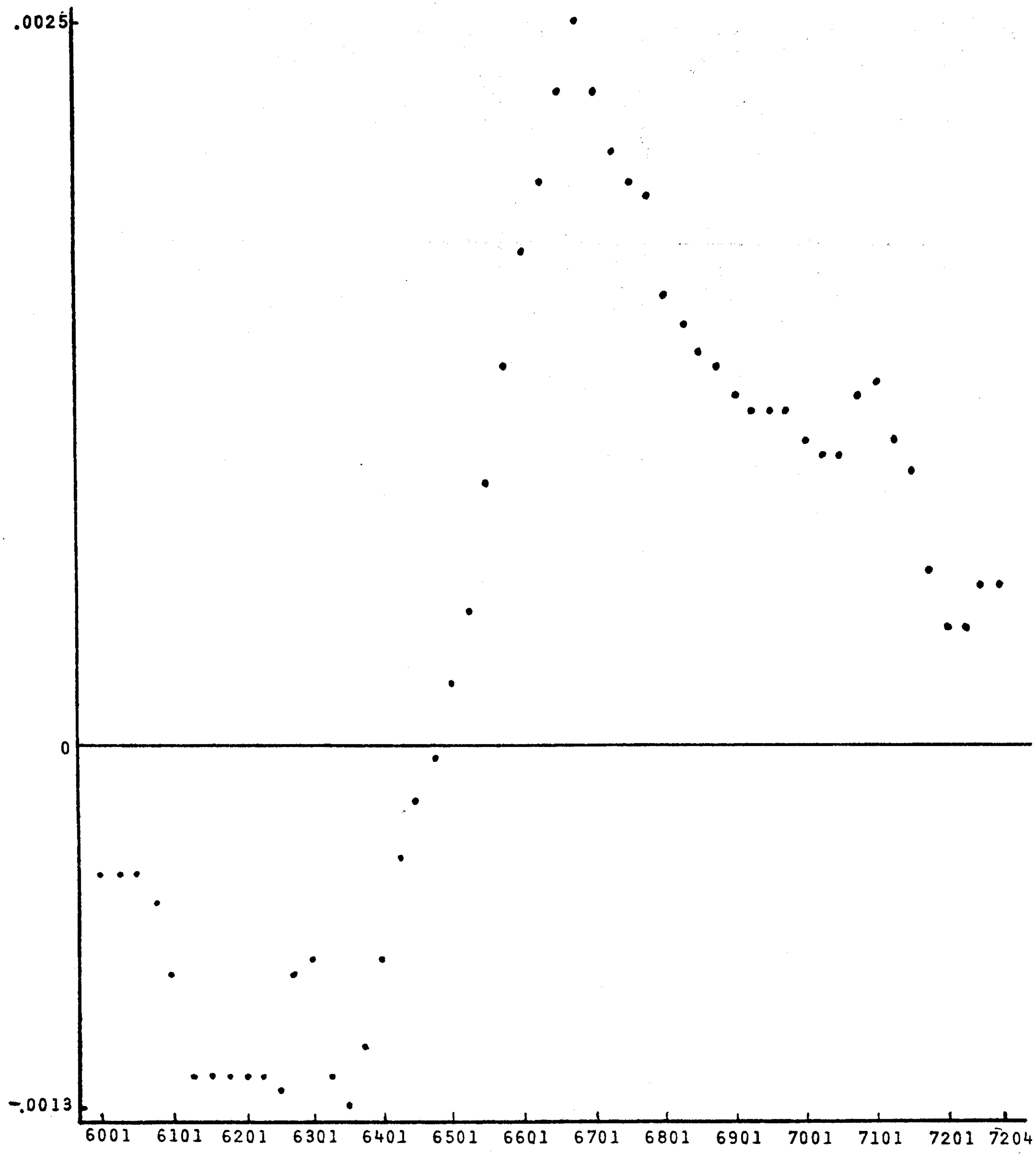

FIGURE 1C - Gordon-Jorgenson Model: Recursive Estimates of a_1 (OLSQ)

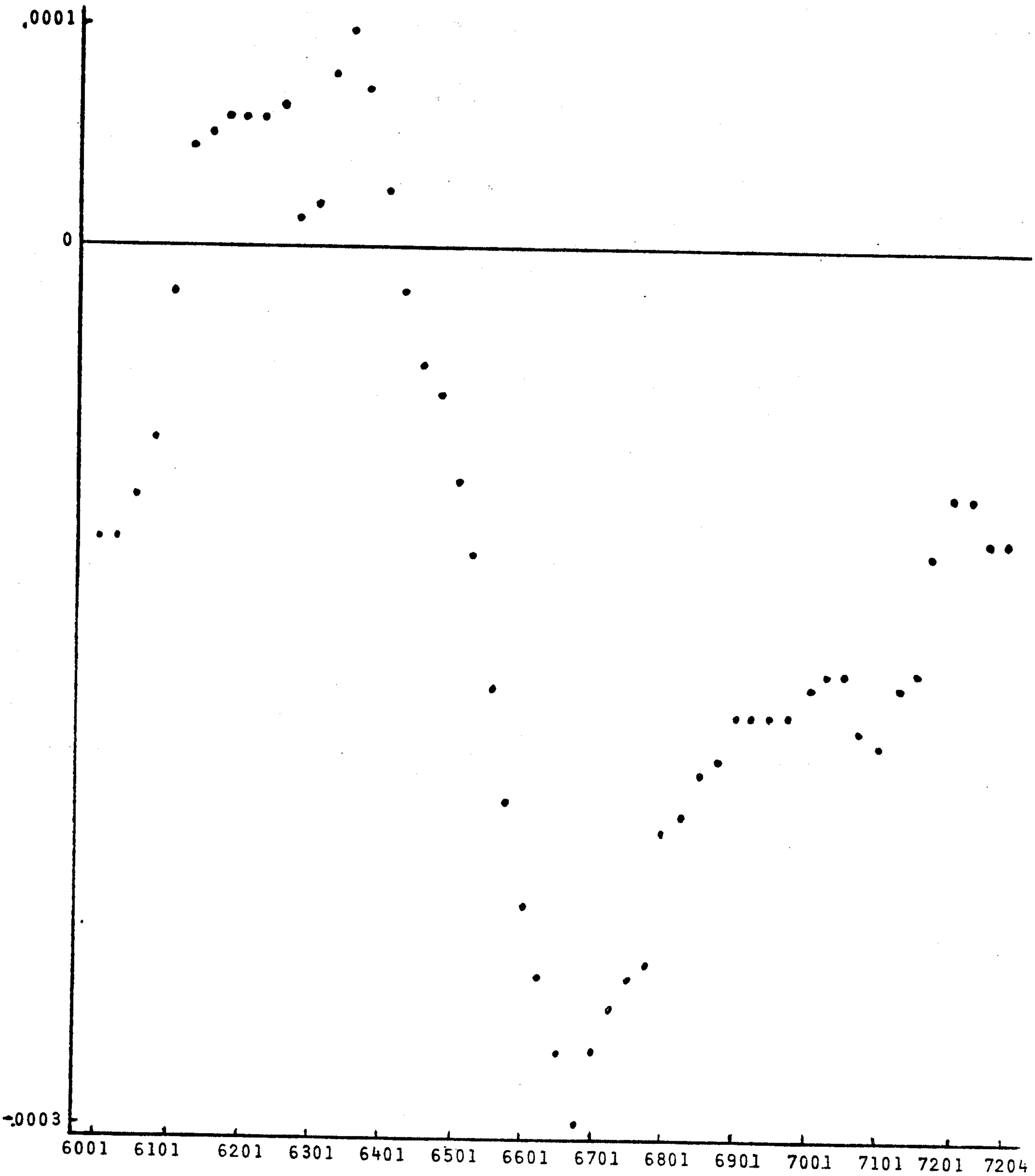

FIGURE 1D - Gordon-Jorgenson Model: Recursive Estimates of a_2 (OLSQ)

TABLE 2A

Gordon-Jorgenson Model: Recursive Residuals (OLSQ)

1957/I-1972/IV

Quarter[1]	RECF1[2]	RECF2	RECF3	RECF4	RECF8
5701.00	.357818E-01	0.	0.	0.	0.
5702.00	-.344723	-.824489E-01	0.	0.	0.
5703.00	.120167	-.241558	-.585280E-01	0.	0.
5704.00	-.935423	-.351524	-.483561	-.176727	0.
5801.00	-2.04387	-1.94285	-.764922	-.696671	0.
5802.00	-.969770	-1.67364	-1.46516	-1.11036	0.
5803.00	-.796603	-1.25508	-2.10779	-2.30558	0.
5804.00	-.831249	-1.01309	-.601838	-1.46396	-.276832
5901.00	-.162178	-.730342	-.844723	.885099E-01	-.564509
5902.00	.121453	-.394862E-01	-.652319	-.715626	-.349033
5903.00	-1.06616	-.681087	-.566173	-.996482	-.658250
5904.00	-1.11794	-1.54247	-1.04076	-.818519	.231374
6001.00	-.907771	-1.35424	-1.72163	-1.19407	.199977
6002.00	-.414690E-01	-.482498	-1.02357	-1.47529	-1.11299
6003.00	-1.05578	-.951924	-1.28864	-1.69881	-1.33530
6004.00	-1.65791	-1.94997	-1.71022	-1.92689	-1.25092
6101.00	-3.04991	-3.45022	-3.55445	-3.05741	-2.09879
6102.00	-2.44936	-3.31443	-3.69914	-3.76695	-3.05228
6103.00	-1.50728	-2.15884	-3.10130	-3.51081	-3.03434
6104.00	-.588587	-1.00796	-1.72926	-2.75373	-2.74874
6201.00	-.238491E-01	-.194138	-.667516	-1.45326	-2.58861
6202.00	.398205	.374461	.166929	-.365951	-3.00049
6203.00	.126367	.242354	.221039	-.254155E-02	-3.05701
6204.00	-1.27645	-1.09637	-.894438	-.843186	-3.42393
6301.00	-1.89849	-2.25431	-1.95764	-1.66525	-2.91848
6302.00	-1.55247	-2.15531	-2.48715	-2.17607	-2.25361
6303.00	-.250038	-.852312	-1.50987	-1.87450	-1.37497
6304.00	.397218	.240470	-.432526	-1.09986	-.952705
6401.00	.689805	.795105	.578467	-.135381	-.793128
6402.00	.971774	1.16626	1.21568	.939141	-.778703
6403.00	1.61535	1.82993	1.95461	1.91539	-.558196
6404.00	1.06178	1.41885	1.64907	1.78744	-.272944
6501.00	1.85327	2.04835	2.39798	2.58534	1.06671
6502.00	1.37985	1.78524	1.99291	2.36207	1.94383
6503.00	2.38961	2.66012	3.04861	3.22018	3.23956
6504.00	2.36044	2.89233	3.15963	3.54679	3.91615
6601.00	2.56069	3.08958	3.62773	3.87206	4.65271
6602.00	2.38182	2.97788	3.52380	4.06629	5.02395
6603.00	2.21741	2.80036	3.43382	3.90344	5.17071
6604.00	1.58479	2.20265	2.84233	3.51880	5.18114
6701.00	-1.57833	-.914229	-.792906E-01	.736942	3.23503
6702.00	-.544930	-1.13965	-.404572	.458570	3.41643
6703.00	-.504857	-.706619	-1.32350	-.528190	2.72704
6704.00	.454139	.253308	.756835E-02	-.661916	2.52777
6801.00	1.61674	1.66826	1.44339	1.17732	2.56179
6802.00	.251751	.913647	1.01898	.842885	1.40664

TABLE 2A(continued)

Quarter[1]	RECF1	RECF2	RECF3	RECF4	RECF8
6803.00	.685086	.728844	1.37120	1.43665	.947518
6804.00	.420879	.618989	.667951	1.32924	.271486
6901.00	1.60633	1.66055	1.79251	1.74221	1.69343
6902.00	.374977	.712641	.798389	.979769	1.41324
6903.00	.410651	.478438	.836154	.920727	1.76284
6904.00	.373479	.443668	.511301	.859745	1.75007
7001.00	-1.26358	-1.13770	-1.03615	-.932465	-.574585E-01
7002.00	-.568404	-.877775	-.751653	-.649759	.205172
7003.00	.922599	.765300	.416701	.499850	1.14705
7004.00	-2.77299	-2.50359	-2.56729	-2.79465	-1.63588
7101.00	-.171411	-.852942	-.628506	-.728711	-.581686
7102.00	1.01176	.923891	.160386	.354265	.207763
7103.00	.497430	.791176	.702334	-.633845E-01	-.539415E-01
7104.00	1.84262	1.89770	2.12844	1.96984	1.16619
7201.00	1.38766	1.96370	2.00627	2.23195	1.39959
7202.00	-.119159	.322885	.988081	1.10303	.678776
7203.00	-1.34017	-1.32819	-.849760	-.134454	-.333327
7204.00	-.745724E-01	-.291257	-.309686	.558641E-01	.935315

[1]Quarter of the observation predicted.

[2]RECFk refers to the k-steps ahead recursive residuals (k = 1, 2, 3, 4, 8).

TABLE 2B

Gordon-Jorgenson Model (OLSQ): Test Statistics[1]

Number of residuals = 64

			p-values[3]
Global Location Tests[2]	t-Test	.0619	.9506
	No of Positive Residuals	32	1.0000
	Wilcoxon Test	1053	.9307
Runs Tests[4]	No of Runs	16	.000019
	Length of the Longest Run	13	.0065
Serial Correlation Tests[5]	Modified Von Neumann Ratio	.6779	≤ .002
	Rank Tests		

Serial Correlation Tests[5] — Rank Tests

k	Signed-Rank Tests			Sign-Tests		
	S_k	S'_k	p-value	S_k	S'_k	p-value
1	1735	4.977	.00000065	48	4.158	.000038
2	1421	3.116	.0018	41	2.540	.0151
3	1284	2.431	.0150	37	1.664	.1237
4	1091	1.296	.1951	33	.7746	.5190
5	1041	1.177	.2390	33	.9113	.4350
6	1095	1.854	.0637	35	1.576	.1480
7	1058	1.839	.0659	35	1.722	.1112
8	983	1.509	.1313	32	1.069	.3497
9	1015	2.053	.0401	33	1.483	.1770
10	958	1.856	.0635	32	1.361	.2203
11	877	1.430	.1528	31	1.236	.2717
12	807	1.075	.2825	30	1.109	.3317

[1]Based on the one-step ahead recursive residuals.

[2]See Dufour (1982, Section 4.3). These are two-sided tests.

[3]Marginal significance levels.

[4]See Dufour (1982, Section 4.5). These are one-sided tests : $P[R \leq 16] = .000019$ and $P[L \geq 16] = .0065$, where R = no of runs (of + 's or -'s) and L = length of the longest run.

[5]S_k is a rank statistic for testing serial dependence [see Dufour (1982, Section 4.6)], where k is the lag used, $a_N(r) = 1$ for the sign test and $a_N(r) = r$ for the signed-rank test; $S'_k = (S_k - \mu_k)\sigma_k$, where $\mu_k = E(S_k)$ and $V(S_k) = \sigma_k^2$ under the null hypothesis. We consider here two-sided tests (against positive or negative serial dependence). For a more complete theory of these tests, see Dufour (1981).

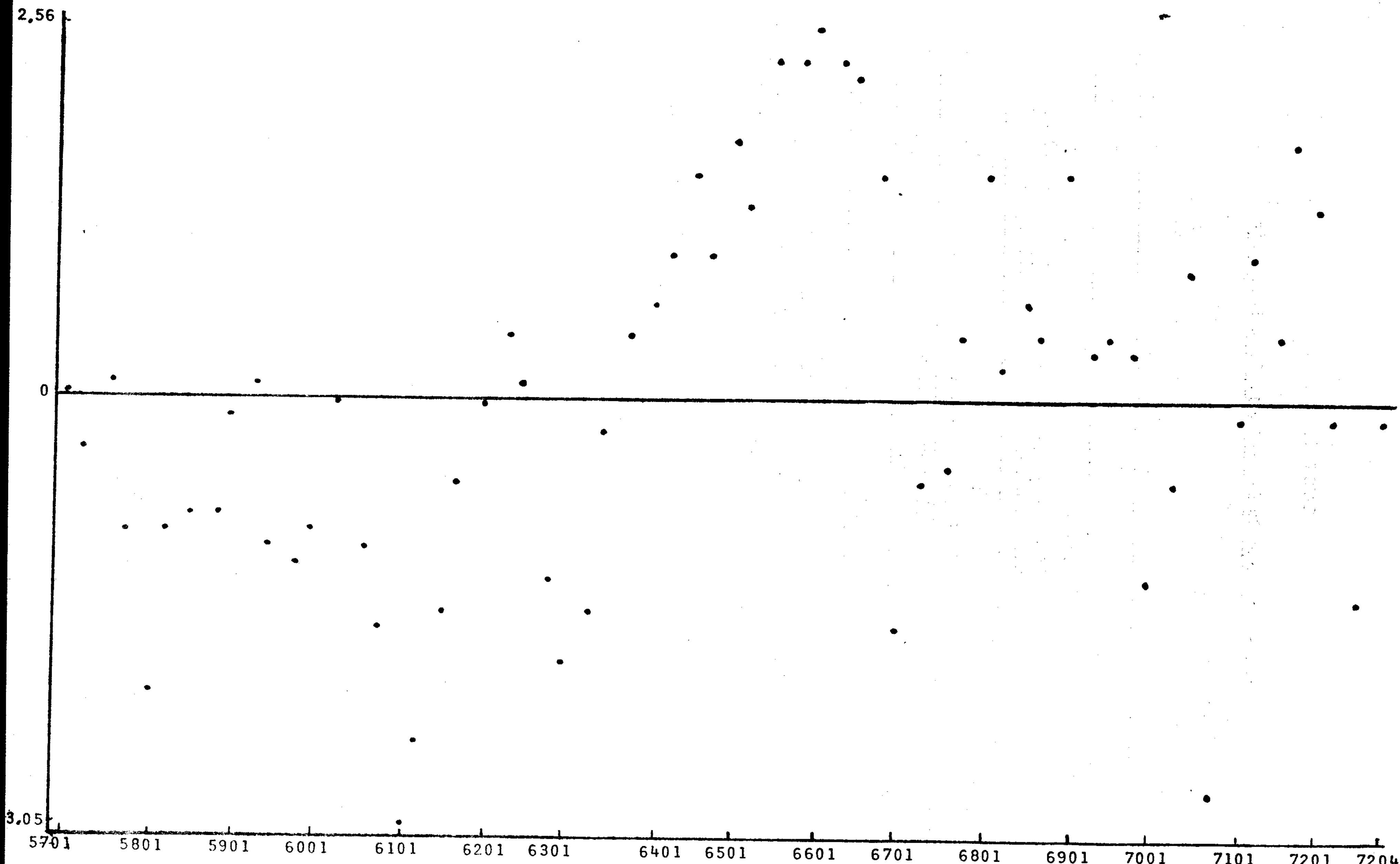

FIGURE 2A - Gordon-Jorgenson Model: One-Step Ahead Recursive Residuals (OLSQ)

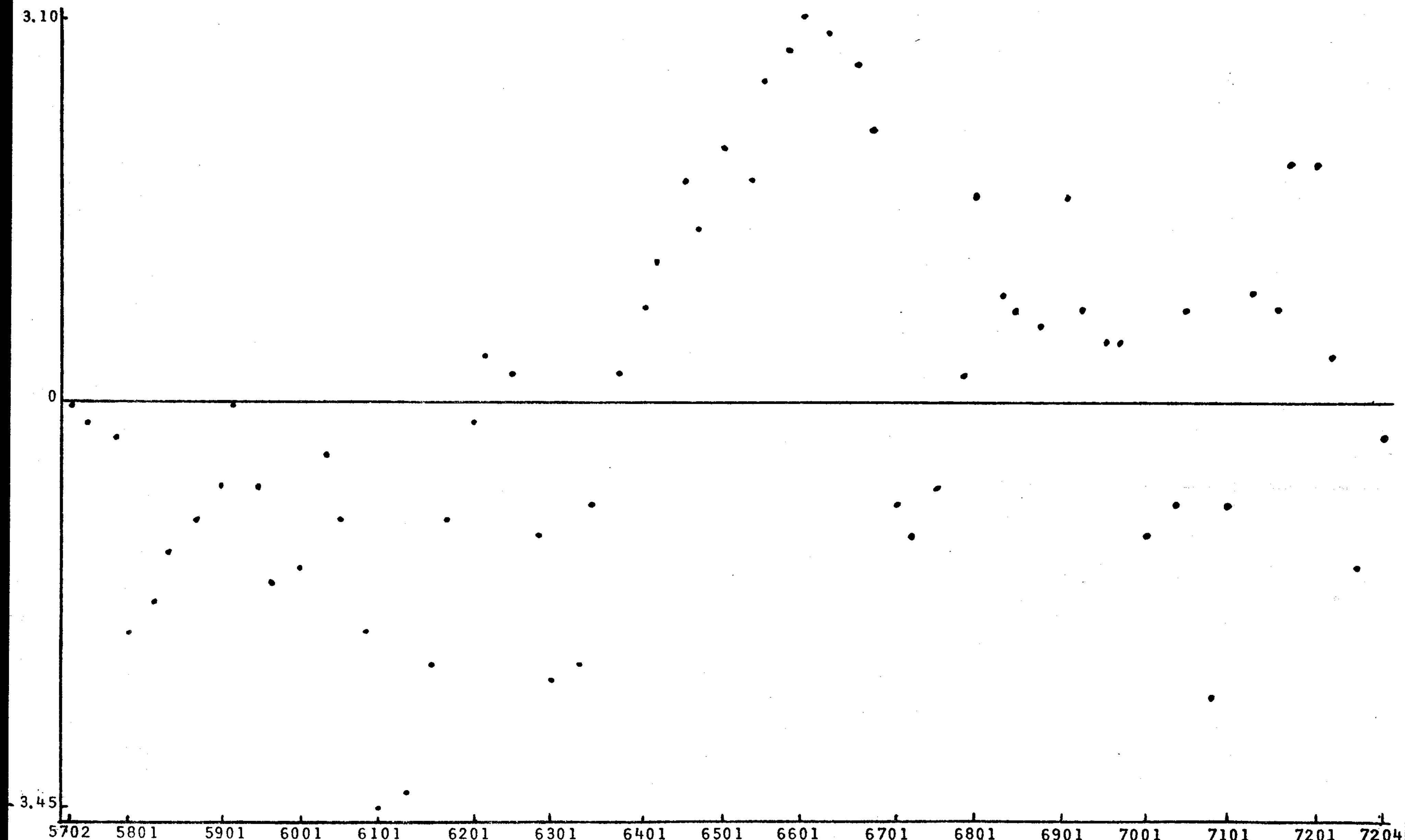

FIGURE 2B - Gordon-Jorgenson Model: Two-Steps Ahead Recursive Residuals (OLSQ)

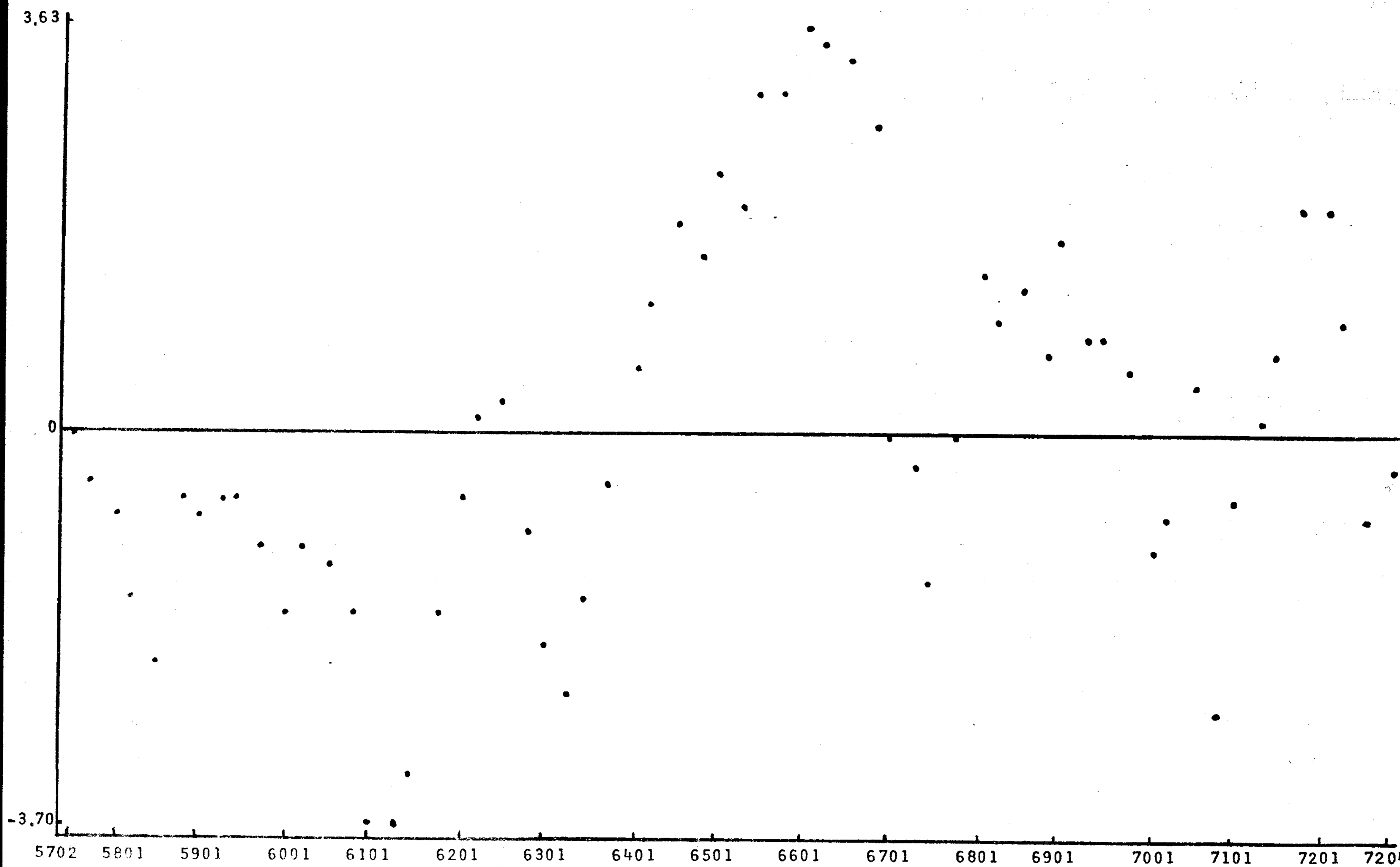

FIGURE 2C - Gordon-Jorgenson Model: Three-Steps Ahead Recursive Residuals (OLSQ)

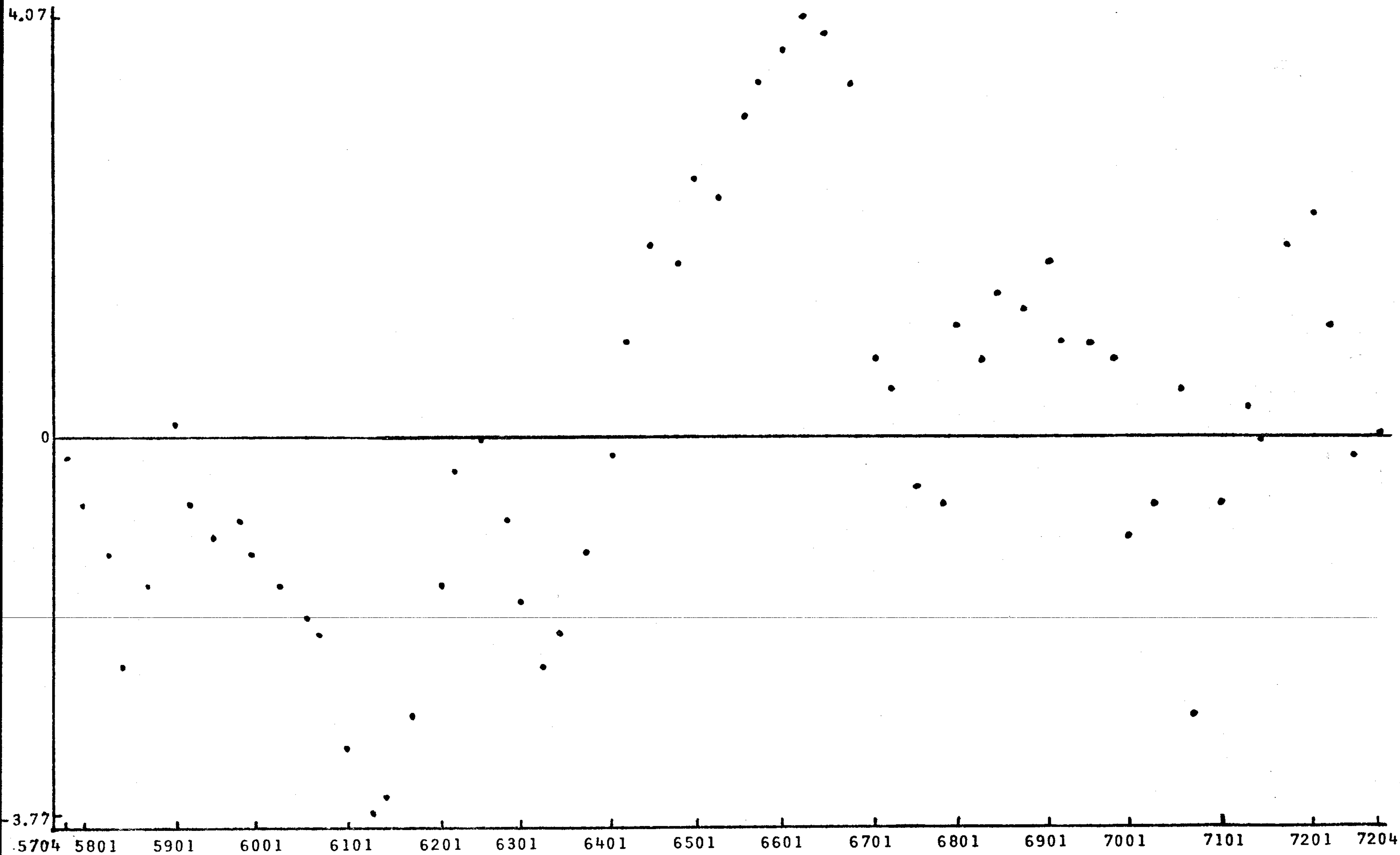

FIGURE 2D - Gordon-Jorgenson Model: Four-Steps Ahead Recursive Residuals (OLSQ)

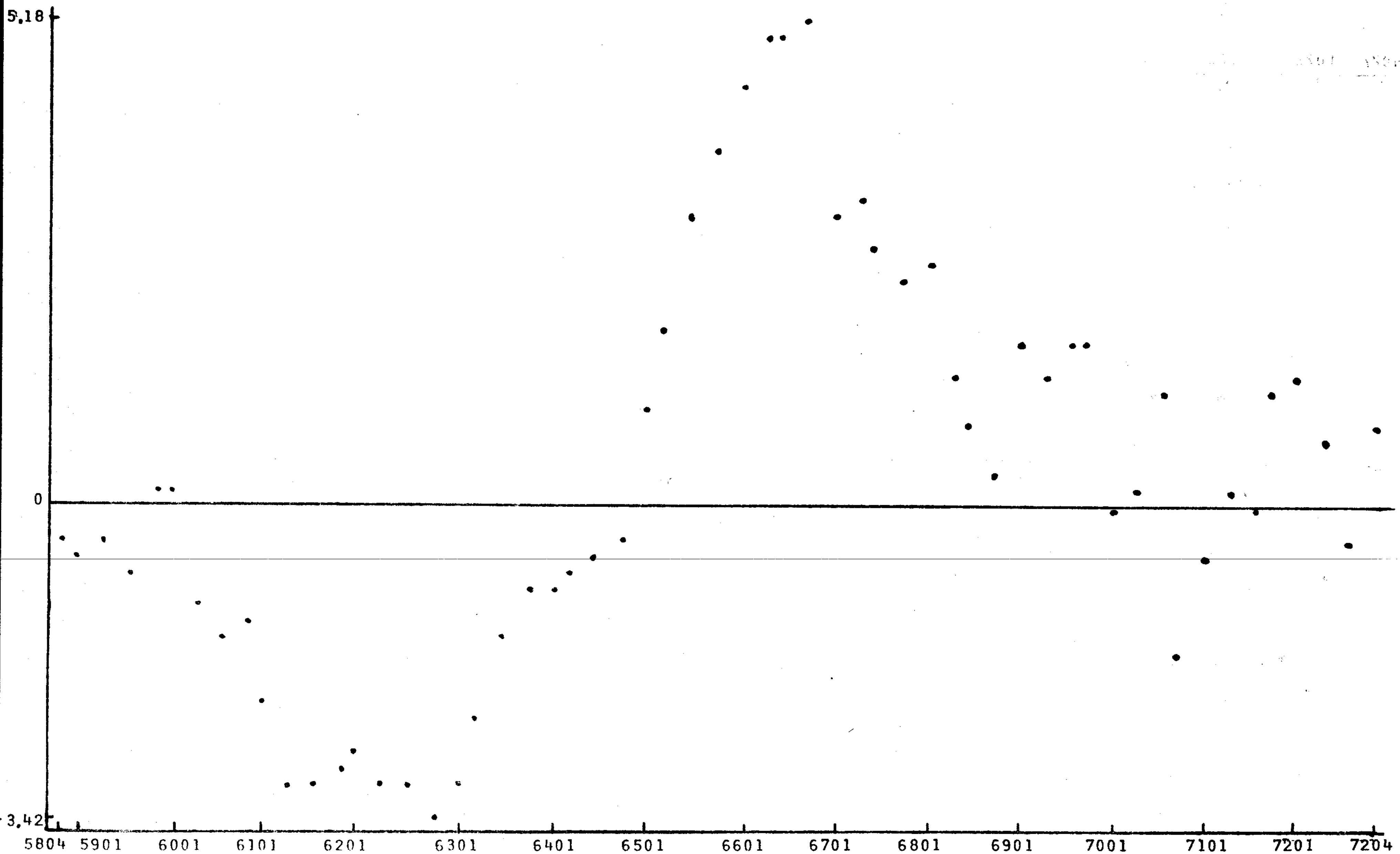

FIGURE 2E - Gordon-Jorgenson Model: Eight-Steps Ahead Recursive Residuals (OLSQ)

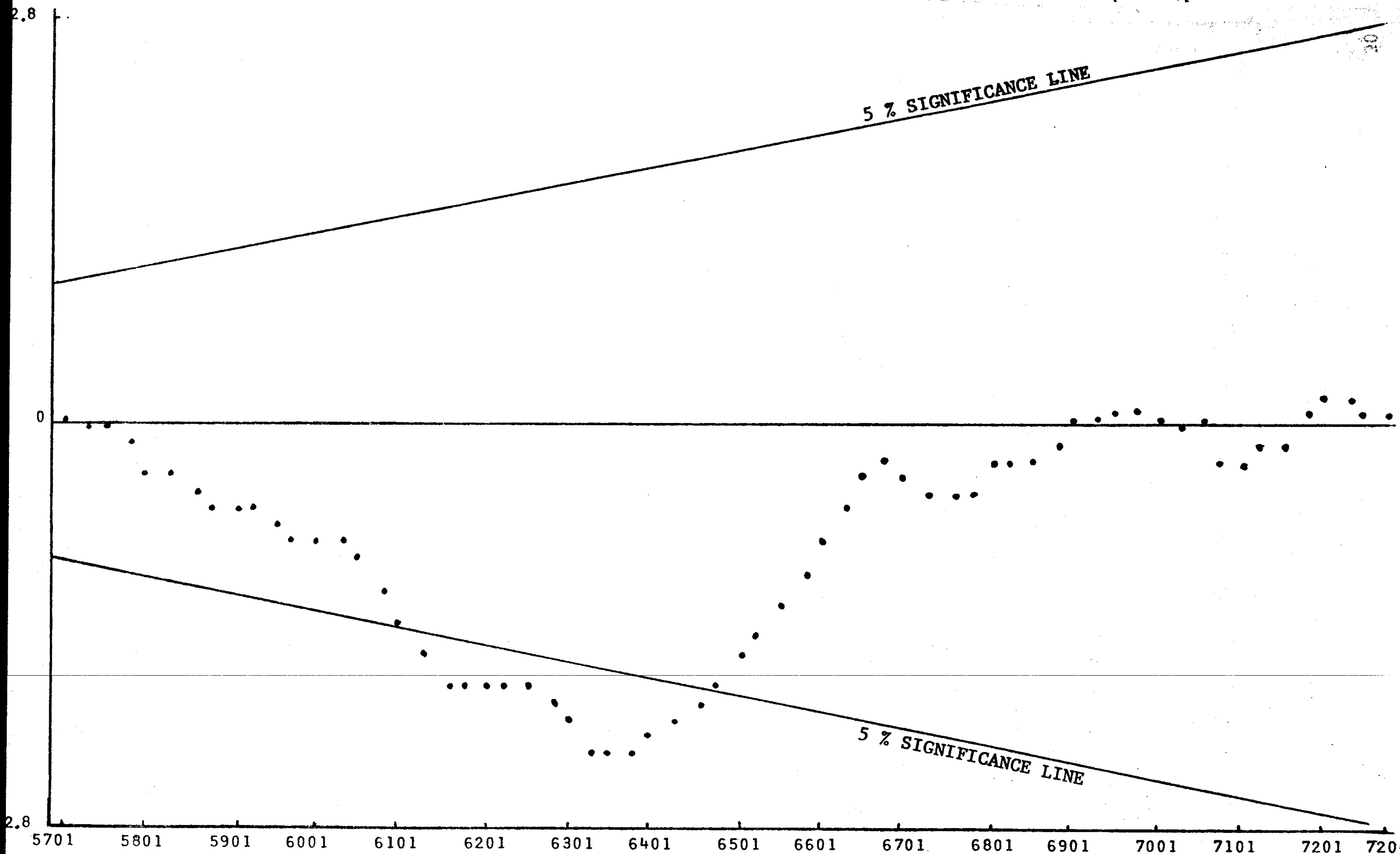

FIGURE 2F - Gordon-Jorgenson Model: CUSUM of Recursive Residuals (OLSQ)[1]

[1] Based on the one-step ahead recursive residuals.

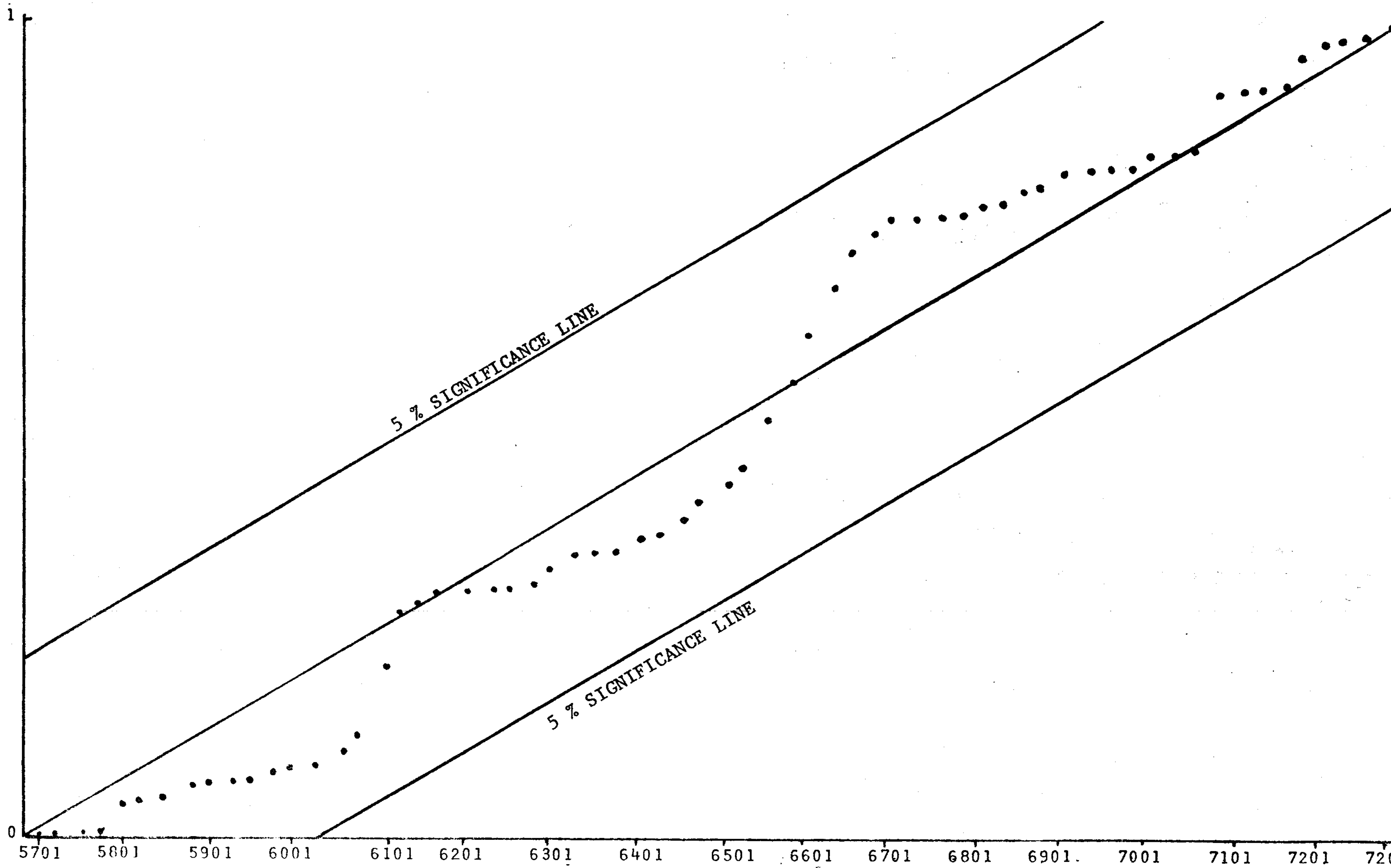

FIGURE 2G - Gordon-Jorgenson Model: CUSUM of Squares of Recursive Residuals (OLSQ)[1]

[1] Based on the one-step ahead recursive residuals.

TABLE 3

Gordon-Jorgenson Model: Recursive Estimates ($\hat{\rho}$ = .6223)

1956/I-1972/IV

Quarter	α	δ	a_1	a_2
5604.00	-363.748	-1.91163	.518633E-01	-.710690E-02
5701.00	-271.134	1.24255	-.222180E-02	.799600E-04
5702.00	-306.559	1.13282	.155615E-02	-.442480E-03
5703.00	-314.043	1.40918	-.489178E-02	.348860E-03
5704.00	255.343	-.771678	.724910E-02	-.623850E-03
5801.00	-390.875	1.17268	.566410E-02	-.104434E-02
5802.00	-313.137	.913366	.623072E-02	-.104370E-02
5803.00	-252.749	.748905	.239200E-02	-.556600E-03
5804.00	-259.519	.801848	-.622460E-03	-.217950E-03
5901.00	-277.244	.873323	-.137558E-02	-.144900E-03
5902.00	-273.937	.860795	-.133151E-02	-.147570E-03
5903.00	-103.161	.231265	-.721660E-03	-.951300E-04
5904.00	-50.1640	.342670E-01	-.144723E-02	.221500E-04
6001.00	-38.3509	-.894261E-02	-.163983E-02	.519400E-04
6002.00	-53.8004	.468043E-01	-.157717E-02	.337700E-04
6003.00	-23.0150	-.705826E-01	-.180887E-02	.796600E-04
6004.00	-.462214	-.155772	-.219601E-02	.137680E-03
6101.00	33.4245	-.278184	-.281945E-02	.231320E-03
6102.00	41.0973	-.302985	-.309990E-02	.268980E-03
6103.00	42.3626	-.303744	-.302924E-02	.263310E-03
6104.00	40.5652	-.301413	-.304556E-02	.262450E-03
6201.00	38.6987	-.298446	-.305022E-02	.260390E-03
6202.00	36.6418	-.296053	-.306303E-02	.258680E-03
6203.00	35.0770	-.275048	-.233840E-02	.182110E-03
6204.00	36.4972	-.241134	-.192264E-02	.149790E-03
6301.00	40.3477	-.222249	-.249006E-02	.226420E-03
6302.00	41.2835	-.219471	-.267170E-02	.249310E-03
6303.00	37.0177	-.220990	-.183046E-02	.147200E-03
6304.00	33.4978	-.213525	-.127597E-02	.813600E-04
6401.00	30.3777	-.201690	-.915440E-03	.393100E-04
6402.00	26.5522	-.181868	-.668920E-03	.112700E-04
6403.00	23.4592	-.166613	-.803300E-03	.255400E-04
6404.00	23.0605	-.164247	-.794070E-03	.245500E-04
6501.00	15.4255	-.117344	-.388450E-03	-.193500E-04
6502.00	13.6567	-.105738	-.297970E-03	-.288900E-04
6503.00	4.14655	-.413808E-01	.101710E-03	-.698700E-04
6504.00	-1.53345	-.639650E-03	.306170E-03	-.897800E-04
6601.00	-8.20061	.493642E-01	.466860E-03	-.103610E-03
6602.00	-12.3620	.820182E-01	.522670E-03	-.106820E-03
6603.00	-16.4799	.114366	.665440E-03	-.119750E-03
6604.00	-17.8388	.125164	.735110E-03	-.126490E-03
6701.00	-5.79023	.265277E-01	.848100E-04	-.640100E-04
6702.00	-8.58116	.464725E-01	.825200E-03	-.145170E-03
6703.00	-7.33953	.349505E-01	.834610E-03	-.147670E-03
6704.00	-7.93954	.408946E-01	.764620E-03	-.139050E-03
6801.00	-11.1720	.731919E-01	.378410E-03	-.914500E-04
6802.00	-8.52672	.466729E-01	.675280E-03	-.128290E-03
6803.00	-9.30884	.543967E-01	.607270E-03	-.119640E-03
6804.00	-9.25345	.538634E-01	.609840E-03	-.120000E-03
6901.00	-10.9859	.698044E-01	.602150E-03	-.117120E-03
6902.00	-10.2412	.625934E-01	.612440E-03	-.119250E-03
6903.00	-10.4238	.644700E-01	.603550E-03	-.117980E-03
6904.00	-10.7068	.672478E-01	.693020E-03	-.127580E-03
7001.00	-9.66048	.555920E-01	.497540E-03	-.107620E-03
7002.00	-9.90281	.585579E-01	.513390E-03	-.108880E-03
7003.00	-11.1171	.743164E-01	.339800E-03	-.867000E-04
7004.00	-7.68641	.283328E-01	.110335E-02	-.180270E-03
7101.00	-8.88680	.445555E-01	.781230E-03	-.141360E-03
7102.00	-9.60043	.540641E-01	.544860E-03	-.113260E-03
7103.00	-9.38522	.514271E-01	.642100E-03	-.124560E-03
7104.00	-10.1339	.596158E-01	.241290E-03	-.785700E-04
7201.00	-10.2521	.606785E-01	.182750E-03	-.719000E-04
7202.00	-9.90110	.584354E-01	.346520E-03	-.903000E-04
7203.00	-9.45596	.570885E-01	.471230E-03	-.103940E-03
7204.00	-9.65567	.572007E-01	.468680E-03	-.103920E-03

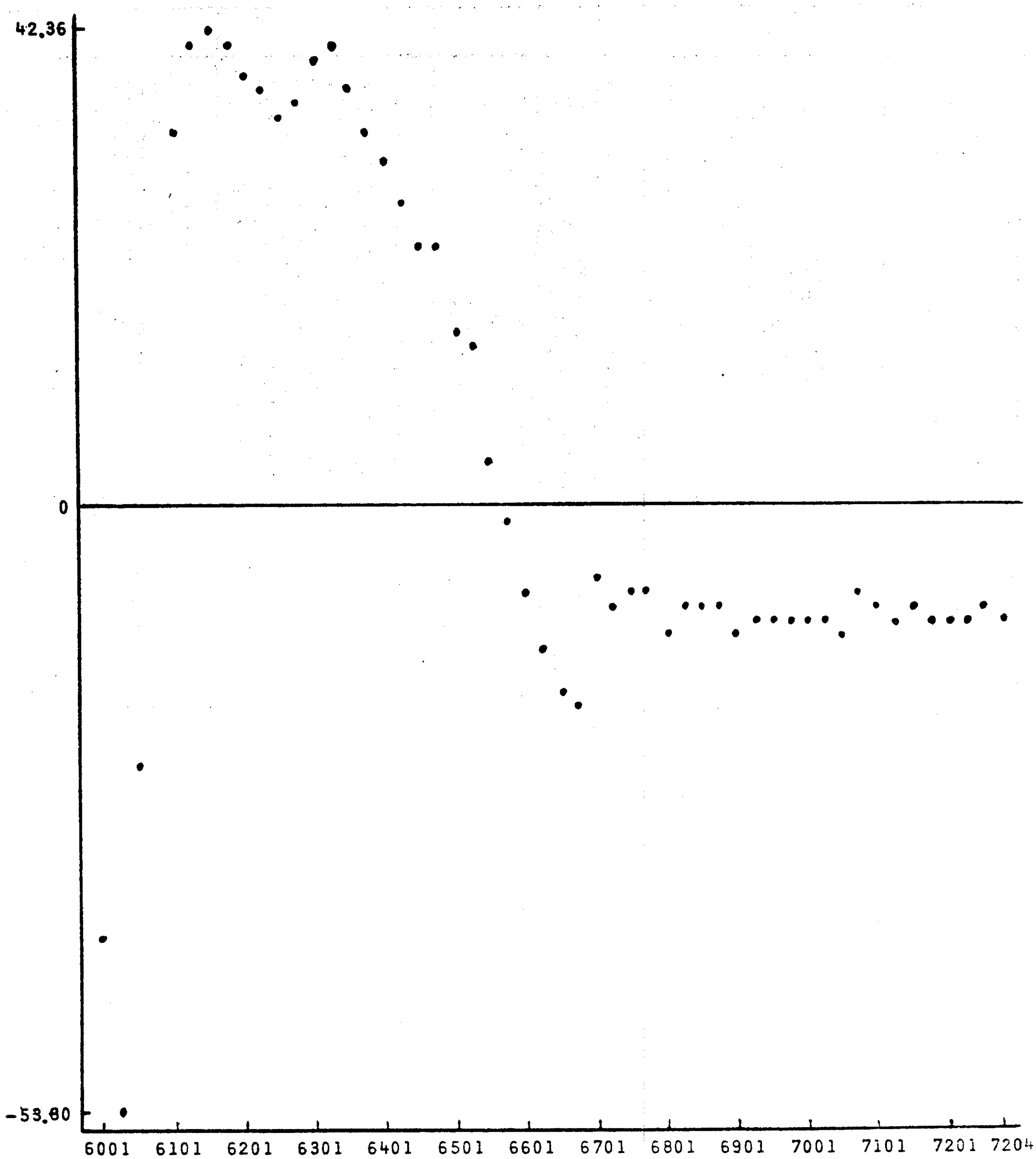

FIGURE 3A - Gordon-Jorgenson Model : Recursive Estimates of $\alpha(\hat{\rho} = .6223)$

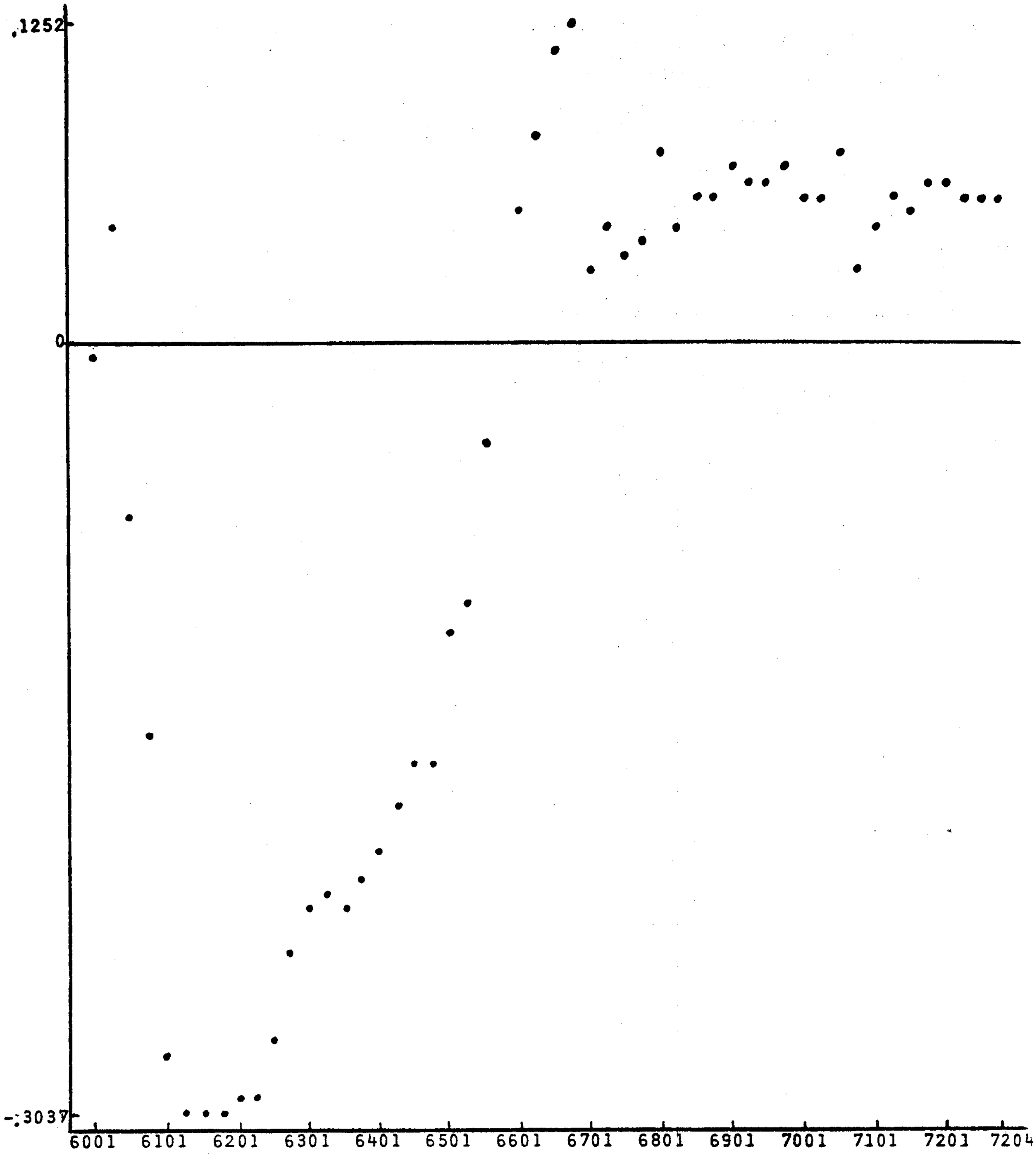

FIGURE 3B - Gordon-Jorgenson Model: Recursive Estimates of $\delta(\hat{\rho} = .6223)$

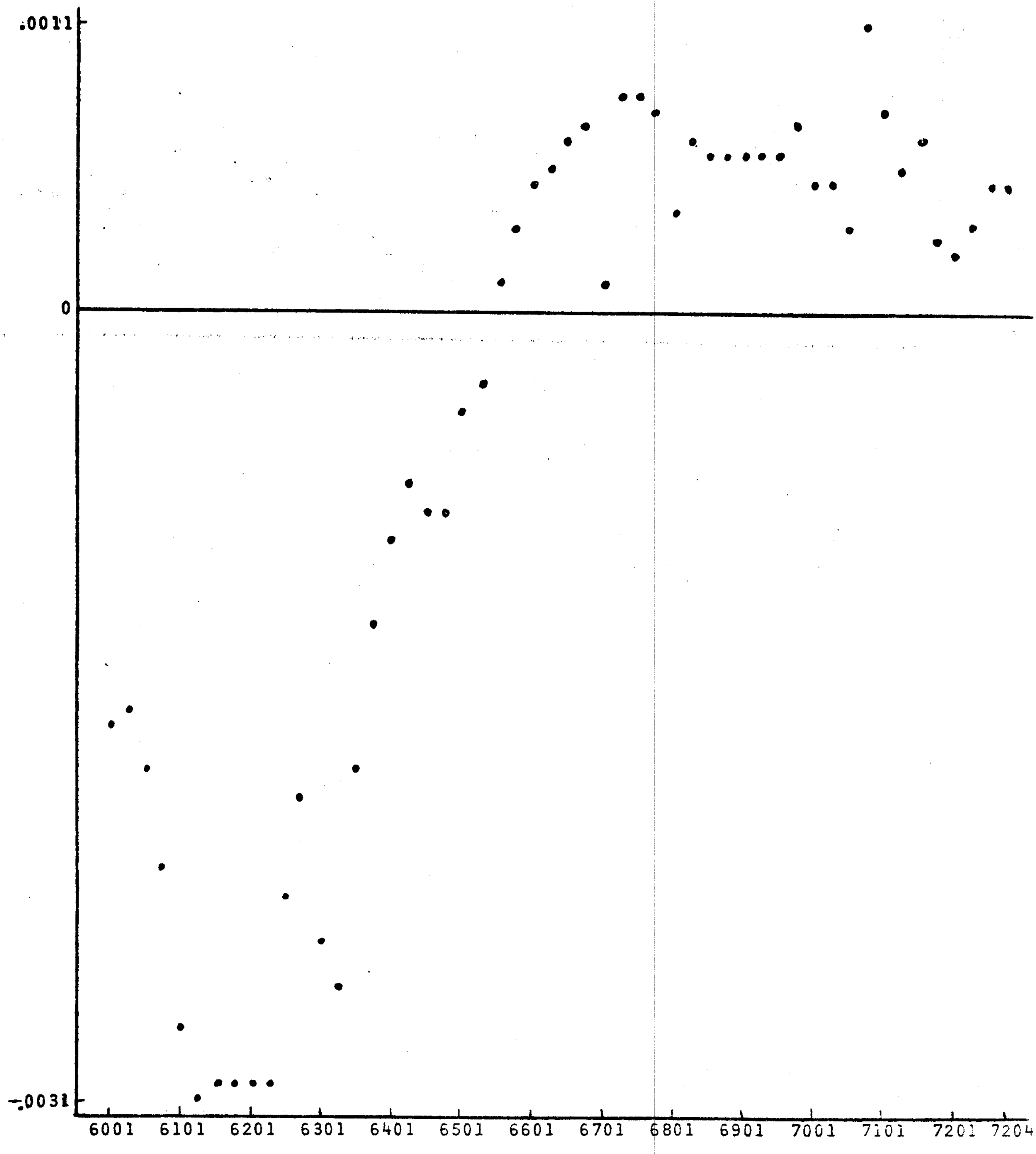

FIGURE 3C - Gordon-Jorgenson Model: Recursive Estimates of a_1 ($\hat{\rho}$ = .6223)

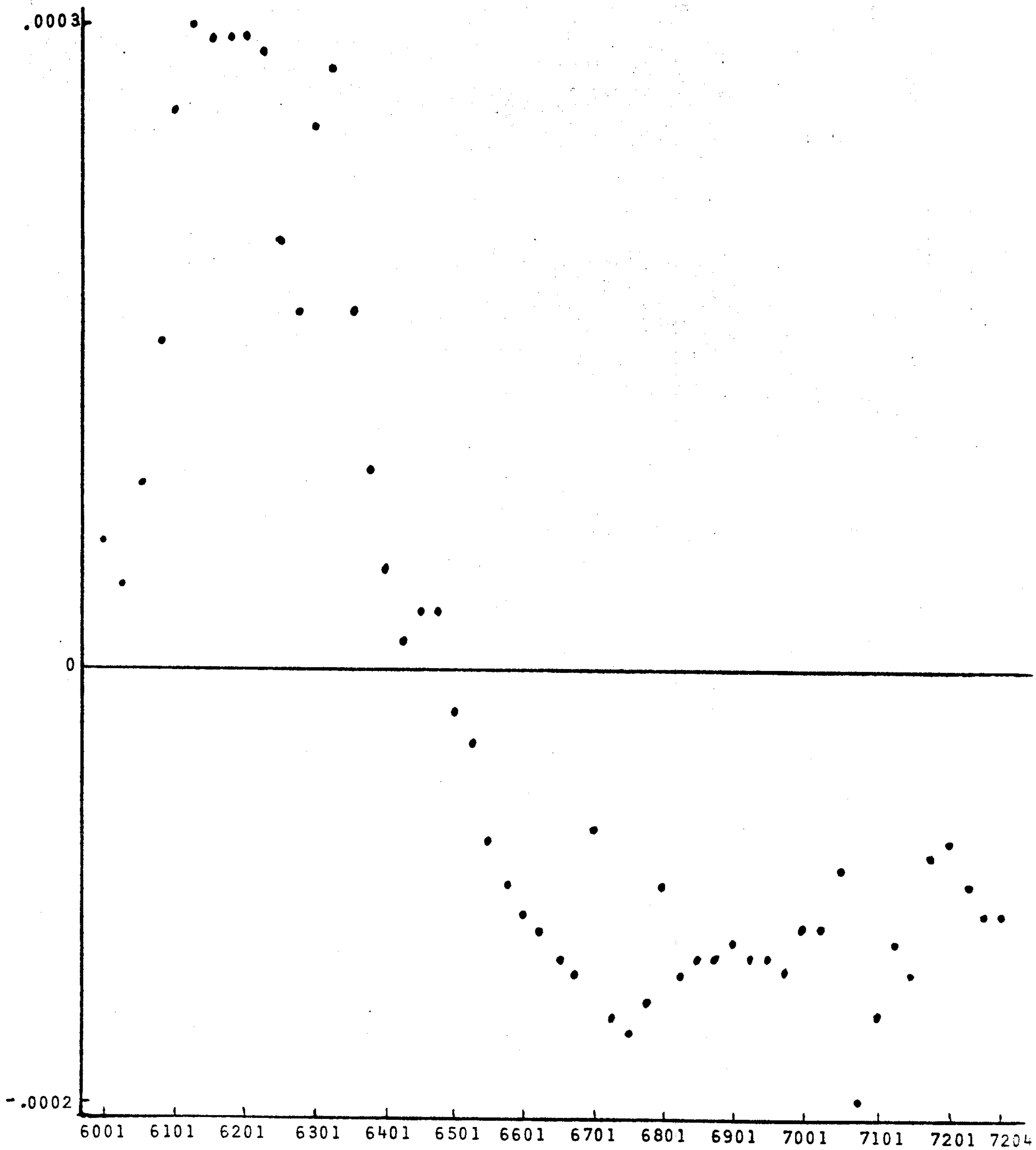

FIGURE 3D - Gordon-Jorgenson Model: Recursive Estimates of a_2 ($\hat{\rho}$ = .6223)

TABLE 4A

Gordon-Jorgenson Model: Recursive Residuals ($\hat{\rho} = .6223$)

1957/I-1972/IV

Quarter	RECF1	RECF2	RECF3	RECF4	RECF8
5701.00	.861672	0.	0.	0.	0.
5702.00	-.287580	.774472	0.	0.	0.
5703.00	.583232	.881855E-01	.859351	0.	0.
5704.00	-1.11262	-.400707	-.474460	.727316	0.
5801.00	-1.93988	-2.18752	-.981472	-.763085	0.
5802.00	.158300	-1.05038	-.411735	-.195995	0.
5803.00	.549209	.505935	-.719871	-.679754	0.
5804.00	.556452	.781836	.797495	.312080E-01	.783200
5901.00	.279880	.569665	.788367	.717501	-.166581
5902.00	-.301946E-01	.108922	.406180	.615887	.457856E-02
5903.00	-1.47404	-1.18670	-.907940	-.534578	-.448557
5904.00	-.686282	-1.47943	-1.25031	-1.06794	.420214
6001.00	-.231746	-.588567	-1.42682	-1.20447	-.608891
6002.00	.456752	.282156	-.195385	-1.19108	-.753106
6003.00	-1.12556	-.805971	-.803487	-1.05663	-1.10604
6004.00	-1.07772	-1.43891	-1.06418	-1.01000	-1.35863
6101.00	-2.12111	-2.36099	-2.61534	-2.07892	-1.90588
6102.00	-.630626	-1.18896	-1.48306	-1.81469	-2.03494
6103.00	-.176838	-.309637	-.904141	-1.22293	-1.25323
6104.00	.243970	.183904	.215625E-01	-.648484	-.914664
6201.00	.270187	.325051	.255593	.759075E-01	-.970369
6202.00	.344389	.403974	.457858	.371803	-1.43147
6203.00	-.528440	-.408761	-.311108	-.213945	-1.39787
6204.00	-1.49047	-1.55137	-1.34909	-1.17753	-1.81667
6301.00	-1.07811	-1.55044	-1.62578	-1.38962	-1.13186
6302.00	-.226633	-.645694	-1.13496	-1.25016	-.695494
6303.00	.855462	.671442	.143797	-.349217	-.835360E-01
6304.00	.649300	.966897	.757065	.212860	-.960698E-01
6401.00	.569109	.780248	1.08905	.860941	-.123869
6402.00	.671528	.813988	1.00152	1.28090	-.175613
6403.00	1.04888	1.16602	1.27158	1.41397	.404249E-01
6404.00	.778999E-01	.302583	.465562	.619036	.272419
6501.00	1.23879	1.22215	1.41795	1.55316	1.60970
6502.00	.257726	.586320	.586701	.801344	1.54319
6503.00	1.54365	1.55464	1.84570	1.79798	2.21923
6504.00	.832721	1.22509	1.24422	1.56935	1.92748
6601.00	.992003	1.19267	1.59664	1.58160	2.14774
6602.00	.609698	.880565	1.10160	1.53266	1.98712
6603.00	.648547	.810999	1.09809	1.32179	1.98875
6604.00	.237405	.455221	.643133	.960593	1.97349
6701.00	-2.41159	-2.12349	-1.69170	-1.33058	.211967
6702.00	1.05775	-.783413E-01	.351760E-01	.301412	1.56513
6703.00	-.288004	.244229	-.867529	-.660025	.650333
6704.00	.104050	.803257E-02	.177431	-.671723	.413239
6801.00	.874075	.804847	.667871	.819867	.504793
6802.00	-.999884	-.574932	-.434692	-.506734	-.635353

TABLE 4A(continued)

Quarter	RECF1	RECF2	RECF3	RECF4	RECF8
6803.00	.401749	.872024E-01	.418159	.411499	-.335805
6804.00	-.356371E-01	.552811E-01	-.235565	.110127	-.724393
6901.00	1.37995	1.34910	1.40427	1.07190	1.26603
6902.00	-.606598	-.353006	-.352814	-.246190	-.187192
6903.00	.153207	.394172E-01	.299380	.283992	.384358
6904.00	.347819	.368905	.243207	.517522	.568530
7001.00	-1.32623	-1.16810	-1.11654	-1.22040	-1.00895
7002.00	.304025	-.356228E-01	.665164E-01	.975497E-01	.357517
7003.00	1.20354	1.24059	.918247	.974578	1.06036
7004.00	-3.44120	-3.02342	-2.89330	-3.10288	-2.46772
7101.00	1.43877	.455759	.754485	.800073	.441682
7102.00	.969352	1.30716	.258897	.573090	.464843
7103.00	-.325133	-.508676E-01	.349426	-.694522	-.421094
7104.00	1.42860	1.26040	1.48201	1.82472	.945050
7201.00	.291061	.665032	.539726	.779876	.432249
7202.00	-1.02822	-.947441	-.537288	-.607637	-.592824
7203.00	-1.43200	-1.56600	-1.49443	-1.15085	-1.41076
7204.00	.636947	.505677	.402631	.431900	.919568

TABLE 4B

Gordon-Jorgenson Model ($\hat{\rho}$ = .6223): Test Statistics

Number of residuals = 64

			p-value
Global Location Tests	t-Test	-.1203	.9042
	No of Positive Residuals	38	.1686
	Wilcoxon Test	1126	.5652
Runs Tests	No of Runs	29	.2250
	Length of the Longest Run	14	.0032
Serial Correlation Tests	Modified Von Neumann Ratio	1.967	≥ .10

Rank Tests

k	Signed-Rank Tests			Sign-Tests		
	S_k	S'_k	p-value	S_k	S'_k	p-value
1	1161	1.047	.2949	35	.8819	.4500
2	1103	.8869	.3751	36	1.270	.2529
3	1114	1.210	.2262	36	1.408	.2000
4	789	-.9276	.3536	26	-1.033	.3663
5	897	.0906	.9278	32	.6509	.6029
6	1126	2.094	.0362	36	1.838	.0869
7	1092	2.109	.0349	37	2.252	.0331
8	787	-.0897	.9285	30	.5345	.6889
9	870	.8379	.4021	28	.1348	1.0000
10	710	-.2798	.7796	26	-.2720	.8919
11	578	-1.217	.2235	24	-.6868	.5831
12	696	.0638	.9492	25	-.2774	.8899

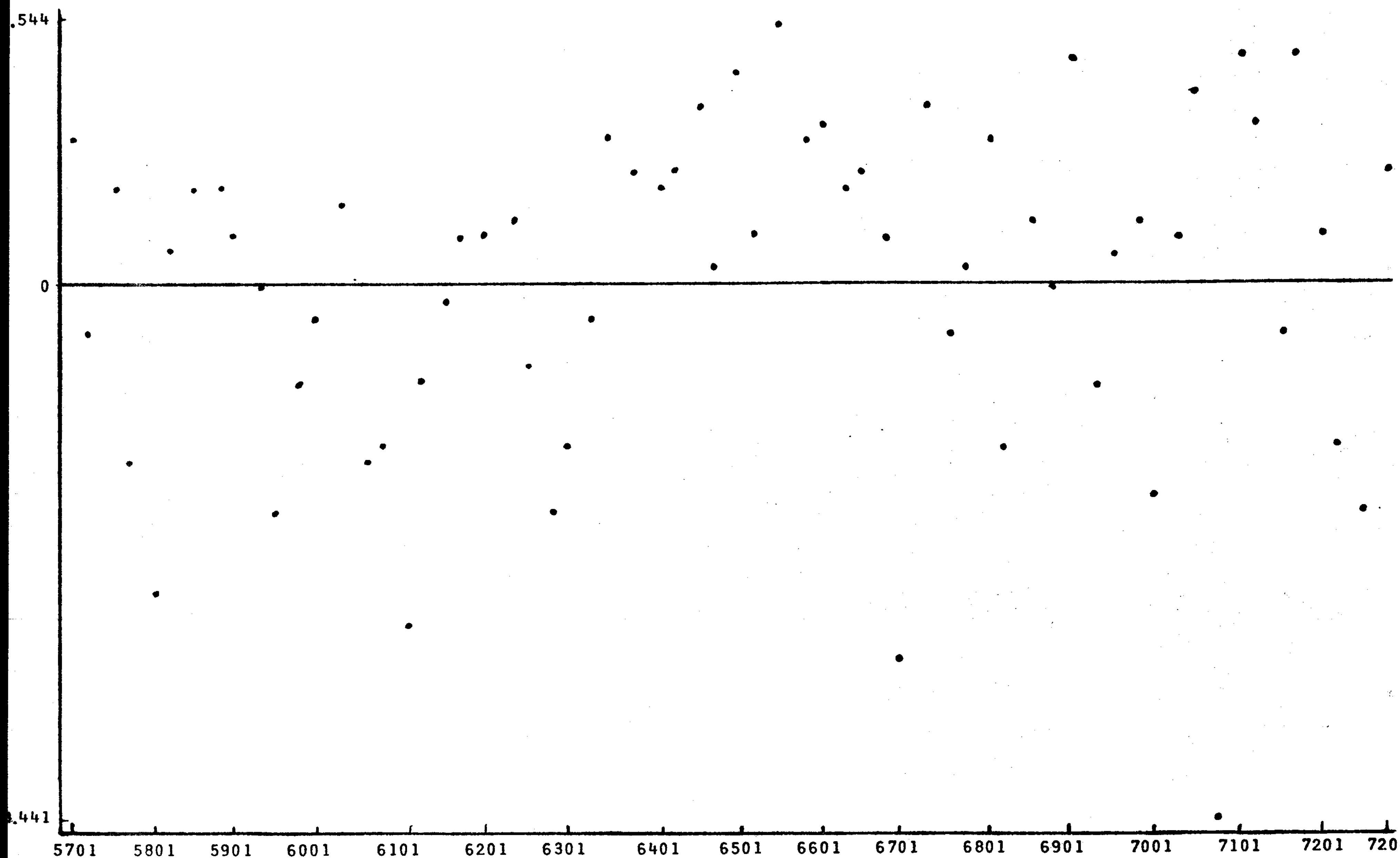

FIGURE 4A - Gordon-Jorgenson Model: One-Step Ahead Recursive Residuals ($\hat{\rho}$ = .6223)

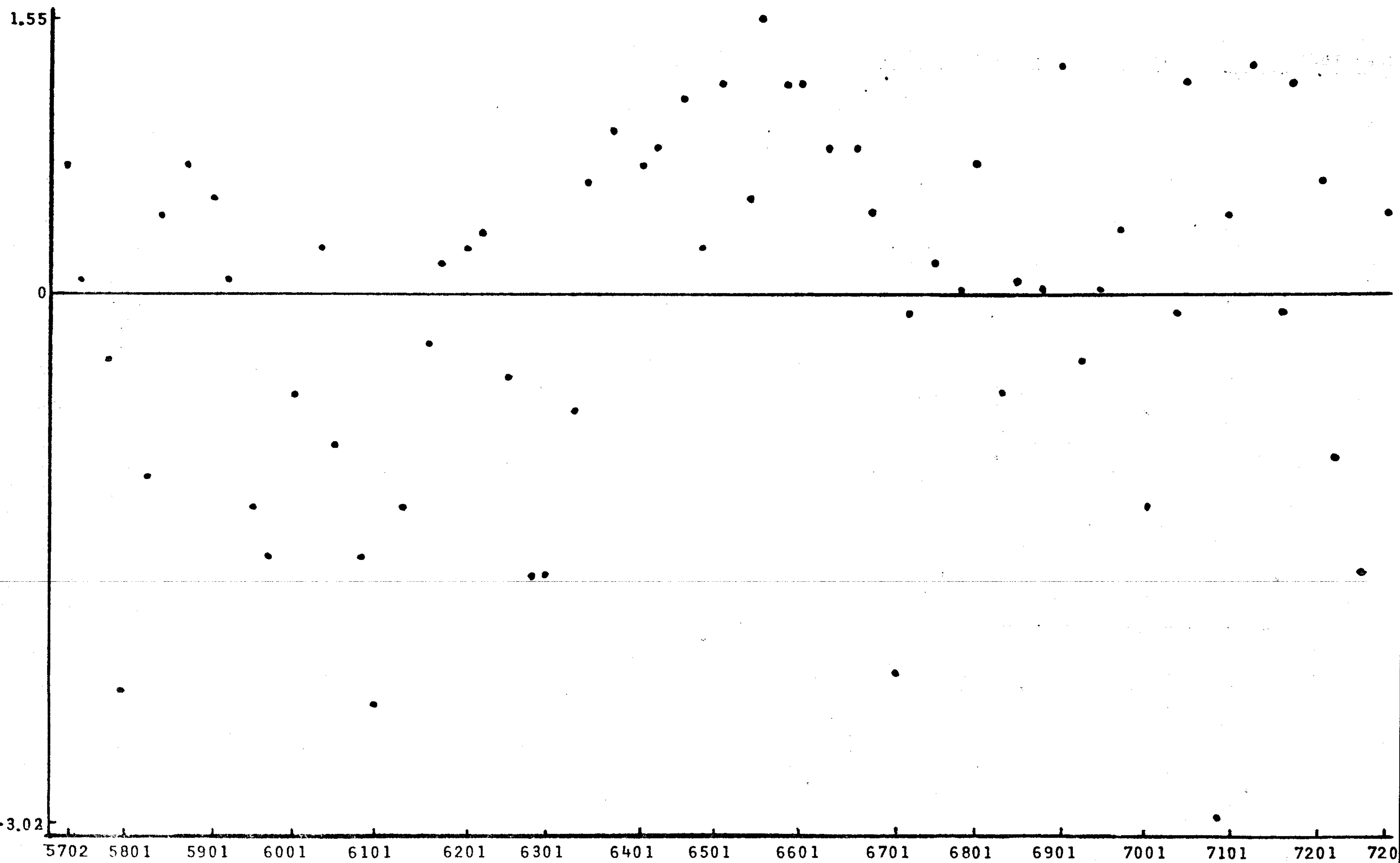

FIGURE 4B - Gordon-Jorgenson Model: Two-Steps Ahead Recursive Residuals ($\hat{\rho}$ = .6223)

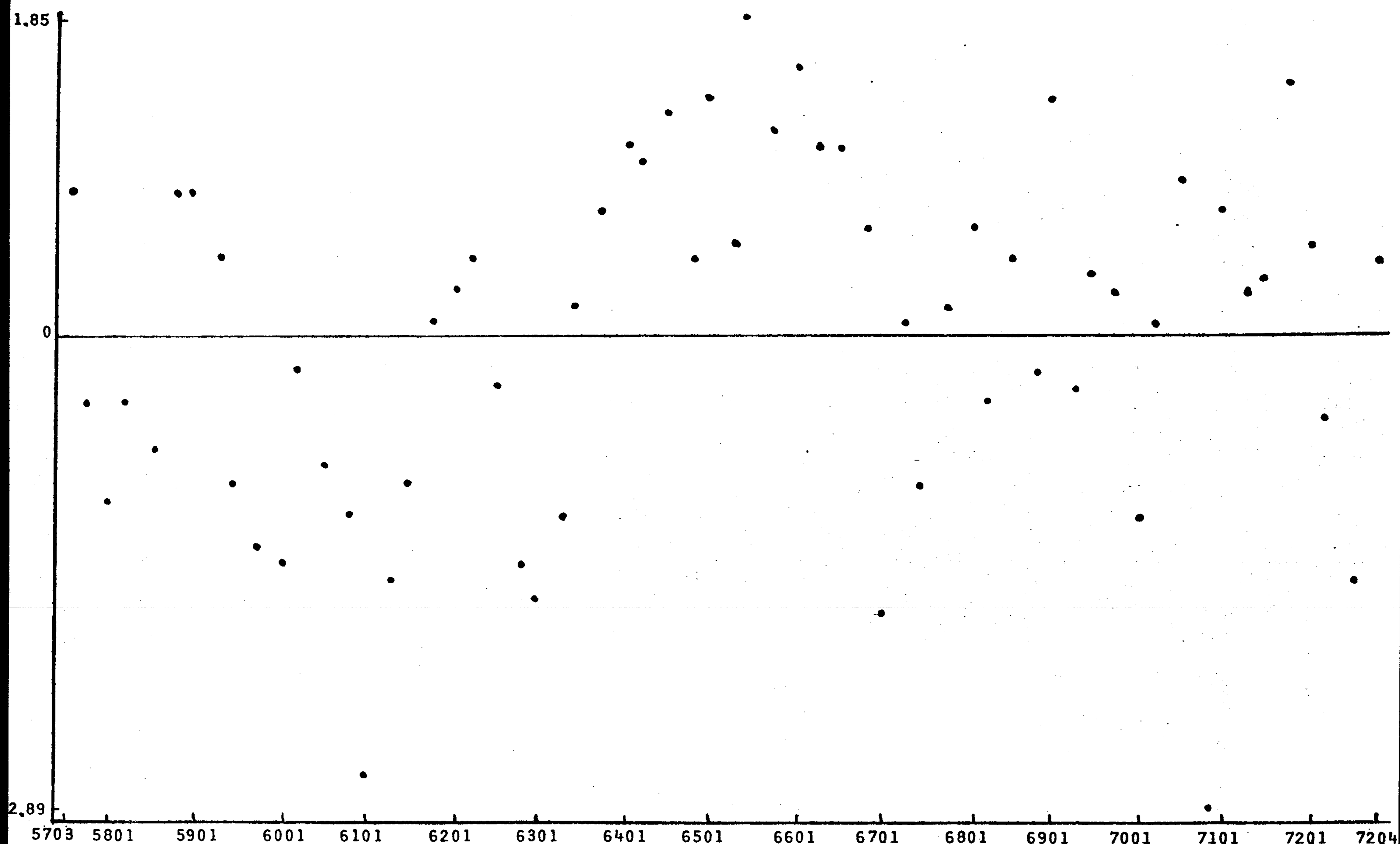

FIGURE 4C - <u>Gordon-Jorgenson Model : Three-Steps Ahead Recursive Residuals ($\hat{\rho}$ = .6233)</u>

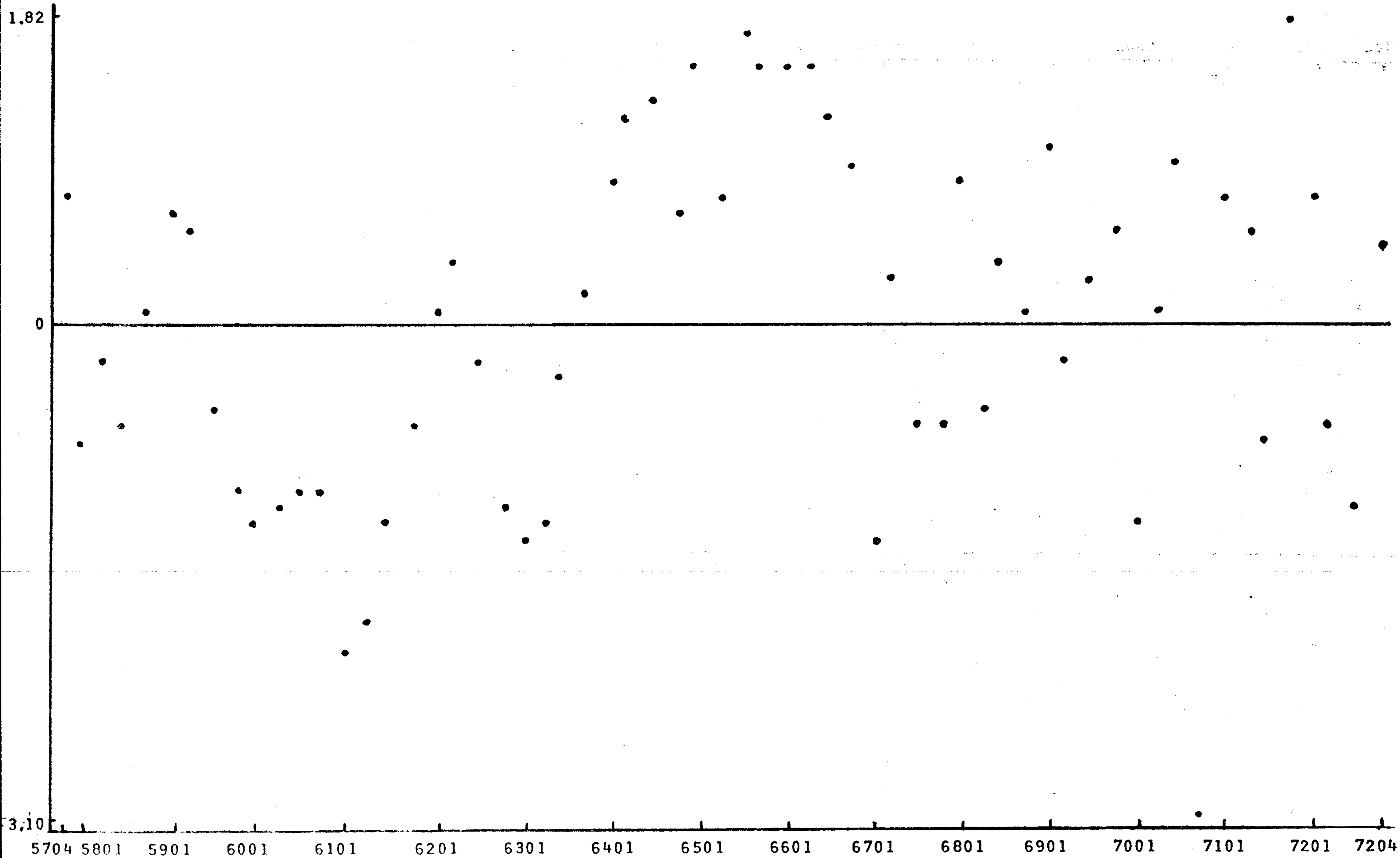

FIGURE 4D – Gordon-Jorgenson Model: Four-Steps Ahead Recursive Residuals ($\hat{\rho}$ = .6223)

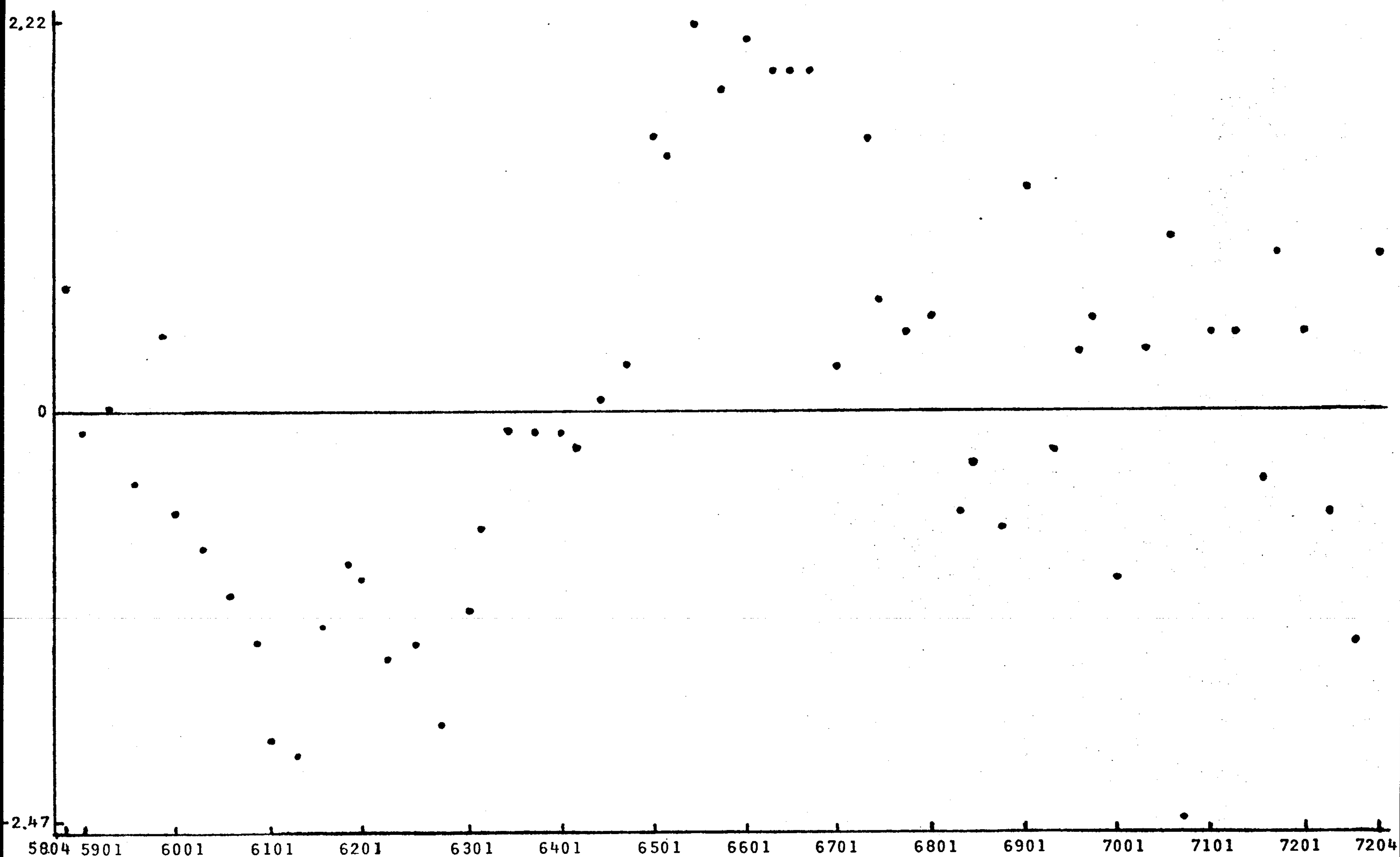

FIGURE 4E - Gordon-Jorgenson Model: Eight-Steps Ahead Recursive Residuals ($\hat{\rho} = .6223$)

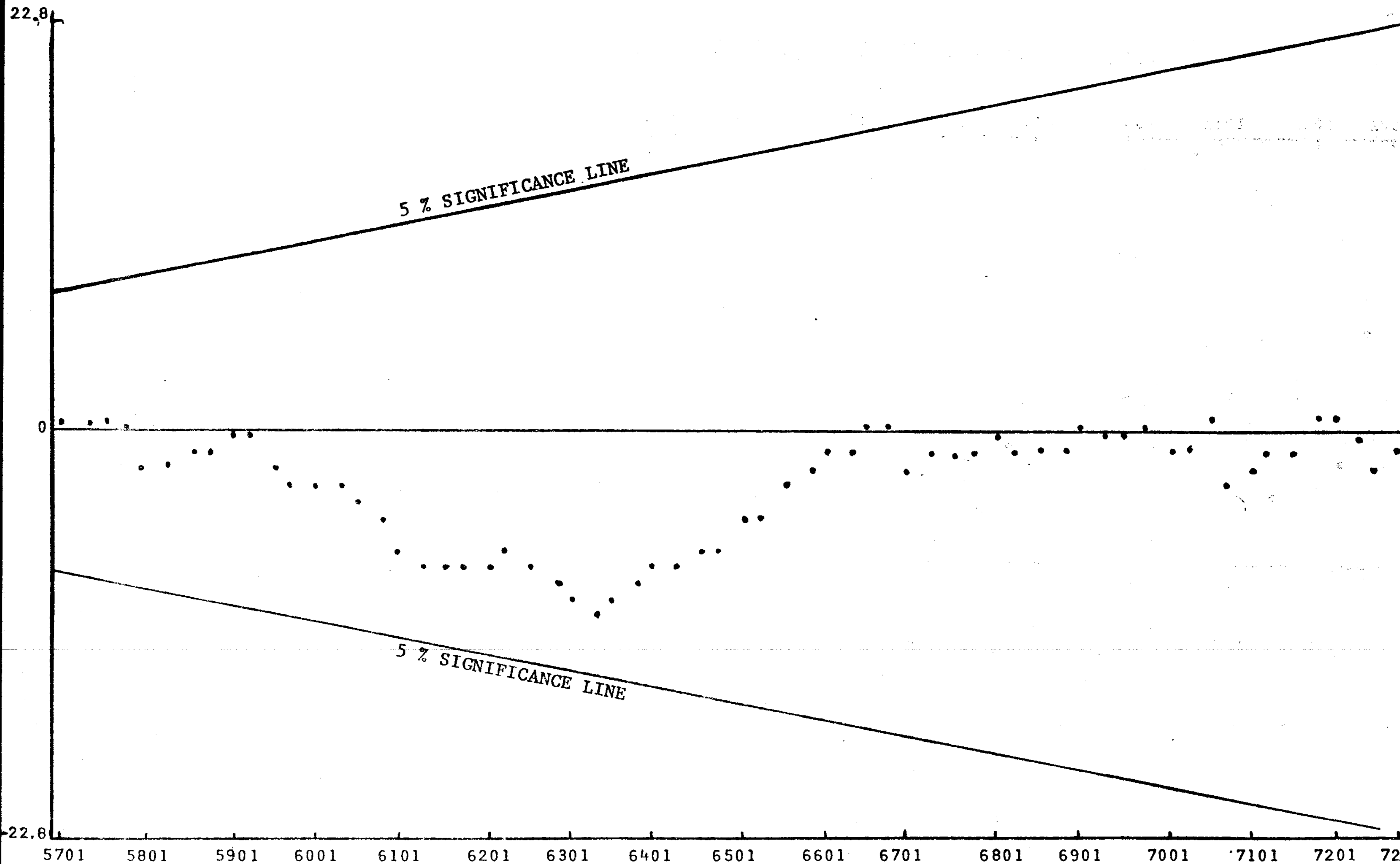

FIGURE 4F - Gordon-Jorgenson Model: CUSUM of Recursive Residuals ($\hat{\rho}$ = .6223)

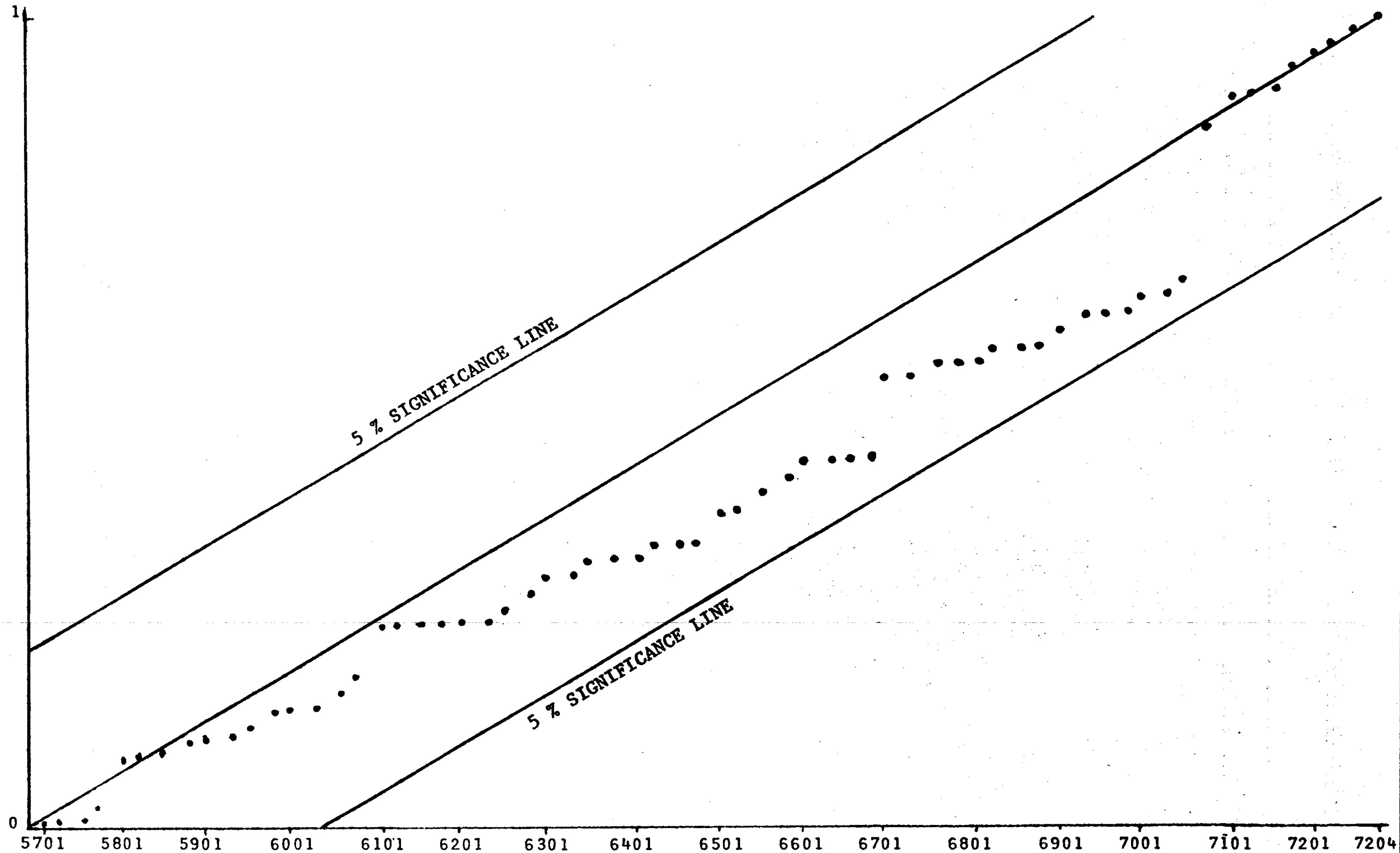

FIGURE 4G - Gordon-Jorgenson Model: CUSUM of Squares of Recursive Residuals ($\hat{\rho} = .6223$)

TABLE 5

Gordon-Jorgenson Model: Recursive Estimates ($\hat{\rho}$ = .6223, Capital Subtracted)

1956/I-1922/IV

Quarter	α	a_1	a_2
5603.00	-269.217	.255279E-01	-.337676E-02
5604.00	-533.578	.279458E-01	-.414221E-02
5701.00	44.4818	.295271E-02	-.279030E-03
5702.00	-9.25772	.570352E-02	-.685720E-03
5703.00	68.8340	-.410830E-03	.140310E-03
5704.00	4.58204	.613426E-02	-.707420E-03
5801.00	-63.2684	.733955E-02	-.970030E-03
5802.00	-81.4923	.529594E-02	-.778160E-03
5803.00	-75.3145	.387347E-02	-.608640E-03
5804.00	-67.0780	.364840E-03	-.203870E-03
5901.00	-65.3075	-.119685E-02	-.273900E-04
5902.00	-66.8731	-.238700E-02	.101450E-03
5903.00	-60.6049	-.133530E-02	-.297000E-05
5904.00	-55.3328	-.136920E-02	.111900E-04
6001.00	-51.7038	-.144892E-02	.271500E-04
6002.00	-55.6916	-.154230E-02	.297400E-04
6003.00	-43.7917	-.133791E-02	.302200E-04
6004.00	-31.6055	-.144037E-02	.653000E-04
6101.00	-11.5303	-.167787E-02	.130640E-03
6102.00	-4.31984	-.200291E-02	.180750E-03
6103.00	-2.84977	-.191119E-02	.173390E-03
6104.00	-3.73363	-.192502E-02	.173220E-03
6201.00	-4.59414	-.193300E-02	.172460E-03
6202.00	-5.98786	-.194906E-02	.171580E-03
6203.00	-5.76906	-.180056E-02	.155480E-03
6204.00	-.981220	-.149145E-02	.130120E-03
6301.00	4.34310	-.200030E-02	.196760E-03
6302.00	5.01822	-.209762E-02	.208850E-03
6303.00	.470875	-.123765E-02	.104630E-03
6304.00	-1.67775	-.781920E-03	.498900E-04
6401.00	-2.77298	-.547340E-03	.217400E-04
6402.00	-3.60712	-.405850E-03	.444000E-05
6403.00	-4.65327	-.541190E-03	.176000E-04
6404.00	-4.44952	-.554150E-03	.194200E-04
6501.00	-5.90437	-.268710E-03	-.150300E-04
6502.00	-5.85985	-.279200E-03	-.137800E-04
6503.00	-7.45749	.686700E-04	-.554100E-04
6504.00	-8.19962	.251700E-03	-.771400E-04
6601.00	-9.08444	.455020E-03	-.101370E-03
6602.00	-9.62948	.574710E-03	-.115670E-03
6603.00	-10.3707	.855280E-03	-.148250E-03
6604.00	-10.8145	.108389E-02	-.174520E-03
6701.00	-8.85886	-.135990E-03	-.350800E-04
6702.00	-9.63780	.729460E-03	-.132960E-03
6703.00	-9.48714	.597730E-03	-.118000E-03
6704.00	-9.45833	.605080E-03	-.118770E-03
6801.00	-9.73482	.518540E-03	-.109610E-03
6802.00	-9.43976	.591200E-03	-.117190E-03
6803.00	-9.54382	.585340E-03	-.116720E-03
6804.00	-9.52379	.582340E-03	-.116350E-03
6901.00	-9.99664	.714830E-03	-.131930E-03
6902.00	-9.83204	.664940E-03	-.126080E-03
6903.00	-9.89208	.678930E-03	-.127740E-03
6904.00	-9.98831	.821540E-03	-.143810E-03
7001.00	-9.77337	.473430E-03	-.104620E-03
7002.00	-9.80918	.536490E-03	-.111720E-03
7003.00	-9.96651	.653850E-03	-.125100E-03
7004.00	-9.56351	.558620E-03	-.113700E-03
7101.00	-9.67842	.545990E-03	-.112520E-03
7102.00	-9.78678	.491540E-03	-.106650E-03
7103.00	-9.70090	.568400E-03	-.115070E-03
7104.00	-10.0124	.261710E-03	-.814000E-04
7201.00	-10.0879	.203940E-03	-.750800E-04
7202.00	-9.84532	.352510E-03	-.912600E-04
7203.00	-9.46094	.470720E-03	-.103850E-03
7204.00	-9.65569	.468680E-03	-.103920E-03

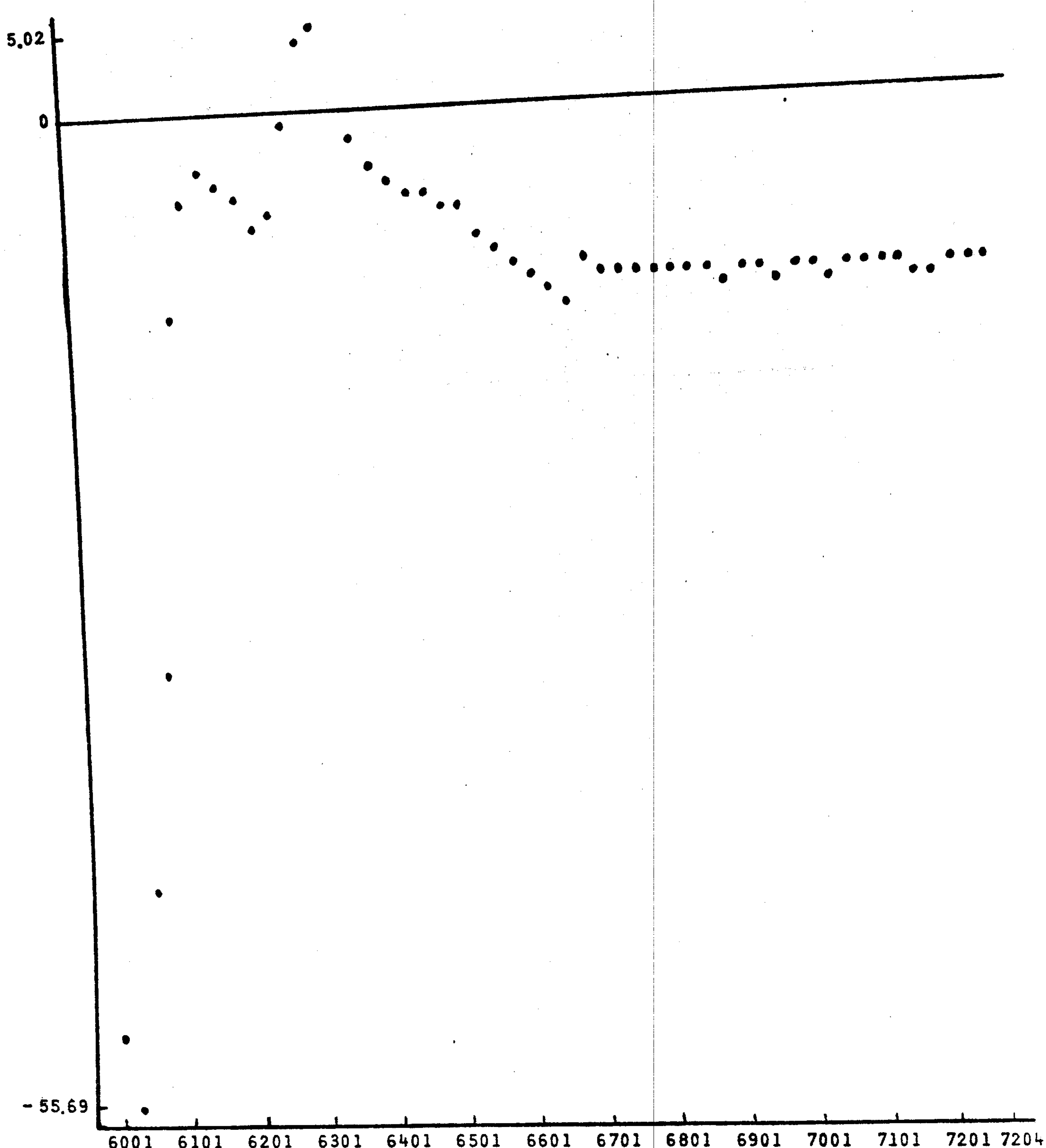

FIGURE 5A - Gordon-Jorgenson Model: Recursive Estimates of $\alpha(\hat{\rho} = .6223$, Capital Subtracted)

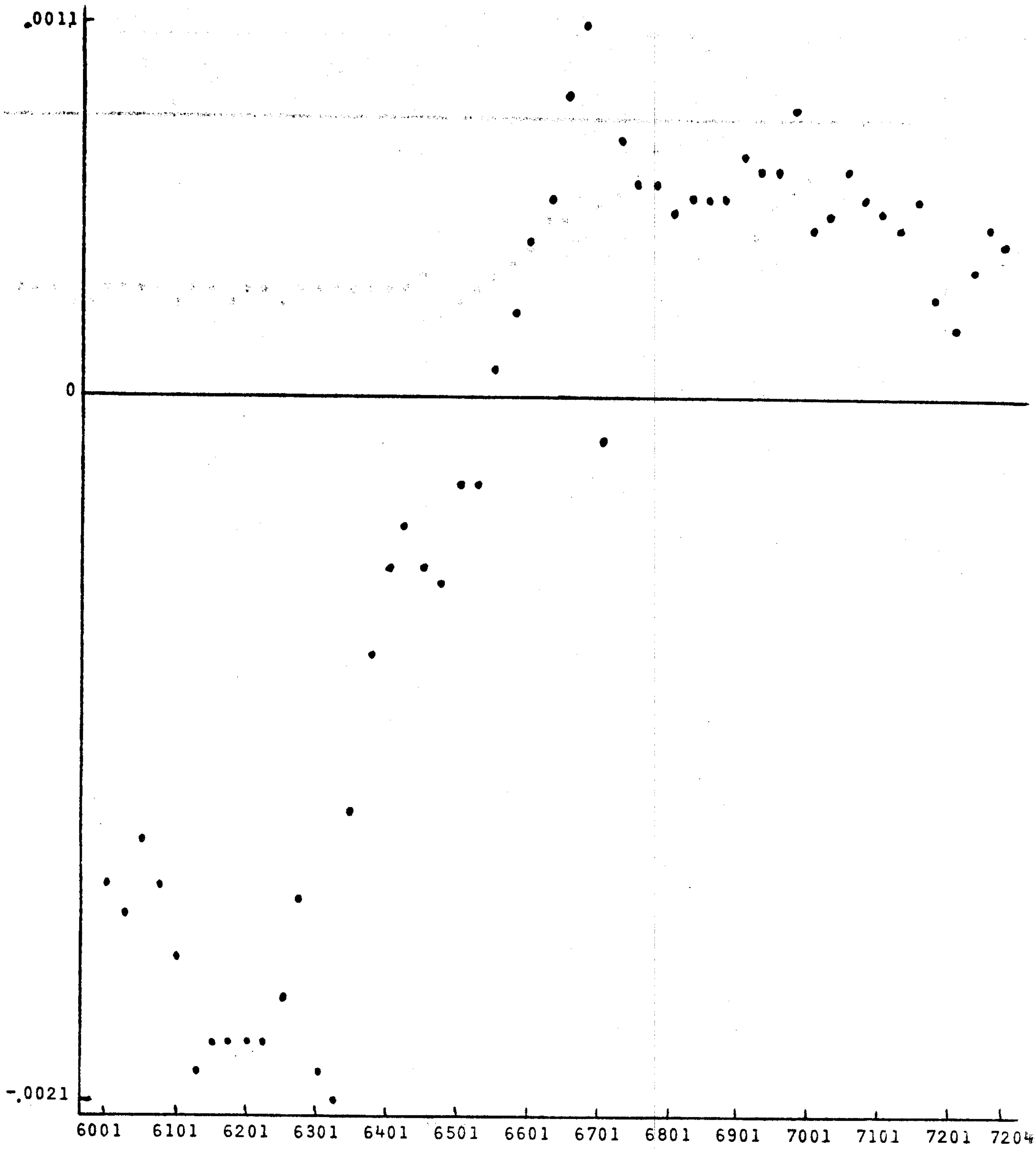

FIGURE 5B - Gordon-Jorgenson Model: Recursive Estimates of a_1 ($\hat{\rho}$ = .6223, Capital Subtracted)

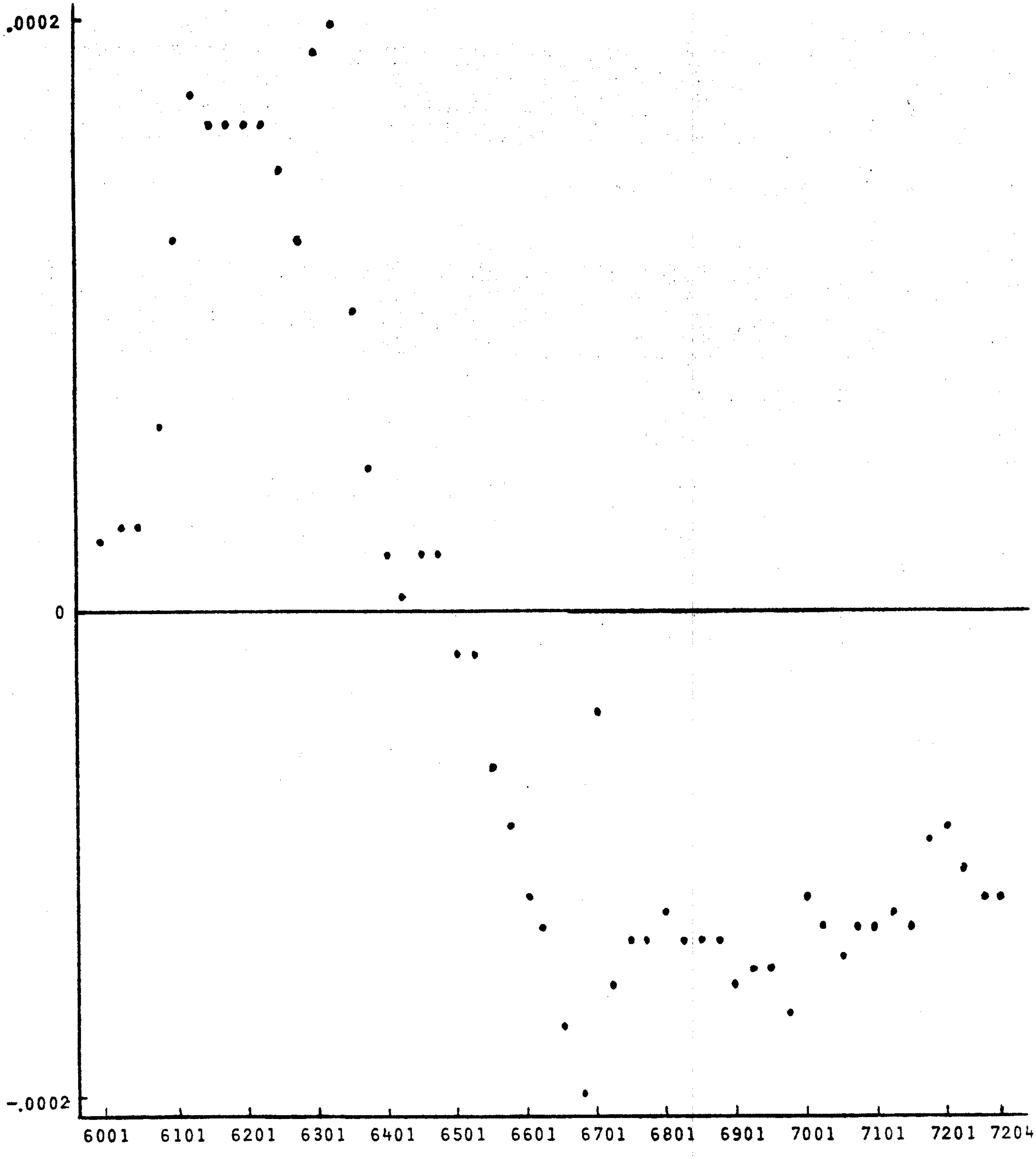

FIGURE 5C - Gordon-Jorgenson Model: Recursive Estimates of a_2 ($\hat{\rho}$ = .6223, Capital Subtracted)

TABLE 6A

Gordon-Jorgenson Model: Recursive Residuals ($\hat{\rho}$ = .6223, Capital Subtracted)

1956/IV-1972/IV

Quarter	RECF1	RECF2	RECF3	RECF4	RECF8
5604.00	-.419694	0.	0.	0.	0.
5701.00	.854156	.181309	0.	0.	0.
5702.00	-.237042	.713384	.150001	0.	0.
5703.00	.652180	.171667	.858797	.316754	0.
5704.00	-1.08274	-.223677	-.321946	.676919	0.
5801.00	-1.99345	-2.26273	-.965953	-.715471	0.
5802.00	-.833853	-1.67581	-1.99275	-.798198	0.
5803.00	.199495	.907592E-01	-.674265	-1.22007	0.
5804.00	.668033	.618592	.675055	.188707	.244858
5901.00	.627281	.908778	.802234	.891831	.738961
5902.00	.718484	.902349	1.12232	.981438	.254629E-01
5903.00	-.768923	-.498644	-.214881	.236334	.541508
5904.00	-.561211	-.696917	-.580798	-.478264	.181193E-01
6001.00	-.332159	-.433081	-.571752	-.475021	.168041
6002.00	.385944	.301757	.174221	-.534351E-01	-.708933E-01
6003.00	-1.27506	-1.13316	-1.17989	-1.27712	.486614
6004.00	-1.40125	-1.66671	-1.50272	-1.53725	-.832997
6101.00	-2.54739	-2.80172	-3.03529	-2.80115	-1.48472
6102.00	-1.02275	-1.53992	-1.82554	-2.08994	-2.74589
6103.00	-.222203	-.430339	-1.07241	-1.42419	-2.12547
6104.00	.143051	.745723E-01	-.165715	-.865916	-1.63972
6201.00	.154716	.186748	.110270	-.149991	-1.39211
6202.00	.271669	.302910	.331465	.237760	-1.39909
6203.00	-.116377	-.302461E-01	.191268E-01	.665088E-01	-1.66049
6204.00	-1.26640	-1.16343	-.997316	-.878074	-1.52243
6301.00	-.917977	-1.30901	-1.24246	-1.04825	-1.89570
6302.00	-.117980	-.476046	-.883896	-.870087	-1.09282
6303.00	.871205	.733640	.274106	-.139698	-.522898
6304.00	.548255	.884724	.732214	.260793	.705888E-01
6401.00	.391158	.575150	.917320	.754704	.211775E-01
6402.00	.428952	.524501	.694003	1.01885	-.326520E-01
6403.00	.935737	1.00102	1.06543	1.18511	-.117763
6404.00	-.153775	.407539E-01	.137993	.246138	.792679E-01
6501.00	.971435	.920759	1.08856	1.16277	.113334
6502.00	-.315002E-01	.181954	.145335	.331406	1.31595
6503.00	1.32099	1.28430	1.47265	1.40154	1.08814
6504.00	.662283	.911750	.880820	1.09029	1.71954
6601.00	.910516	1.01915	1.26977	1.22692	1.32919
6602.00	.638440	.785474	.899354	1.15960	1.58743
6603.00	.792710	.889761	1.04773	1.16664	1.43529
6604.00	.472395	.628306	.734379	.906122	1.50833
6701.00	-2.34545	-2.15100	-1.91367	-1.75908	1.49161
6702.00	1.01602	.139817	.286082	.482986	-.913589
6703.00	-.368854	.113845	-.615845	-.446989	1.19182
6704.00	-.858638E-01	-.985141E-01	-.644339E-01	-.287790	.226154
6801.00	.888678	.877344	.867902	.878118	.136887
					.914863

TABLE 6A(continued)

Quarter	RECF1	RECF2	RECF3	RECF4	RECF8
6802.00	-.980866	-.900789	-.904860	-.917245	-.913657
6803.00	.339659	.264984	.335592	.327035	.146033
6804.00	-.624709E-01	-.382514E-01	-.106899	-.415733E-01	-.348925
6901.00	1.41598	1.40638	1.42736	1.35773	1.55855
6902.00	-.531135	-.406092	-.409822	-.384043	-.440121
6903.00	.215166	.173178	.290457	.284600	.295015
6904.00	.407980	.425308	.365099	.521813	.520366
7001.00	-1.29278	-1.16006	-1.13764	-1.18716	-1.02740
7002.00	.303136	.732842E-01	.161946	.178624	.278849
7003.00	1.35047	1.37135	1.22291	1.26817	1.33942
7004.00	-3.58583	-3.53186	-3.51136	-3.58922	-3.44430
7101.00	1.00802	.906229	.944296	.952785	.902477
7102.00	.791409	.822714	.732661	.753879	.764792
7103.00	-.432866	-.378695	-.340046	-.409695	-.371814
7104.00	1.39789	1.30914	1.37016	1.41188	1.44046
7201.00	.331093	.595673	.516569	.582290	.499944
7202.00	-1.00852	-.936422	-.636687	-.701085	-.681503
7203.00	-1.42995	-1.55410	-1.48749	-1.22613	-1.27009
7204.00	.636909	.506988	.409056	.440080	.649845

TABLE 6B

Gordon-Jorgenson Model ($\hat{\rho}$ = .6223, Capital Deducted): Test Statistics

Number of residuals = 65

			p-values
Global Location Tests	t-Test	-.4535	.6502
	No of Positive Residuals	35	.6201
	Wilcoxon Test	1112	.7962
Runs Tests	No of Runs	34	.6460
	Length of the Longest Run	7	.3892
Serial Correlation Tests	Modified Von Neumann Ratio	1.974	≥ .10

Serial Correlation Tests — Rank Tests

k	Signed-Rank Tests S_k	S'_k	p-value	Sign-Tests S_k	S'_k	p-value
1	1101	.4079	.6833	31	-.2500	.9007
2	1117	.7462	.4556	35	.8819	.4500
3	1106	.9079	.3639	30	-.2540	.8991
4	818	-.9158	.3598	25	-1.408	.2000
5	866	-.3607	.7183	25	-1.291	.2451
6	1100	1.623	.1046	34	1.172	.2976
7	1092	1.831	.0671	36	1.838	.0869
8	738	-.7032	.4820	25	-.9272	.4270
9	973	1.427	.1534	33	1.336	.2288
10	748	-.1843	.8538	26	-.4045	.7877
11	639	-.8912	.3728	25	-.5443	.6835
12	806	.8012	.4230	28	.4121	.7838

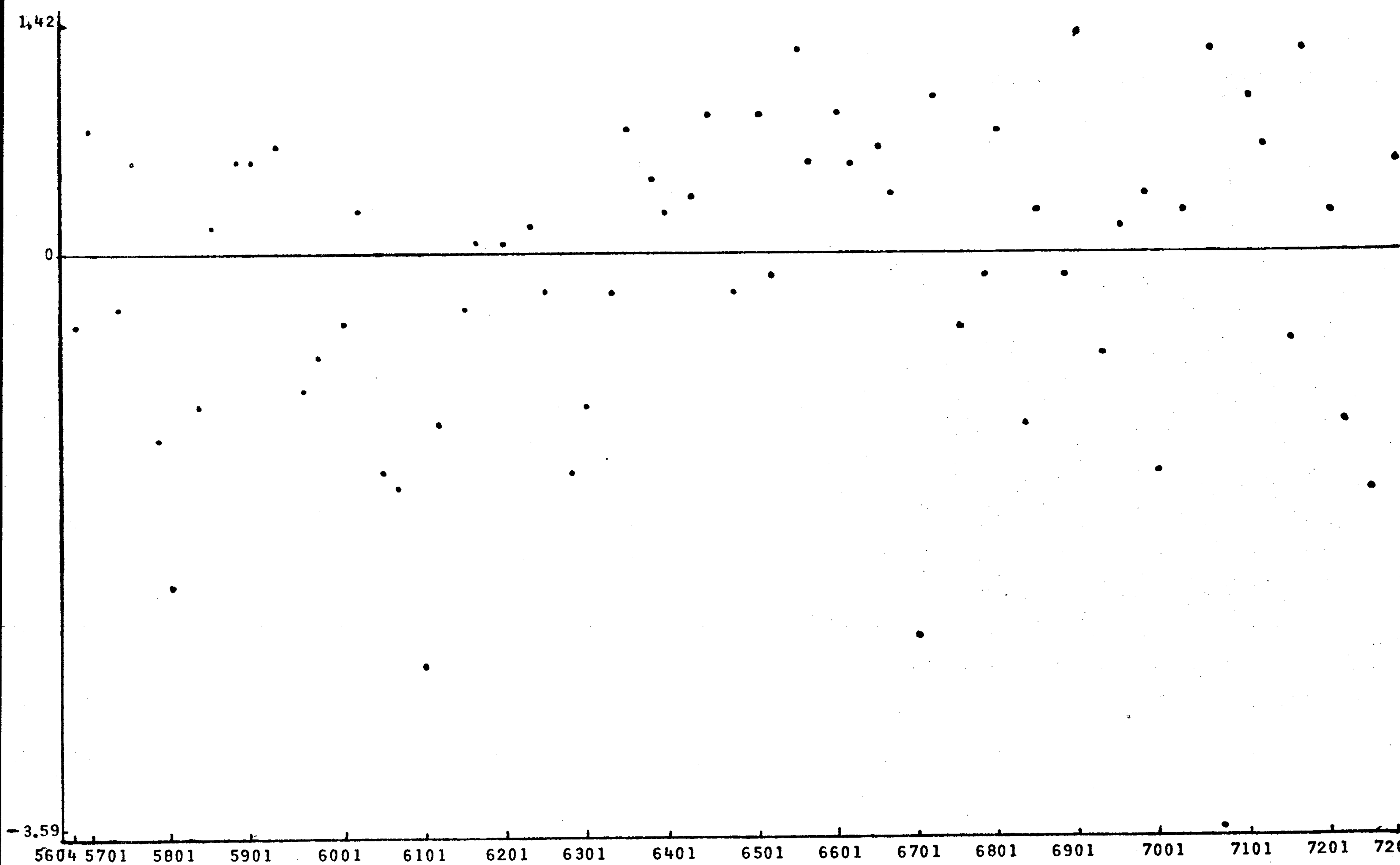

FIGURE 6A - Gordon-Jorgenson Model: One-Step Ahead Recursive Residuals ($\hat{\rho}$ = .6223, Capital Subtracted)

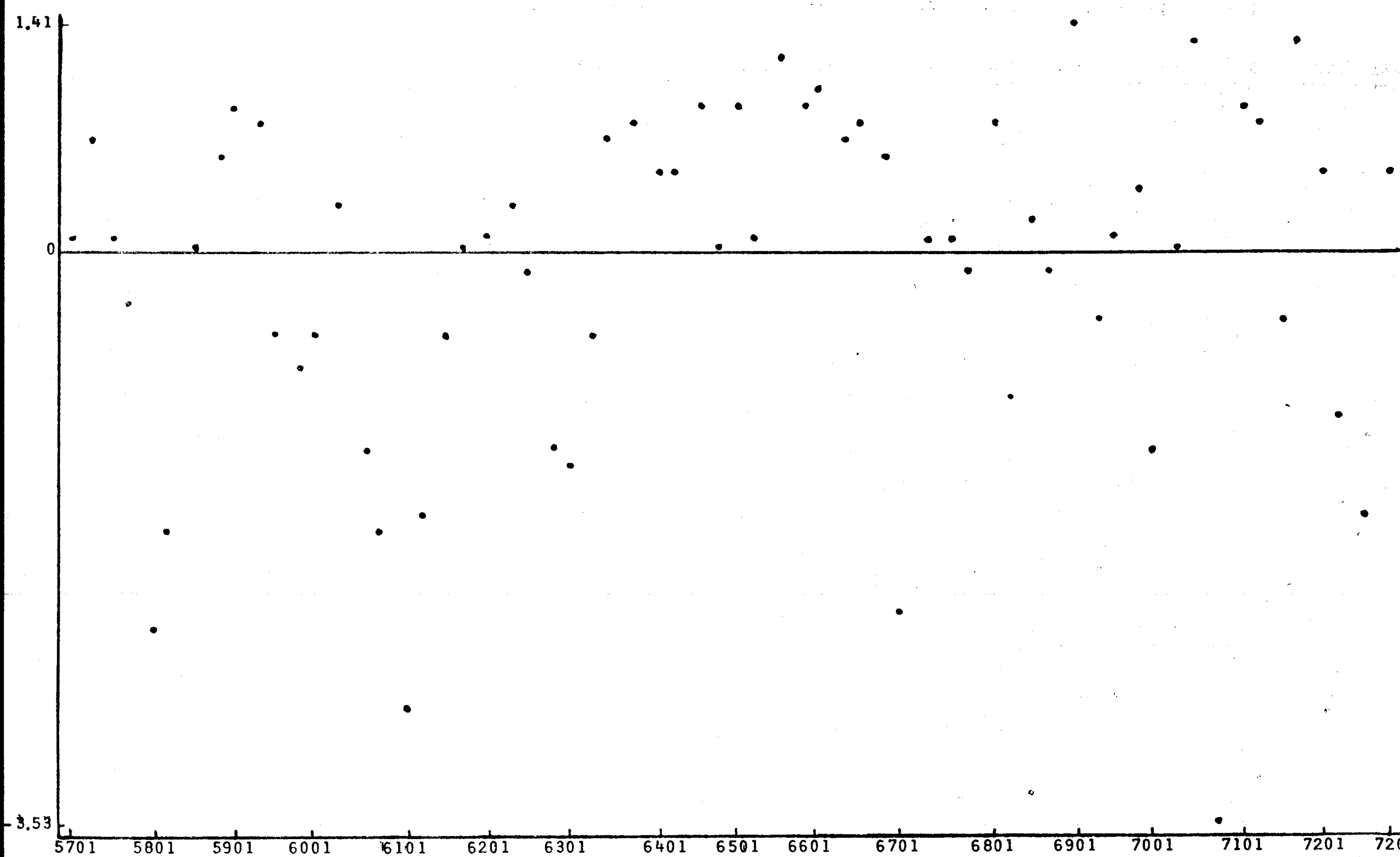

FIGURE 6B - Gordon-Jorgenson Model: Two-Steps Ahead Recursive Residuals ($\hat{\rho}$ = .6223, Capital Subtracted)

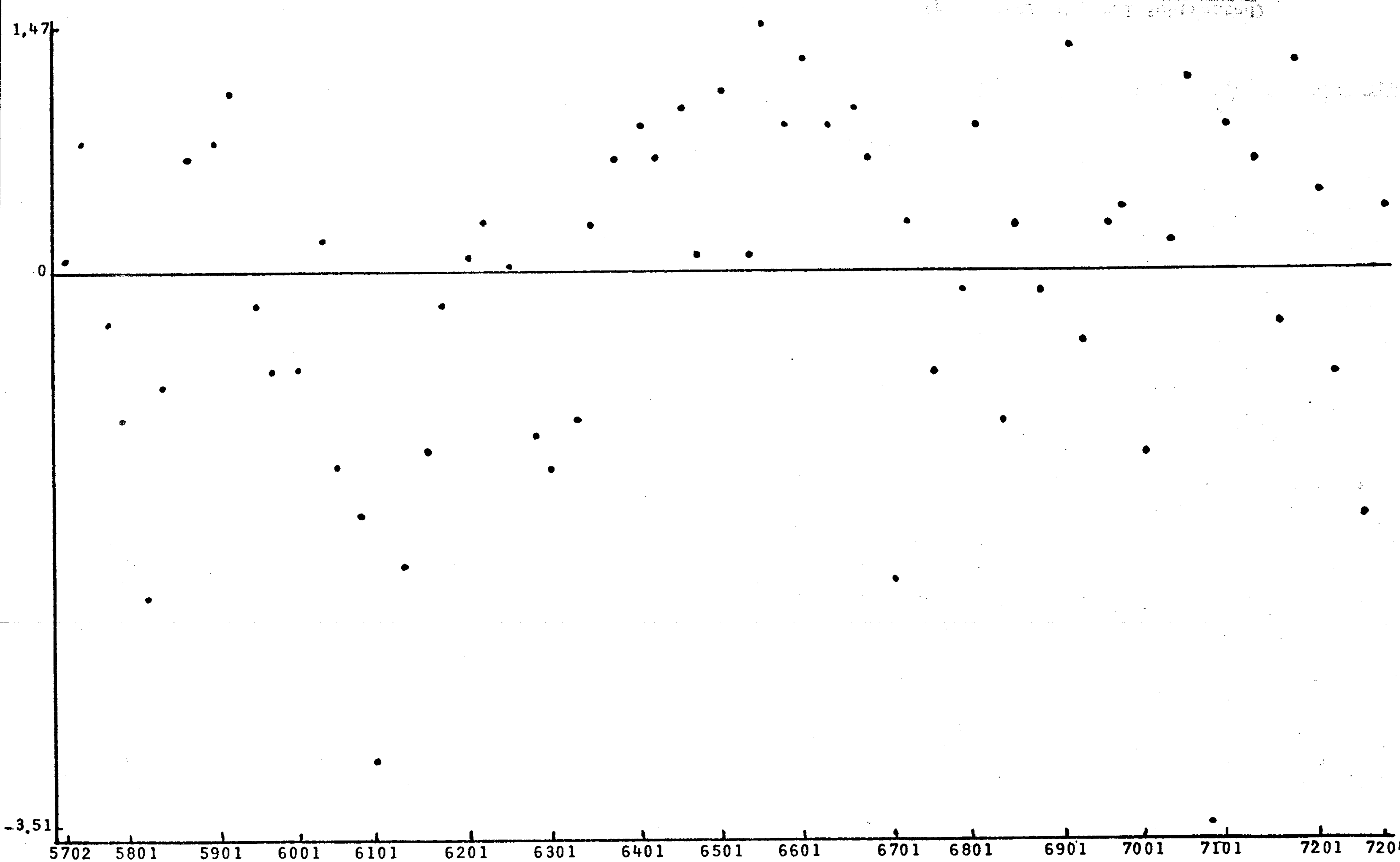

FIGURE 6C - Gordon-Jorgenson Model: Three-Steps Ahead Recursive Residuals ($\hat{\rho}$ = .6223, Capital Subtracted)

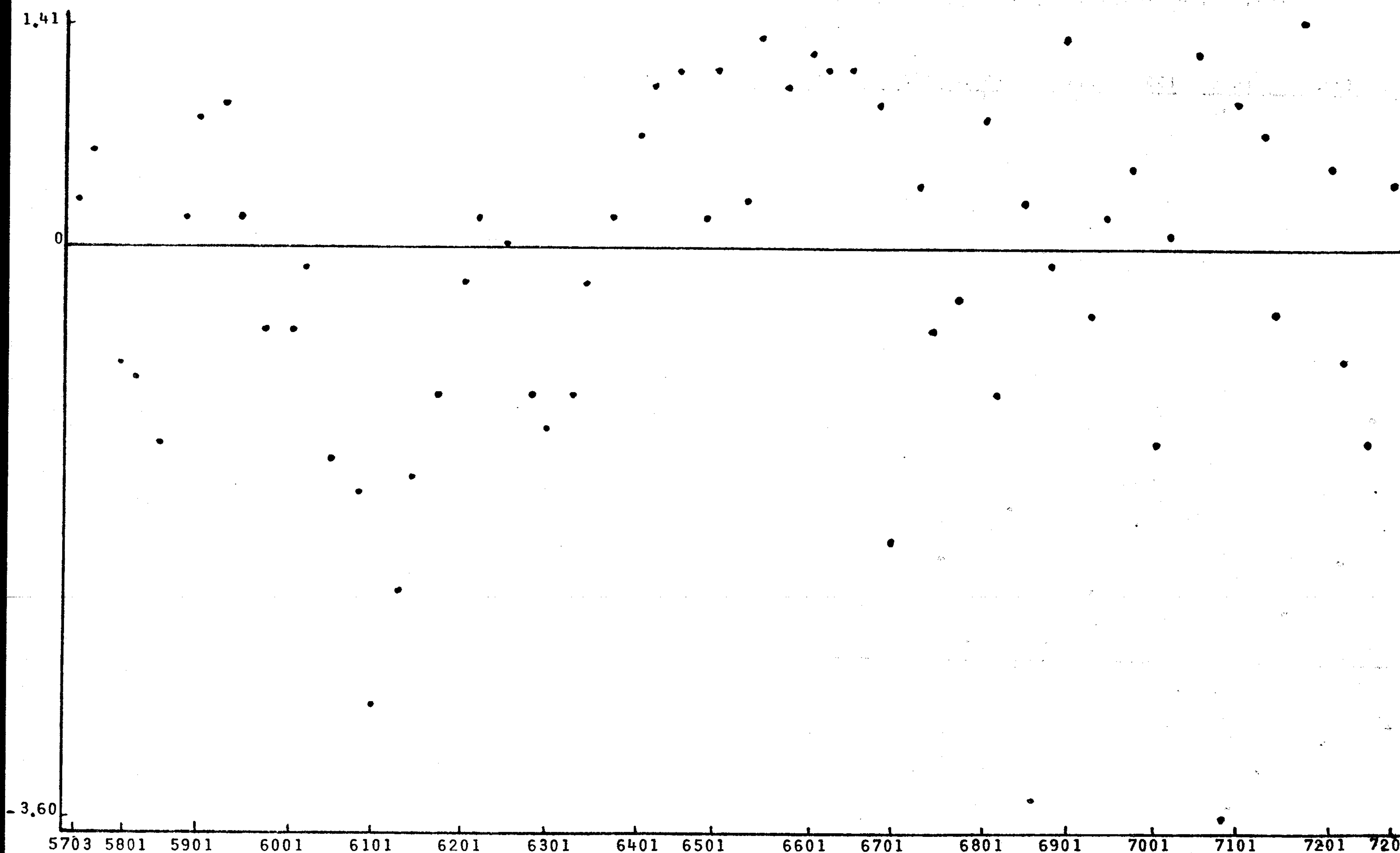

FIGURE 6D - Gordon-Jorgenson Model: Four-Steps Ahead Recursive Residuals ($\hat{\rho}$ = .6223, Capital Subtracted)

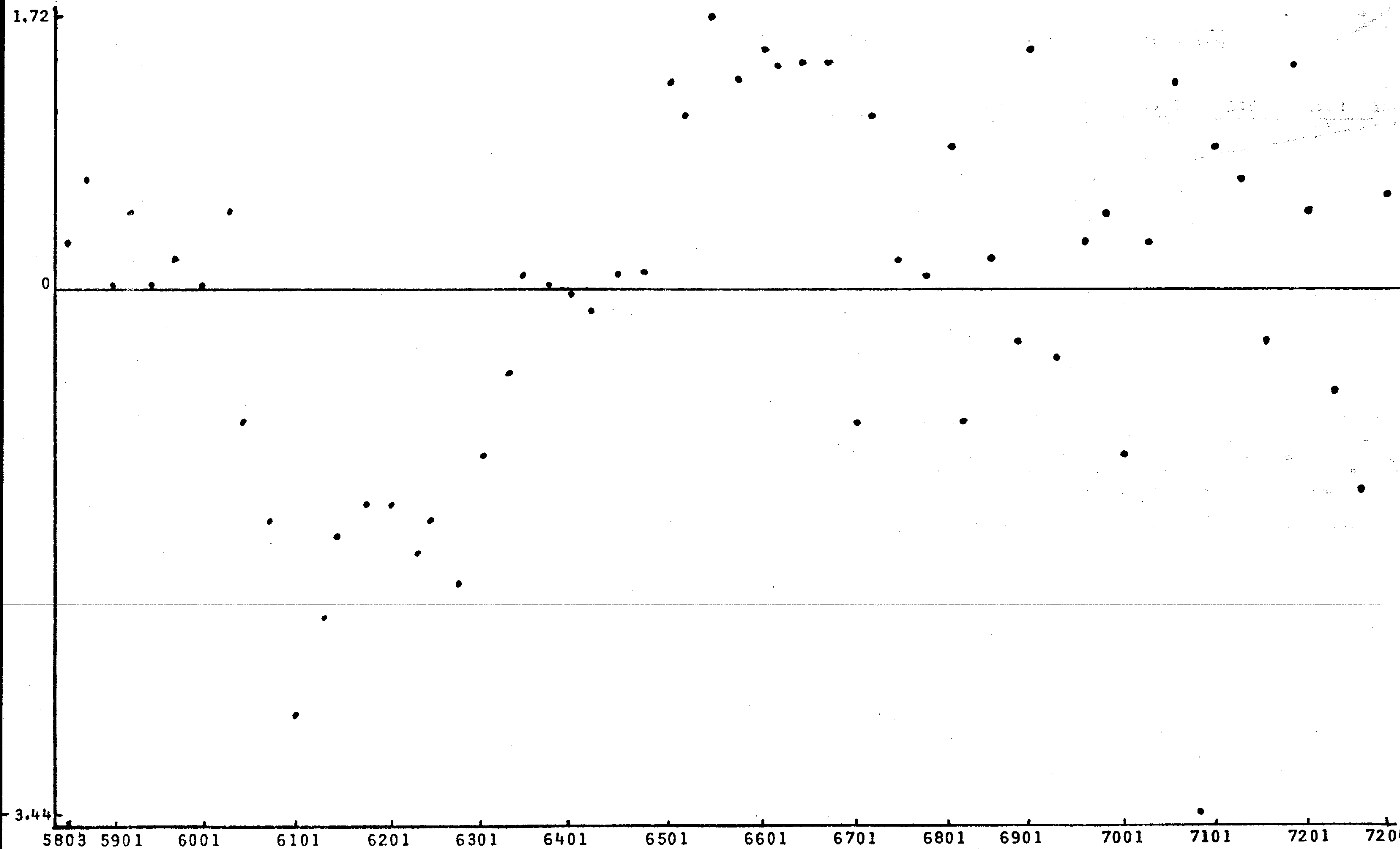

FIGURE 6E - Gordon-Jorgenson Model: Eight-Steps Ahead Recursive Residuals ($\hat{\rho}$ = .6223, Capital Subtracted)

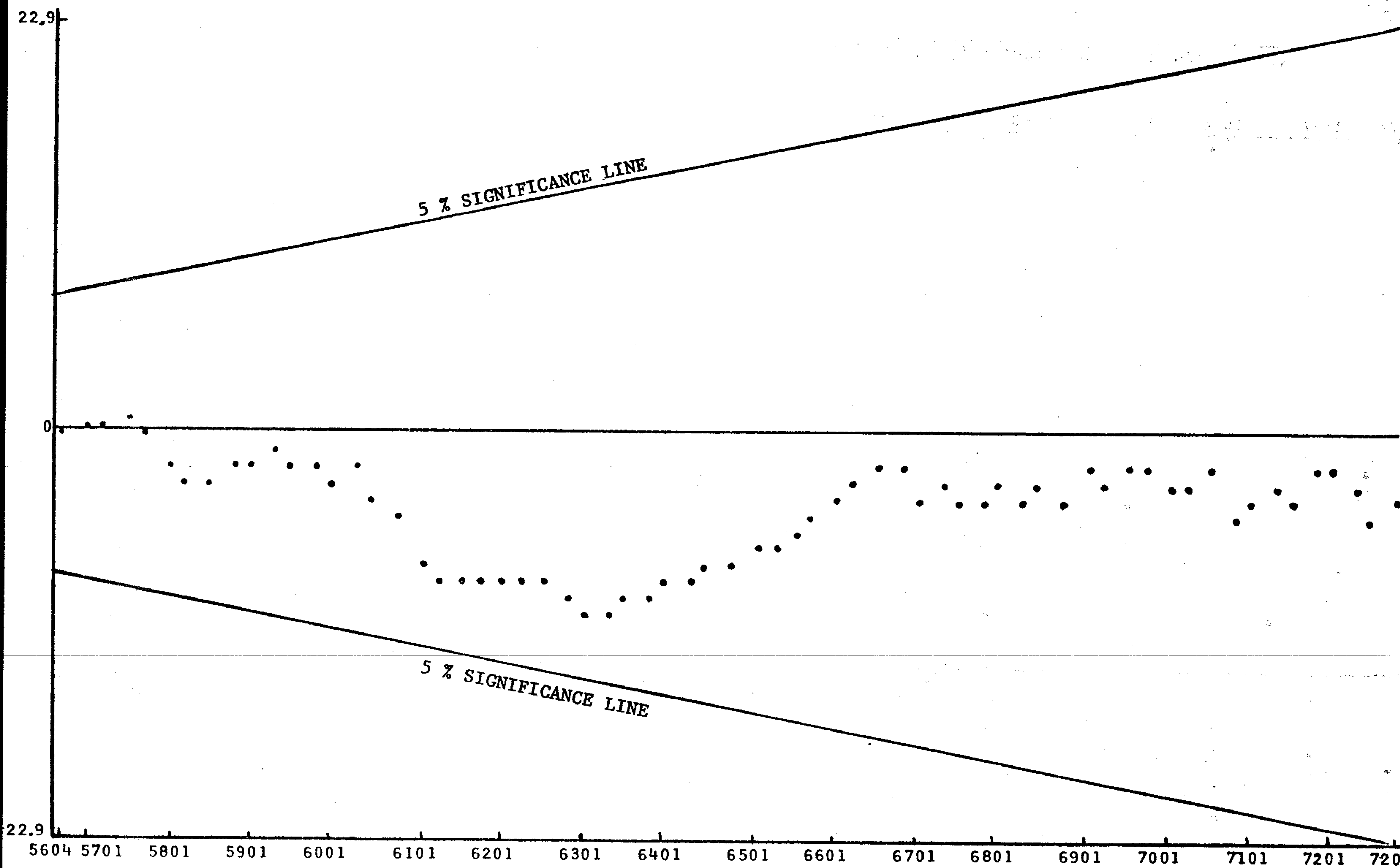

FIGURE 6F - Gordon-Jorgenson Model: CUSUM of Recursive Residuals ($\hat{\rho}$ = .6223, Capital Subtracted)

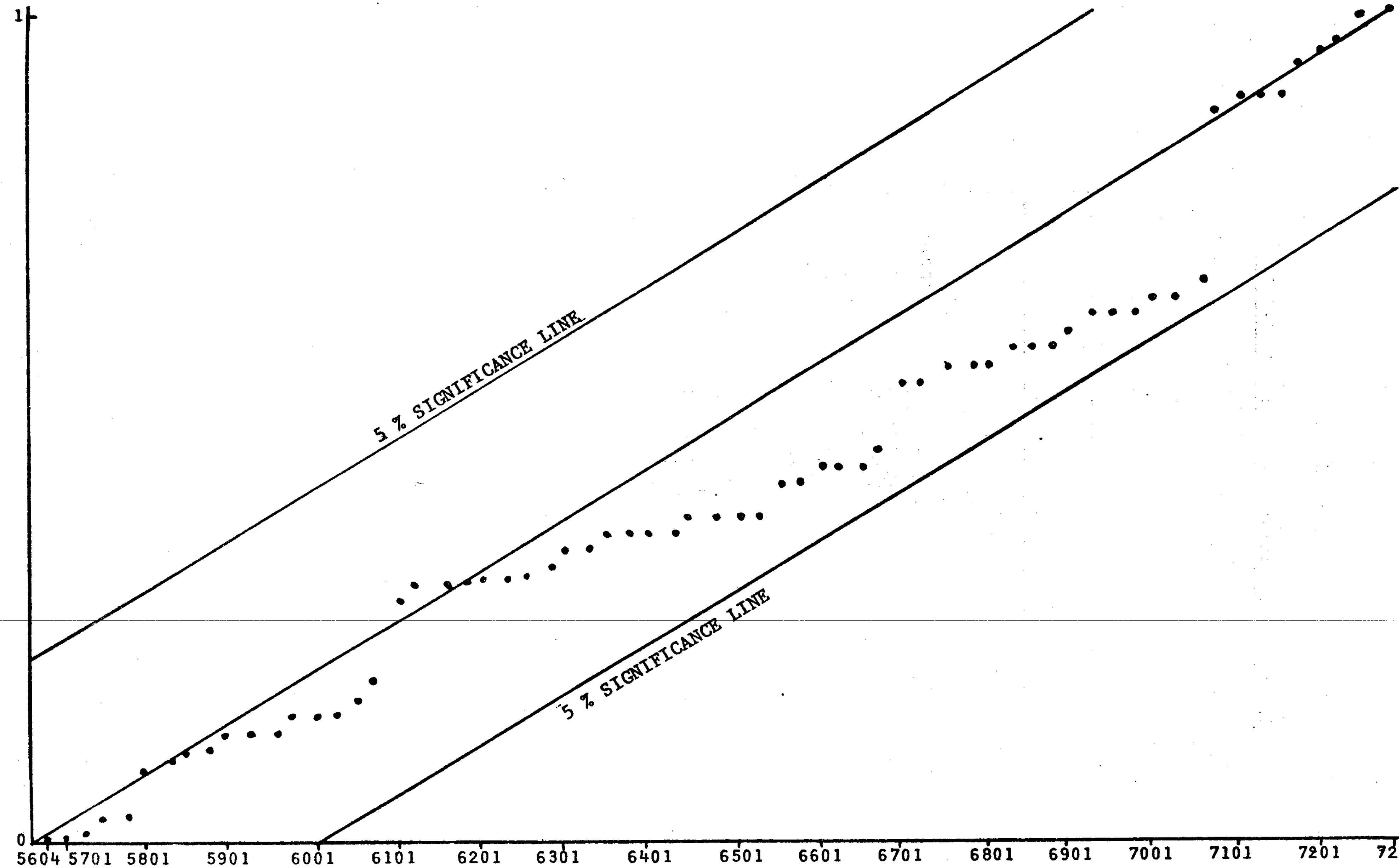

FIGURE 6G - Gordon-Jorgenson Model: CUSUM of Squares of Recursive Residuals ($\hat{\rho}$ = .6223, Capital Subtracted)

TABLE 7

Effective Investment Tax Credit (1961-1972)[1]

Quarter	TC	Y
6101	0.	0.
6102	0.	0.
6103	0.	0.
6104	0.	0.
6201	.310000E-01	1.00000
6202	.350000E-01	1.00000
6203	.390000E-01	1.00000
6204	.430000E-01	1.00000
6301	.470000E-01	1.00000
6302	.510000E-01	1.00000
6303	.550000E-01	1.00000
6304	.560000E-01	1.00000
6401	.560000E-01	0.
6402	.560000E-01	0.
6403	.560000E-01	0.
6404	.560000E-01	0.
6501	.560000E-01	0.
6502	.560000E-01	0.
6503	.560000E-01	0.
6504	.560000E-01	0.
6601	.560000E-01	0.
6602	.560000E-01	0.
6603	.560000E-01	0.
6604	0.	0.
6701	0.	0.
6702	.560000E-01	0.
6703	.560000E-01	0.
6704	.560000E-01	0.
6801	.560000E-01	0.
6802	.560000E-01	0.
6803	.560000E-01	0.
6804	.560000E-01	0.
6901	.560000E-01	0.
6902	0.	0.
6903	0.	0.
6904	0.	0.
7001	0.	0.
7002	0.	0.
7003	0.	0.
7004	0.	0.
7101	0.	0.
7102	.400000E-01	0.
7103	.500000E-01	0.
7104	.560000E-01	0.
7201	.560000E-01	0.
7202	.560000E-01	0.
7203	.560000E-01	0.
7204	.560000E-01	0.

[1] TC is the rate of the investment tax credit and Y is the dummy variable for the Long Amendment. Before 1961, TC and Y are both equal to zero.

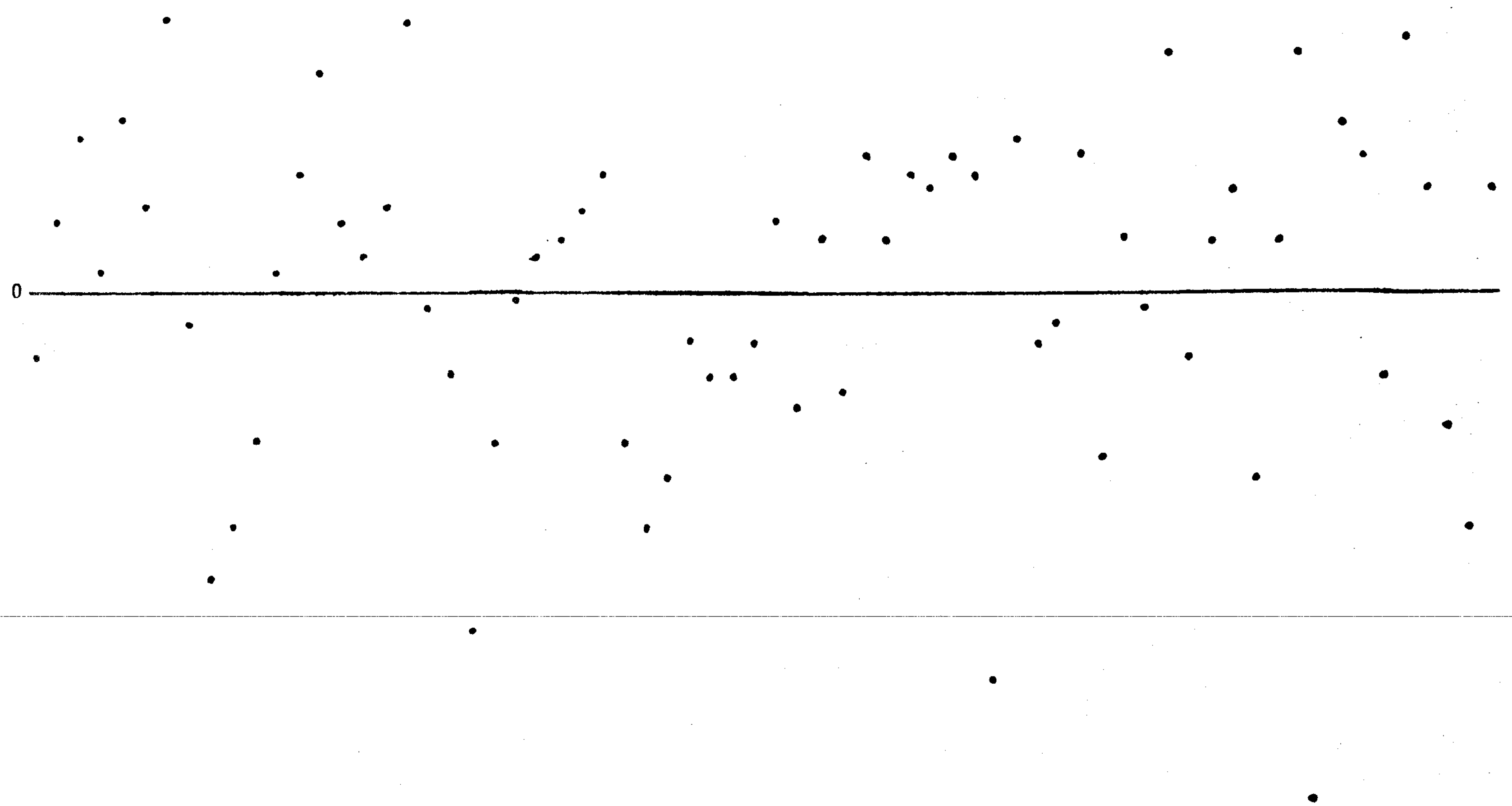

FIGURE 7 - Gordon-Jorgenson Model: Generalized Least Squares Residuals (1956/I-1972/IV)

[1]After autoregressive transformation with $\hat{\rho} = .6223$.

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