THE FAMA-MACBETH APPROACH REVISITED

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Summary

The three-step approach devised by Fama and MacBeth (1973) survived most of the empirical results of their paper to become a standard methodology in the financial literature for its undeniable merits of simplicity and clarity. Nonetheless, their procedure fails to properly account for estimation errors and lack of independence among cross-sectional residuals. This uncertainty may lead to false inference, when simple t-statistics are calculated to empirically validate or disprove hypothesis based on the estimated parameters. In this paper we propose a multi-step econometric methodology that attempts to control for the main drawbacks of the FM technology and mitigates the sensitivity of any analysis of CAPM implications to the choice of a proxy for the market portfolio, as suggested by Kandel & Stambaugh (1995). The procedure is based on the work by McElroy & Burmeister (1988) and is developed around a Bilinear version of the CAPM following the early contribution of Brown & Weinstein (1983). We apply two versions of the new approach to the same set of data originally employed by Fama and MacBeth in their analysis of the two-parameter Sharpe-Lintner model. The new resulting empirical evidence leads us to the conclusion that, although there seems to be on average a positive trade-off between return and risk over the time frame 1926-1968, nonlinearities and non-beta measures of risk play a very important and apparently systematic role in explaining the cross-sectional variability of excess returns. [This version, August 1999]

1. Introduction

Fama-MacBeth (FM) (1973) represents a landmark contribution toward the empirical validation or refusal of the basic implications of the Capital Asset Pricing Model. A relevant portion of the available financial literature, see for example the remarkable work by Roll (1977), devoted its attention to the issue of determining the mean-variance efficiency of the market portfolio. FM first interpreted the CAPM as implying a basic linear relationship between stock returns and market betas which should completely explain the cross-section of returns at a specific point in time.

In order to test the effectiveness of the CAPM in justifying that observed cross-sectional variability of returns, FM designed and implemented a basic two-step regression methodology that eventually survived the first set of empirical results that it generated, to become a standard approach in the field.

In this paper, we attempt to provide detailed answers to three main questions arising from the analysis of FM's work. First, are the model specification they adopted and the two-step estimation technique they elaborated exempt from statistical and economic critique? Second, if the answer to the first question is negative, is it possible to attack the general FM problem with different tools whose results are immune from some of the flaws of their procedure? Last, but not least, do the estimates obtained with new and apparently more reliable econometric work confirm or deny some of the general conclusions of their analysis?

The next paragraph describes briefly the FM paradigm, and provides a replication of their main empirical findings. Paragraph 3 focuses on the problems in the FM technique that the current financial literature has identified as affecting the statistical reliability of their results, and provides a (partially) new methodology to account for them. Paragraph 4 presents an application of this approach to the same set of data originally used by Fama and MacBeth. Paragraph 5 concludes.

2. Fama-MacBeth: a Replication

The basic theoretical claim described in FM and resulting from the Sharpe-Lintner version of the CAPM simply states that variability in market betas accounts for a significant portion of the cross-sectional variability of stock returns at a certain point in time, or for a specified sample period. In order to make this proposition empirically testable the authors describe the following stochastic model for returns:

$$R_{it} = \gamma_0 + \beta_i R_{mt} + \varepsilon_{it} \qquad [\ 1\ ]$$

$$E(R_i) = E(R_f) + \beta_i \left[E(R_m) - E(R_f) \right] \qquad [\ 2\ ]$$

Assuming that the betas are known, equation [1] and [2] are generalized into:

$$R_{it} = \gamma_{0t} + \gamma_{1t}\beta_i + \gamma_{2t}\beta_i^2 + \gamma_{3t}S_i + \eta_{it} \qquad [\ 3\ ]$$

where S(i) represents the standard deviation of residual returns ε(i) for security i, for i = 1,…..,n. From equation [3] FM are able to test some of the major implications of the CAPM simply through basic statistical analysis of the estimates for the various γs, under the assumption that both the returns and (consequently) the parameters describing their stochastic process are normally distributed and temporally IID. Indeed, this assumption allows the construction of simple t-test for the following set of hypothesis:

C1 - Linearity	$H_0 : E\left[\hat{\gamma}_{2t}\right] = 0$
C2 - No Systematic Effect of Non-Beta Risk	$H_0 : E\left[\hat{\gamma}_{3t}\right] = 0$
C3 - Positive Expected Return-Risk Trade-off	$H_0 : E\left[\hat{\gamma}_{1t}\right] = E\left[R_{mt}\right] - E\left[R_{ft}\right] > 0$
SL - Sharpe-Lintner CAPM	$H_0 : E\left[\hat{\gamma}_{0t}\right] = R_{ft}$
ME - Market Efficiency	all the stochastic coefficients and the disturbances $\hat{\eta}_{it}$ are "fair games"

Hypothesis C1 to C3 specify, to paraphrase FM, the general expected return implications of the two-parameter model described in equations [1] and [2], as they suggest that investors hold efficient portfolios and the market portfolio itself is efficient. The SL hypothesis is simply an attempt to verify whether a very specific two-parameter model describing market equilibrium is consistent with the empirical data. As such, its refusal does not affect any of the more general, hence more interesting, assumptions regarding the asserted validity of the CAPM in explaining the cross-section variability of equity returns. ME is a “not-strong” form proposition of capital markets’ efficiency, and originates from the CAPM assumption that markets are perfect, in the sense that stock prices reflect all publicly available information at any specific point in time. This in turn implies that the observation of past values of the estimated parameters γs should not lead to non-zero future estimates of the risk premium, the impact of non-linearities and the return disturbances. Nonetheless, this argument does not appear to be convincing, and it did not receive additional attention from the subsequent literature, for it ignores the fact that serial correlation for the resulting estimates may result from the way the estimators are constructed and the stock return data are collected, and not from presumed market inefficiencies. Moreover, the impact of those effects is by itself not easily quantifiable. Consequently, in this paper we focus on C1-C3 as the main object of FM analysis and of our subsequent empirical investigation.

The empirical implementation of this approach involves the following three-step procedure:

Step 1

Equation [1] is estimated for each of the stocks in the sample;

Step 2

Assuming that the betas resulting from step 1 are given, cross-sectional OLS regressions [3] are run for each of the available dates, and time series of the parameters’ estimates are consequently generated;

Step 3

The time series for the γs are analyzed and tests for C1-C3 are performed using simple t-test statistics.

The data utilized by FM for this study are monthly percentage returns[1] for all common stocks traded on the New York Stock Exchange (NYSE) during the period going from January 1926 to June 1968, as recorded by the Center for Research in Security Prices of the University of Chicago.

The Market return $R_m(t)$ is the "Fisher's Arithmetic Index", i.e. an equally weighted average of the returns on all stocks listed on the NYSE in month t. The risk-free rate $R_f(t)$ is calculated from the average Street Convention quoted yield reported in the Fama-Bliss Database for 1-month Treasury Bills from January 1926 to June 1968, according to the following formula:

$$P_t = 100 - \left(\frac{D}{360}\right) \cdot R_{AVG,t}^{Street} \qquad \text{D = duration, in days}$$

$$R_{ft}^{Annual} = \left(\frac{100}{P_t} - 1\right) \cdot \frac{365}{D}$$

$$R_{ft} = \left(1 + R_{ft}^{Annual}\right)^{1/12} - 1$$

As stated in step 2, the cross-sectional regressions of equation [3] run under the strong assumption that the estimated betas deriving from step 1 correspond to the true and unknown market betas. This choice unavoidably introduces an "error-in-variable" complication: the efficiency and consistency of the resulting estimates for the parameters γ are going to be negatively affected by the degree of uncertainty related to the supposedly known regressors in [3].

FM cope with this issue by aggregating the available stocks into beta-portfolios in order to increase the precision of the resulting beta estimates. The sample period 1926-1968 is divided into 9 subsets, as described in Table 1. Each subset is in turn segmented into three non-overlapping sub-periods. Individual stocks' betas are estimated during the first one, and stocks are subsequently ranked according to those estimates. Then, 20 portfolios are created by grouping the stocks by the beta ranking. Portfolio betas are calculated for each month of the second ("estimation") sub-period. Finally, cross-sectional regression

[1] Including dividends and capital gains, with the appropriate adjustment for capital changes, such as splits and stock dividends. In the appendix, we report the sample Fortran code used to retrieve the needed data.

equations [3] are estimated and time-series for the resulting parameter-estimates are derived for every month of the final sub-period.

The attached formula sheets in the appendix describe precisely all the procedures and the formulas adopted for the derivation of the γs. Table 2 reports the betas and related sample statistics resulting from four selected estimation periods. As evident from the last row of each of the sub-period tables, the standard errors of the portfolio betas are one-third to one-seventh the standard errors of the individual betas. The gain in precision seems evident[2].

Table 3 reports summary results and test statistics for each of the following four panels for the cross-sectional regressions:

PANEL A	$R_{Pt} = \hat{\gamma}_{0t} + \hat{\gamma}_{1t}\hat{\beta}_{Pt} + \hat{\eta}_{Pt}$
PANEL B	$R_{Pt} = \hat{\gamma}_{0t} + \hat{\gamma}_{1t}\hat{\beta}_{Pt} + \hat{\gamma}_{2t}\hat{\beta}^2_{Pt} + \hat{\eta}_{Pt}$
PANEL C	$R_{Pt} = \hat{\gamma}_{0t} + \hat{\gamma}_{1t}\hat{\beta}_{Pt} + \hat{\gamma}_{3t}\overline{S}_P(\hat{\varepsilon}_i) + \hat{\eta}_{Pt}$
PANEL D	$R_{Pt} = \hat{\gamma}_{0t} + \hat{\gamma}_{1t}\hat{\beta}_{Pt} + \hat{\gamma}_{2t}\hat{\beta}^2_{Pt} + \hat{\gamma}_{3t}\overline{S}_P(\hat{\varepsilon}_i) + \hat{\eta}_{Pt}$

The last panel, D, corresponds to equation [3]. Table 3 contains the major tests of the implications of the two-parameter models. Results are there presented for 10 periods, the overall sample 1926-1968, three long sub-periods, 1935-1945, 1946-1955, 1956-1968, and six short subperiods which, with the exception of the first, cover 5 years each. The estimates from panel B and D do not seem to reject the hypothesis formulated in C1 that the relationship between expected return and beta is linear. The t-statistics reported for the coefficient γ_2 leads us to the conclusion that the estimated parameter is not significantly different from zero in a statistical sense. The values of $t(\gamma_2)$ for the overall period 1935-1968 in panels B and D are just –0.50 and –0.48 respectively, and remain "small" for significance levels above 75% for most of the considered sub-samples. For the long subset 1946-1955 the t-statistics are instead –2.71 and –2.80. However, this seems to be resulting from a specific time-period, 1951-1955, where in fact the t-values are again significant.

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[2] Evident but not sufficient, as we will emphasize and explore more carefully in the next paragraph.

The statistic $t(\gamma_3)$ in Panels C and D in table 3 also allows us not to reject C2: the devised measure of risk, in addition to beta, does not affect expected returns in any of the sub-periods there examined, for the values of the t-test are small and randomly positive and negative.

Although satisfactorily for the two-parameter model, the results obtained so far would be vain if the most critical hypothesis still to analyze, C3, had to be rejected. This would in turn imply that the available data do not sustain the fundamental assumption that there is on average a positive trade-off between risk and return. Fortunately for the believers of the CAPM, this seems to be the case, at least for panels A and C. The results are somehow mixed for panels B and D, where the model offers a statistically meaningful representation of the data for just some of the sub-samples considered in the analysis. FM claim that small t-statistics for most of those sub-periods reflect the <<……substantial month-to-month variability of the parameters of the risk-return regressions… >>[3]. We argue instead, as it will be explained more precisely in the next paragraph, that the estimators resulting from their three-step approach are consistent but not efficient. It is this lack of efficiency, materializing in higher standard errors of the resulting estimates, not simply the variability of the estimates of the model of equation [1], to generate smaller t-statistics for the hypothesis we are testing.

The behavior of the time series for the estimated γ_1, γ_2, and γ_3 is consistent with the ME hypothesis that the capital markets are efficient. As evident from the ρ columns in table 3, the serial correlations for each of the three parameters are generally low both in terms of explanatory power and statistical significance.

Table 4 offers a perspective on the behavior of the market during each of the sub-periods under examination, and on the empirical validation of the two-parameter Sharpe-Lintner model. If their version of the CAPM were correct, then we would expect the estimated value for the average γ_0 to be statistically close to the expected return on any zero-beta security or portfolio, and the excess market return to be statistically close to γ_1. However, just in two of the considered samples, 1935-1940 and 1961-1968, Rm(t) – Rf(t) is similar to the corresponding γ_1. This appears to be a consequence of the average risk-free rate

[3] Fama-MacBeth (1973), page 624.

being smaller than the average γ_0. FM observe that the most efficient test for the SL hypothesis is provided by the results of panel A, as the standard error of the resulting estimates for the constant coefficient of the cross-sectional regressions of equation [3] are substantially lower than their counterparts in panels B to D. Nonetheless, except for the earliest and the latest periods (1935-45 and 1961-1968), the values of $t(\gamma_0 - R_f)$ are large, thus leading us to reject the Sharpe-Lintner version of the CAPM[4].

Finally, Table 5 reports an attempt by FM to account for the proportion of the variability of the values obtained for the γs that is potentially explained by estimation errors, or in other words by lack of precision of the coefficient estimates used to analyze the two-parameter model, rather than by the variability of the underlying and unobserved true parameters. The authors construct an F-test for the null hypothesis that the estimation error is big, i.e. that the sample variance of the month-by-month estimated γs is equal to the variance of the estimation error. The resulting F values listed in table 5 for each of the four panels are generally small (except for panel A). This suggests that the reliability of the estimates for the γs declines considerably when non-linearity and non-beta risk factors are included in the cross-sectional regressions of equation [3].

In short, given the assumption that the adopted proxy for the market portfolio is efficient, FM's results appear to support the hypothesis that the pricing of securities in the sample period 1935-1968 is in line with most of the implications of the two-parameter model for expected returns. Specifically, the data confirm the existence of a positive trade-off between risk and return, that on average nonlinearity effects are zero and that non-beta risk factors do not have additional explanatory power for the cross-sectional variability of returns, when beta has been properly accounted for. More ambiguous are the results for the specific Sharpe-Lintner version of the CAPM adopted as basic theoretical framework. Nonetheless, the issue of determining the precision of the estimates for the parameters of interest in the model proposed by Fama and MacBeth affects the conclusions we derive

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[4] It is interesting to observe that the SL version of the CAPM seems to hold for the quadratic model of panel B and the enlarged version of panel D. However, this last case appears to be largely influenced by the presence of the quadratic term and not by the non-beta risk term, for which the rejection of the SL hypothesis is strong in panel C. These considerations make the testing of the two-parameter approach more ambiguous.

from the analysis of their major results. Can we devise an estimation procedure that attempts to control for and maximizes the degree of precision involved in the cross-sectional regressions for panels A to D by generating efficient estimates of the parameters of interest? The next paragraph is devoted to provide a satisfactory answer to this compelling question.

3. A Multi-Step approach to Gamma Estimation

The Fama-MacBeth methodology has become a standard for the estimation and testing of different versions of the CAPM and the APT model of Ross. Their three-step sequence for the estimation of factor-loadings and factor-prices revealed to be especially effective for multi-factor models, as it can easily be modified to accommodate additional non-beta measures of risk. Nonetheless, as briefly emphasized in paragraph 2, the FM approach is affected by three major problems, that eventually weaken many of the conclusions that may result from its practical application to financial data:

- **a) Errors-In-Variable Problem:** the cross-sectional regressions defined in equation [3] are based on the assumption that the betas are given, i.e. that the betas resulting from the basic model of equation [1] correspond to the true and unobservable market betas. The resulting and unavoidable errors in generating the needed beta-risk factor affect the precision by which the parameters of the cross-sectional regressions are estimated, hence the validity of the conclusions that may be derived from those estimates.
- **b) Cross-Sectional Independence Problem:** in estimating the cross-sectional model of panels A to D through OLS, FM implicitly assume that the variance-covariance matrix of the residuals η at each point in time t is proportional to a diagonal matrix. This choice, when not adequately supported by the actual data, makes the resulting estimates for γs consistent but not efficient. Consequently, the t-statistics for these parameters may lead to false inference about the hypothesis under examination.
- **c) The Roll Critique:** the true market portfolio is unobservable, and the proxy used for the market return is not necessarily mean-variance efficient. If this is

the case, then, as masterly emphasized by Roll (1977) and Roll and Ross (1994), evidence of the lack of a relation (or instead of a strong relation) between expected return and beta may be resulting from the adoption of the wrong proxy, rather then from the validity of the underlying theory. This happens because, if the true market portfolio is mean-variance efficient, the cross-sectional relationship between expected returns and betas reveals to be very sensitive to even small deviations of the true market portfolio from the proxy adopted for the empirical estimation of the model.

Fama and MacBeth explicitly recognize the existence of the Errors-In-Variable issue in their procedure: the beta-grouping of step 1 is an early attempt to increase the precision of the beta estimates by running the cross-sectional regressions described in equation [3] for portfolio of stocks, rather than for individual stocks. Shanken (1992) argues that, although the FM approach reduces the measurement error for the betas, especially in small samples of the available data, the resulting estimation error for the gammas cannot be ignored, even in large samples. He finds that the FM procedure for computing standard errors keeps overstating the precision of the gamma estimates, and devises a two-pass methodology, originally proposed by Litzenberger and Ramaswamy (1979), to explicitly correct for the variability in the factors and generate asymptotically valid confidence intervals for the parameters of interest.

Two versions of the correction algorithm are provided here. The first one, from Shanken (1992), adjusts the t-statistics estimated through the FM three-step approach by a coefficient *c* that, in a single-factor portfolio, simply corresponds to the squared value of the well-know Sharpe ratio, according to the following formula:

$$c = \left| \frac{\hat{\gamma}_{it}}{S(R_m)} \right| \qquad i = 0,1,2,3 \qquad\qquad t^* = \frac{t^{FM}}{\sqrt{1+c}}$$

Table 6 presents the FM t-statistics corrected by the factor *c* for each of the modules described in paragraph 2.

A second version is provided by Campbell-Lo-MacKinlay (1997) and more explicitly adjusts the standard errors of the gammas with the observed mean and standard deviation for the excess market return:

$$Z_{mt} = R_{mt} - R_{ft}$$

$$\sigma_{\gamma_i}^2{}' = \sigma_{\gamma_i}^2 \cdot \left| 1 + \frac{(\hat{\mu}_m - \hat{\gamma}_0)}{\hat{\sigma}_m^2} \right|$$

$$t' = \frac{\hat{\gamma}_i}{\sigma_{\gamma_i}{}'}$$

Table 7 reports the adjusted t-statistics for the Campbell-Lo-MacKinlay algorithm for each of the four panels and each of the ten sub-periods of interest.

As evident from the analysis of the modified t-stats, both the proposed refinements do not generate a significant impact on the results of FM, hence on the corresponding inference. Although this evidence may lead us to the conclusion that the portfolio-grouping algorithm corrects for most of the Error-In-Variable effect and that each of the suggested corrections eliminates any residual estimation bias, in fact none of the proposed solutions accounts for the possibility that, as a result of the unobservability of the true beta, other variables, like non-beta risk factors and non-linearity factors, enter spuriously in the cross-sectional regressions of model [3]. Moreover, none of the mechanisms described above attempts to control for the consequences of the cross-sectional independence problem and the Roll critique.

In order to cope with all of the issues described above, we propose a multi-step application of the pioneering work by McElroy and Burmeister (1988), based on the bilinear paradigm described in Brown and Weinstein (1983), that:

I) explicitly accounts for the Error-In-Variable problem,

II) assumes a non-diagonal Variance-Covariance matrix for the cross-sectional residuals, and

III) mitigates the sensitivity of the relationship between expected return and beta to the assumed proxy for the market portfolio, along the lines of Kandel and Stambaugh (1995).

The methodology we devised assumes that the portfolio partitions suggested by FM and the estimates of the risk-prices generated by their OLS cross-sectional regressions represent just a first step toward Efficient and Full-Information Maximum Likelihood Estimators of both the market betas and the parameters of interest. The gammas and the betas resulting from the simple three-step approach permit us to provide initial values for the estimation of a bilinear version of the Sharpe-Lintner CAPM and an initial covariance matrix for an Iterated Non-Linear GLS estimation of the coefficients of the specified model for the expected returns. NLGLS allows us to reduce the sensitivity of the results of the cross-sectional analysis to the proxy we choose for the market portfolio, as suggested by Kandel and Stambaugh (1995), and at the same time to account for potential non-independence in the cross-sectional residuals. Two different approaches are here designed to generate an efficient estimate for the Variance-Covariance matrix from which to start the GLS estimation[5]. In the first case (Method I), the residuals are initially assumed to be cross-sectionally independent. Using the FM estimates as starting values, an Iterated NLOLS generates new coefficient values and an estimated Covariance Matrix of residuals. That matrix and those estimates then represent the starting point for the Iterated NLGLS procedure. In the second case (Method II), the FM estimates for gammas and betas are utilized to generate time series of residuals for each of the N grouped portfolios. Then, an N by N Covariance matrix is calculated and an Iterated NLGLS regression is run.

The following stochastic generalization for a model describing excess returns is devised:

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\begin{aligned}
R_{it} &= \mu_{it} + \beta_i R_{mt} + \varepsilon_{it} \\
\mu_{it} &= R_{ft} + \gamma_1 \beta_i + \gamma_2 \beta_i^2 + \gamma_3 S_i(t-1) \qquad [\,4\,] \\
S_i(t-1) &= (R_{i(t-1)} - R_{f(t-1)}) - \beta_i R_{m(t-1)}
\end{aligned}
$$

, where S(t-1) is the new non-beta risk component we consider for the analysis.

We suggest a Bilinear version of the model in equation [4] as the empirical analog to be estimated:

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[5] The need to provide an efficient estimate for the true Variance-Covariance matrix Σ and the difficulty in generating such an estimate has until now limited the adoption of the Kendal-Stambaugh suggestion.

$$R_{it} = R_{ft} + \gamma_1\beta_i + \gamma_2\beta_i^2 + \gamma_3 S_i(t-1) + \beta_i R_{mt} + \varepsilon_{it}$$
$$Z_{it} = R_{it} - R_{ft} = \beta_i\left(\gamma_1 + R_{mt}\right) + \gamma_2\beta_i^2 + \gamma_3\left(R_{i(t-1)} - R_{f(t-1)} - \beta_i R_{m(t-1)}\right) + \varepsilon_{it} \qquad [\,5\,]$$

The estimation of different versions of equation [5] corresponding to the four panels A to D described in FM proceeds according to a series of successive steps conceived to select the most appropriate initial values for both the coefficients of interest and the Covariance Matrix for the cross-section of residuals.

- **Method 1:** The multi-step procedure is articulated as follows:

<u>Step 1</u> The three-steps FM approach is applied to the available set of data in order to provide initial estimates for the gamma and the beta parameters.

<u>Step 2</u> The covariance matrix for the cross-sectional estimated residuals of equation [5], Σ, is assumed to be proportional to a N by N identity matrix, and Iterated Non-Linear OLS[6] is run over the following adjusted panels:

PANEL A $$Z_{Pt} = R_{Pt} - R_{ft} = \beta_P\left(\gamma_1 + R_{mt}\right) + \eta_{Pt}$$

PANEL B $$Z_{Pt} = R_{Pt} - R_{ft} = \beta_P\left(\gamma_1 + R_{mt}\right) + \gamma_2\beta_P^2 + \eta_{Pt}$$

PANEL C $$Z_{Pt} = R_{Pt} - R_{ft} = \beta_P\left(\gamma_1 + R_{mt}\right) + \gamma_3\left(R_{P(t-1)} - R_{f(t-1)} - \beta_P R_{m(t-1)}\right) + \eta_{Pt}$$

PANEL D $$Z_{Pt} = R_{Pt} - R_{ft} = \beta_P\left(\gamma_1 + R_{mt}\right) + \gamma_2\beta_P^2 + \gamma_3\left(R_{P(t-1)} - R_{f(t-1)} - \beta_P R_{m(t-1)}\right) + \eta_{Pt}$$

<u>Step 3</u> NLOLS betas and gammas are used to calculate an empirical Covariance matrix for the cross-sectional residuals. As such, the resulting Σ has not to be diagonal[7].

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[6] Iterated NLOLS and NLGLS algorithms use a straightforward multi-level iteration. At entry, initial values for the parameters and Σ are provided. A first set of parameter estimates is obtained, conditioned on those initial values. The parameters are then used to recompute Σ. Then a new regression generates new sets of parameters and Σ. Convergence is assessed in terms of the log determinant of the estimated Covariance matrix for the cross-sectional residuals. If the change is less then 0.00001, the procedure exits, otherwise it continues, for a maximum of 100 iterations.

Step 4 NLOLS betas, gammas and empirical Σ become the starting estimates for an Iterated NLGLS regression for each of the panels described above.

Step 5 NLGLS estimators for gammas are then used to test hypothesis C1 to C3 of Fama-MacBeth with the usual t-statistics.

- **Method II :** In this case, the original estimates for gammas and betas resulting from the simple FM three-step approach (and not the NLOLS parameters) are used to generate an initial empirical Covariance matrix for the cross-sectional residuals. Then, step 4 and 5 follow.

The econometric procedures proposed in this paper generate strongly consistent and asymptotically normal estimators, even if the error distribution departs from normality. If this is not the case, then both the techniques we described above yield Full-Information Maximum Likelihood Estimators, the basis for classical asymptotic hypothesis testing. In the next paragraph we provide for an application of our two empirical methods to the same sample of data described by Fama and MacBeth, and test the validity of their conclusions with a more efficient set of parameters' estimates.

4. A New Analysis of the Fama-MacBeth data sample

The results of the replication exercise we presented in paragraph 2 are here used as a starting point for an application[8] of the two multi-step Non-Linear Regression approaches devised in this paper for the same data sample originally analyzed by Fama and MacBeth. Table 8 reports the Full-Information MLEs for γ_1, γ_2, and γ_3, the corresponding t-statistic and McElroy's R-squared measure[9] for each of the two methods and each of the four system-panels A to D. The same 10 sub-periods as in FM are considered.

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[7] Indeed, the empirical Σs we estimated in paragraph 4 appeared to be highly not-diagonal.

[8] The empirical analysis described in this paragraph has been implemented *via* the latest version (2.0) of the widely praised Limdep 7.0 Econometric package of prof. William Greene. In the appendix, coding samples for each of the two methods and the four panels are reported.

[9] This measure is computed as:

Before approaching the problem of hypothesis testing, Table 9 offers us a very interesting perspective on the size of the improvement in the degree of precision in parameter estimation resulting from our procedure. Table 9 in fact shows the beta estimates derived from the two multi-step regression for the overall sample 1935-1968[10] and the corresponding t-statistics. The standard errors for the beta estimates are at least two to three times smaller than the ones obtained from the simple portfolio grouping procedure and reported in table 2. Consequently, the t-statistics for our Full-Information MLEs are two to three times bigger than in the FM results. The reduction in estimation uncertainty is even more impressive for the gamma parameters, where the standard errors implied by both Methods 1 and 2 (not reported here but available on request) are generally more than ten times smaller than their counterparts in Fama-MacBeth[11]. These results lead to more precise, although somehow surprising inference in tests for the validation of hypothesis C1 to C3.

Let's start with C1, i.e. linearity of the relationship between expected excess return and beta-measures of risk. Contrary to the early conclusions based on the results of FM replication, the t-values of table 8 for panels B to D and for Methods 1 and 2 direct us to reject the null hypothesis. Same is the case when non-beta measures of risk are considered, as for panels C and D, and *t*(γ_3) is examined. In just two of the 10 subsets of the data, 1946-1950 and 1956-1960, the evidence supports the assertion that beta is sufficient to explain a significant portion of the cross-sectional variability of portfolio returns. Finally, we consider the important null hypothesis C3, i.e. that the expected excess return-risk trade-off is positive, as argued by any general interpretation of the Capital Asset Pricing Model. Fortunately again for CAPM lovers, this seems to be the

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$R^2_{Mc} = \sum_i \sum_j \sigma_{i,j} (\frac{1}{N}) \sum_{k=1}^{N} (Z_{ki} - \overline{Z}_i)(Z_{kj} - \overline{Z}_j) = tr(\Sigma^{-1} V_Z)$, where Vz is the sample covariance matrix for the portfolio excess returns.

[10] The same tables for each of the other nine subsets of the original data are available from the author on request.

[11] As expected, the gain in precision is slightly more significant for Method 1. Nonetheless, Method 2 leads us to the interesting conclusion that even the estimated Covariance matrix resulting from the pure FM approach may lead to a huge reduction of estimation uncertainty, when Iterated NLGLS is used.

case, for the sample period 1926-1968. Values for $t(\gamma_1)$ are statistically significant, and γ_1 positive for most of the subsets considered in the analysis, although still different from the average excess market returns listed in table 4. In short, we cannot reject the hypothesis that the pricing of securities listed in the NYSE between 1926 and 1968 is consistent with the attempts by risk-averse investors to hold efficient portfolios, as postulated by the CAPM.

5. A Brief Conclusion

The three-step approach devised by Fama and MacBeth survived most of the empirical results of their paper to become a standard methodology in the financial literature for its undeniable merits of simplicity and clarity. Nonetheless, their procedure fails to properly account for estimation errors and lack of independence among cross-sectional residuals. This uncertainty may lead to false inference, when simple t-statistics are calculated to empirically validate or disprove hypothesis based on the estimated parameters. In this paper we proposed a multi-step econometric methodology that attempts to control for the main drawbacks of the FM technology and mitigates the sensitivity of any analysis of CAPM implications to the choice of a proxy for the market portfolio.

We applied two versions of the new approach to the same set of data originally employed by Fama and MacBeth in their analysis of the two-parameter Sharpe-Lintner model.

The new resulting empirical evidence leads us to the conclusion that, although there seems to be on average a positive trade-off between return and risk over the time frame 1926-1968, nonlinearities and non-beta measures of risk play a very important and apparently systematic role in explaining the cross-sectional variability of excess returns.

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Table 1

Portfolio Formation, Estimation, and Testing Periods

	Periods								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Portfolio Formation Period	1926-1929	1927-1933	1931-1937	1935-1941	1939-1945	1943-1949	1947-1953	1951-1957	1955-1961
Initial Estimation Period	1930-1934	1934-1938	1938-1942	1942-1946	1946-1950	1950-1954	1954-1958	1958-1962	1962-1966
Testing Period	1935-1938	1939-1942	1943-1946	1947-1950	1951-1954	1955-1958	1959-1962	1963-1966	1967-1968
No. of securities available	680	742	766	867	964	1003	1015	1281	1405
No. of securities meeting data requirements	390	557	579	672	714	770	814	819	807

Table 2

Sample Statistics for Four Selected Estimation Periods

Statistic	I	II	III	IV	V	VI	VII	VIII	IX	X
Portfolios for Estimation Period 1934-1938										
$\hat{\beta}_{P,t-1}$	0.325	0.619	0.561	0.687	0.843	0.644	0.880	0.955	0.979	0.895
$s(\hat{\beta}_{P,t-1})$	0.024	0.027	0.025	0.028	0.024	0.023	0.037	0.029	0.035	0.025
$r(R_P, R_m)^2$	0.737	0.869	0.864	0.881	0.922	0.898	0.874	0.916	0.900	0.923
$s(R_P)$	0.041	0.071	0.064	0.077	0.093	0.072	0.100	0.106	0.110	0.099
$\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.074	0.079	0.076	0.089	0.096	0.073	0.116	0.112	0.112	0.094
$s(\hat{\varepsilon}_P)$	0.021	0.026	0.024	0.026	0.026	0.023	0.035	0.031	0.035	0.027
$s(\hat{\varepsilon}_P)/\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.287	0.324	0.311	0.298	0.273	0.317	0.306	0.274	0.311	0.292
Portfolios for Estimation Period 1942-1946										
$\hat{\beta}_{P,t-1}$	0.462	0.539	0.588	0.595	0.710	0.712	0.776	0.778	0.739	0.854
$s(\hat{\beta}_{P,t-1})$	0.044	0.039	0.043	0.034	0.032	0.033	0.033	0.031	0.037	0.036
$r(R_P, R_m)^2$	0.630	0.741	0.740	0.812	0.866	0.860	0.874	0.887	0.844	0.878
$s(R_P)$	0.035	0.037	0.041	0.040	0.046	0.046	0.050	0.050	0.048	0.055
$\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.054	0.054	0.063	0.054	0.059	0.063	0.063	0.062	0.059	0.067
$s(\hat{\varepsilon}_P)$	0.021	0.019	0.021	0.017	0.017	0.017	0.018	0.017	0.019	0.019
$s(\hat{\varepsilon}_P)/\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.389	0.355	0.330	0.317	0.286	0.274	0.280	0.270	0.322	0.286
Portfolios for Estimation Period 1950-1954										
$\hat{\beta}_{P,t-1}$	0.418	0.559	0.707	0.737	0.780	0.773	0.887	0.966	0.984	0.959
$s(\hat{\beta}_{P,t-1})$	0.040	0.049	0.048	0.036	0.037	0.040	0.048	0.038	0.034	0.033
$r(R_P, R_m)^2$	0.635	0.666	0.763	0.849	0.856	0.839	0.826	0.887	0.903	0.905
$s(R_P)$	0.019	0.025	0.029	0.029	0.031	0.031	0.035	0.037	0.038	0.037
$\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.040	0.044	0.046	0.048	0.049	0.050	0.053	0.053	0.058	0.052
$s(\hat{\varepsilon}_P)$	0.011	0.014	0.014	0.011	0.012	0.012	0.015	0.013	0.012	0.011
$s(\hat{\varepsilon}_P)/\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.286	0.326	0.307	0.233	0.235	0.245	0.279	0.234	0.202	0.216
Portfolios for Estimation Period 1958-1962										
$\hat{\beta}_{P,t-1}$	0.636	0.608	0.698	0.751	0.820	0.851	0.939	0.912	0.995	0.927
$s(\hat{\beta}_{P,t-1})$	0.043	0.050	0.041	0.045	0.050	0.032	0.034	0.037	0.042	0.037
$r(R_P, R_m)^2$	0.759	0.693	0.806	0.801	0.798	0.892	0.896	0.881	0.876	0.886
$s(R_P)$	0.031	0.031	0.033	0.036	0.039	0.038	0.042	0.042	0.045	0.042
$\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.049	0.050	0.055	0.057	0.065	0.058	0.068	0.067	0.069	0.064
$s(\hat{\varepsilon}_P)$	0.015	0.017	0.015	0.016	0.018	0.013	0.014	0.014	0.016	0.014
$s(\hat{\varepsilon}_P)/\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.309	0.344	0.266	0.282	0.273	0.218	0.202	0.213	0.232	0.222

Table 2 (*Continued*)

Sample Statistics for Four Selected Estimation Periods

Statistic	XI	XII	XIII	XIV	XV	XVI	XVI	XVI	XIX	XX
Portfolios for Estimation Period 1934-1938										
$\hat{\beta}_{P,t-1}$	1.029	1.109	1.128	1.114	1.235	1.157	1.312	1.315	1.354	1.408
$s(\hat{\beta}_{P,t-1})$	0.028	0.026	0.033	0.032	0.030	0.028	0.032	0.031	0.042	0.044
$r(R_P, R_m)^2$	0.928	0.936	0.920	0.922	0.935	0.935	0.933	0.936	0.915	0.915
$s(R_P)$	0.114	0.122	0.125	0.123	0.136	0.127	0.144	0.145	0.151	0.157
$\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.094	0.122	0.134	0.118	0.133	0.112	0.139	0.129	0.135	0.153
$s(\hat{\varepsilon}_P)$	0.030	0.031	0.035	0.034	0.035	0.032	0.037	0.037	0.044	0.046
$s(\hat{\varepsilon}_P)/\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.326	0.253	0.262	0.291	0.261	0.289	0.268	0.284	0.325	0.300
Portfolios for Estimation Period 1942-1946										
$\hat{\beta}_{P,t-1}$	0.963	0.984	0.964	1.007	1.365	1.148	1.337	1.295	1.584	1.634
$s(\hat{\beta}_{P,t-1})$	0.030	0.030	0.036	0.035	0.053	0.033	0.038	0.047	0.068	0.082
$r(R_P, R_m)^2$	0.914	0.919	0.896	0.904	0.887	0.921	0.924	0.899	0.872	0.842
$s(R_P)$	0.060	0.062	0.061	0.063	0.087	0.072	0.083	0.082	0.102	0.107
$\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.074	0.073	0.075	0.080	0.101	0.088	0.086	0.088	0.113	0.120
$s(\hat{\varepsilon}_P)$	0.018	0.018	0.020	0.020	0.029	0.020	0.023	0.026	0.036	0.042
$s(\hat{\varepsilon}_P)/\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.241	0.244	0.265	0.246	0.288	0.227	0.267	0.298	0.321	0.354
Portfolios for Estimation Period 1950-1954										
$\hat{\beta}_{P,t-1}$	1.080	1.100	1.145	1.170	1.086	1.260	1.200	1.292	1.392	1.523
$s(\hat{\beta}_{P,t-1})$	0.026	0.048	0.034	0.050	0.044	0.043	0.044	0.046	0.061	0.082
$r(R_P, R_m)^2$	0.936	0.870	0.918	0.873	0.881	0.905	0.898	0.901	0.871	0.826
$s(R_P)$	0.040	0.043	0.043	0.045	0.042	0.048	0.046	0.049	0.054	0.061
$\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.058	0.061	0.060	0.064	0.065	0.062	0.065	0.068	0.072	0.090
$s(\hat{\varepsilon}_P)$	0.010	0.015	0.012	0.016	0.014	0.015	0.015	0.015	0.019	0.025
$s(\hat{\varepsilon}_P)/\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.178	0.251	0.207	0.251	0.222	0.237	0.227	0.228	0.269	0.281
Portfolios for Estimation Period 1958-1962										
$\hat{\beta}_{P,t-1}$	0.973	1.002	1.012	1.049	1.031	1.054	1.069	1.086	1.218	1.356
$s(\hat{\beta}_{P,t-1})$	0.040	0.037	0.035	0.036	0.034	0.042	0.040	0.040	0.048	0.067
$r(R_P, R_m)^2$	0.882	0.897	0.904	0.906	0.910	0.885	0.893	0.895	0.887	0.849
$s(R_P)$	0.044	0.045	0.046	0.047	0.046	0.048	0.048	0.049	0.055	0.064
$\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.069	0.066	0.065	0.069	0.061	0.068	0.074	0.071	0.069	0.075
$s(\hat{\varepsilon}_P)$	0.015	0.015	0.014	0.014	0.014	0.016	0.016	0.016	0.019	0.025
$s(\hat{\varepsilon}_P)/\bar{s}_{P,t-1}(\hat{\varepsilon}_i)$	0.220	0.222	0.218	0.209	0.228	0.239	0.213	0.224	0.269	0.329

Table 3

Summary Results for the Regression

$$R_P = \hat{\gamma}_{ot} + \hat{\gamma}_{1t}\hat{\beta}_P + \hat{\gamma}_{2t}\hat{\beta}_P^2 + \hat{\gamma}_{3t}\bar{s}_P(\hat{\varepsilon}_i) + \hat{\eta}_{Pt}$$

Statistic

Period	$\overline{\hat{\gamma}_0}$	$\overline{\hat{\gamma}_1}$	$\overline{\hat{\gamma}_2}$	$\overline{\hat{\gamma}_3}$	$\overline{\hat{\gamma}_0 - R_f}$	$s(\hat{\gamma}_0)$	$s(\hat{\gamma}_1)$	$s(\hat{\gamma}_2)$	$s(\hat{\gamma}_3)$	$\rho_0(\hat{\gamma}_0 - R_f)$	$\rho_M(\hat{\gamma}_1)$	$\rho_0(\hat{\gamma}_2)$	$\rho_0(\hat{\gamma}_3)$	$t(\bar{\hat{\gamma}}_0)$	$t(\bar{\hat{\gamma}}_1)$	$t(\bar{\hat{\gamma}}_2)$	$t(\bar{\hat{\gamma}}_3)$	$t(\overline{\hat{\gamma}_0 - R_f})$	$\overline{r^2}$	$s(r^2)$
Panel A																				
1935-6/1968	0.0059	0.0081			0.0046	0.038	0.066			0.19	0.01			3.09	2.45			2.41	0.24	0.31
1935-45	0.0033	0.0166			0.0032	0.053	0.098			0.17	-0.04			0.72	1.95			0.69	0.22	0.30
1946-55	0.0088	0.0026			0.0079	0.026	0.043			0.08	0.08			3.79	0.67			3.39	0.27	0.34
1956-6/68	0.0057	0.0050			0.0031	0.030	0.043			0.29	0.16			2.35	1.43			1.28	0.24	0.30
1935-40	-0.0011	0.0144			-0.0011	0.066	0.119			0.18	-0.09			-0.14	1.03			-0.14	0.16	0.29
1941-45	0.0086	0.0193			0.0084	0.031	0.066			0.12	0.15			2.17	2.28			2.12	0.30	0.29
1946-50	0.0051	0.0029			0.0044	0.030	0.049			0.15	0.05			1.30	0.46			1.12	0.35	0.35
1951-55	0.0126	0.0023			0.0114	0.019	0.035			-0.12	0.13			5.12	0.51			4.62	0.20	0.30
1956-60	0.0148	-0.0058			0.0128	0.020	0.034			0.15	0.16			5.64	-1.31			4.85	0.16	0.32
1961-6/68	-0.0004	0.0121			-0.0033	0.033	0.046			0.26	0.11			-0.12	2.48			-0.95	0.29	0.29
Panel B																				
1935-6/1968	0.0025	0.0154	-0.0036		0.0012	0.131	0.278	0.142		-0.17	-0.26	-0.26		0.38	1.11	-0.50		0.19	0.27	0.32
1935-45	0.0053	0.0126	0.0021		0.0052	0.218	0.461	0.237		-0.21	-0.30	-0.29		0.28	0.31	0.10		0.27	0.23	0.31
1946-55	-0.0007	0.0230	-0.0100		-0.0017	0.034	0.097	0.041		-0.02	-0.03	-0.09		-0.23	2.60	-2.71		-0.54	0.31	0.34
1956-6/68	0.0026	0.0117	-0.0033		0.0001	0.057	0.118	0.058		0.25	0.18	0.14		0.56	1.21	-0.71		0.01	0.28	0.32
1935-40	-0.0012	0.0161	-0.0011		-0.0013	0.292	0.621	0.316		-0.22	-0.30	-0.30		-0.04	0.22	-0.03		-0.04	0.17	0.31
1941-45	0.0132	0.0083	0.0059		0.0129	0.053	0.089	0.068		0.00	-0.15	0.07		1.91	0.72	0.67		1.88	0.30	0.31
1946-50	-0.0011	0.0161	-0.0063		-0.0018	0.037	0.105	0.043		0.05	0.01	-0.04		-0.23	1.19	-1.13		-0.37	0.38	0.35
1951-55	-0.0004	0.0300	-0.0137		-0.0016	0.032	0.089	0.038		-0.10	-0.09	-0.17		-0.10	2.62	-2.83		-0.39	0.23	0.31
1956-60	0.0105	0.0040	-0.0050		0.0085	0.035	0.085	0.040		0.17	0.03	0.12		2.32	0.37	-0.98		1.87	0.20	0.31
1961-6/68	-0.0026	0.0168	-0.0022		-0.0055	0.067	0.135	0.067		0.25	0.22	0.14		-0.37	1.17	-0.31		-0.78	0.32	0.32

Table 3 (*Continued*)

Summary Results for the Regression

$$R_P = \hat{\gamma}_{ot} + \hat{\gamma}_{1t}\hat{\beta}_P + \hat{\gamma}_{2t}\hat{\beta}_P^2 + \hat{\gamma}_{3t}\bar{s}_P(\hat{\varepsilon}_i) + \hat{\eta}_{Pt}$$

Period	Statistic																		
	$\overline{\hat{\gamma}_0}$	$\overline{\hat{\gamma}_1}$	$\overline{\hat{\gamma}_2}$	$\overline{\hat{\gamma}_3}$	$\overline{\hat{\gamma}_0 - R_f}$	$s(\hat{\gamma}_0)$	$s(\hat{\gamma}_1)$	$s(\hat{\gamma}_2)$	$s(\hat{\gamma}_3)$	$\rho_0(\hat{\gamma}_0 - R_f)$	$\rho_M(\hat{\gamma}_1)$	$\rho_0(\hat{\gamma}_2)$	$\rho_0(\hat{\gamma}_3)$	$t(\bar{\hat{\gamma}}_0)$	$t(\bar{\hat{\gamma}}_1)$	$t(\bar{\hat{\gamma}}_2)$	$t(\bar{\hat{\gamma}}_3)$	$t(\overline{\hat{\gamma}_0 - R_f})$	$\overline{r^2}$	$s(r^2)$
Panel C																			
1935-6/1968	0.0063	0.0088		-0.0138	0.0050	0.049	0.073		0.885	0.10	-0.11		0.00	2.54	2.42		-0.31	2.02	0.26	0.32
1935-45	0.0038	0.0165		0.0055	0.0037	0.065	0.103		0.866	0.07	-0.18		-0.07	0.67	1.85		0.07	0.65	0.25	0.31
1946-55	0.0107	0.0063		-0.0897	0.0098	0.038	0.058		0.809	0.01	0.03		-0.12	3.11	1.20		-1.21	2.84	0.29	0.34
1956-6/68	0.0049	0.0040		0.0300	0.0023	0.041	0.048		0.959	0.22	0.00		0.11	1.46	1.02		0.38	0.69	0.26	0.31
1935-40	0.0003	0.0145		-0.0057	0.0003	0.071	0.128		0.773	0.09	-0.16		-0.22	0.04	0.96		-0.06	0.03	0.18	0.30
1941-45	0.0079	0.0190		0.0191	0.0077	0.058	0.060		0.973	0.01	-0.29		0.04	1.07	2.46		0.15	1.04	0.32	0.30
1946-50	0.0064	0.0061		-0.0673	0.0058	0.046	0.070		0.864	0.04	0.06		-0.02	1.08	0.68		-0.60	0.96	0.38	0.35
1951-55	0.0150	0.0066		-0.1122	0.0138	0.026	0.044		0.757	-0.13	-0.03		-0.26	4.39	1.16		-1.15	4.03	0.21	0.30
1956-60	0.0125	-0.0082		0.0817	0.0105	0.033	0.045		0.991	0.14	0.02		0.25	2.90	-1.43		0.64	2.44	0.18	0.31
1961-6/68	-0.0002	0.0122		-0.0044	-0.0031	0.045	0.049		0.940	0.23	-0.08		0.01	-0.05	2.36		-0.04	-0.66	0.31	0.30
Panel D																			
1935-6/1968	0.0017	0.0140	-0.0036	0.0379	0.0004	0.147	0.279	0.149	0.918	-0.21	-0.24	-0.27	-0.09	0.23	1.00	-0.48	0.83	0.06	0.28	0.33
1935-45	0.0066	0.0115	0.0027	-0.0018	0.0065	0.244	0.459	0.249	0.871	-0.25	-0.28	-0.29	-0.19	0.31	0.29	0.13	-0.02	0.31	0.25	0.32
1946-55	-0.0014	0.0224	-0.0101	0.0119	-0.0024	0.045	0.097	0.040	0.765	-0.04	-0.02	-0.08	-0.12	-0.34	2.52	-2.80	0.17	-0.58	0.31	0.35
1956-6/68	-0.0002	0.0094	-0.0039	0.0935	-0.0027	0.065	0.129	0.062	1.062	0.16	0.06	0.05	-0.02	-0.03	0.89	-0.77	1.08	-0.51	0.29	0.33
1935-40	0.0002	0.0128	-0.0002	0.0171	0.0001	0.324	0.618	0.332	0.818	-0.24	-0.28	-0.30	-0.21	0.00	0.18	-0.01	0.18	0.00	0.19	0.31
1941-45	0.0144	0.0099	0.0063	-0.0244	0.0141	0.073	0.090	0.067	0.937	-0.36	-0.01	-0.05	-0.18	1.52	0.85	0.72	-0.20	1.50	0.32	0.32
1946-50	-0.0032	0.0162	-0.0075	0.0369	-0.0039	0.043	0.106	0.037	0.690	-0.06	0.01	-0.08	0.01	-0.57	1.19	-1.56	0.41	-0.70	0.38	0.37
1951-55	0.0003	0.0286	-0.0127	-0.0131	-0.0009	0.047	0.088	0.042	0.839	-0.02	-0.08	-0.10	-0.20	0.06	2.51	-2.35	-0.12	-0.14	0.23	0.31
1956-60	0.0057	0.0014	-0.0064	0.1486	0.0037	0.055	0.091	0.047	1.192	-0.18	0.05	-0.10	0.04	0.80	0.12	-1.05	0.97	0.52	0.21	0.31
1961-6/68	-0.0041	0.0146	-0.0023	0.0568	-0.0070	0.071	0.149	0.071	0.971	0.29	0.06	0.09	-0.08	-0.55	0.93	-0.31	0.55	-0.93	0.34	0.33

Table 4

The Behavior of the Market

Period	Statistic: $\overline{R_m}$	$\overline{R_m - R_f}$	$\overline{\hat{\gamma}_1}$	$\overline{\hat{\gamma}_0}$	$\overline{R_f}$	$\frac{\overline{R_m - R_f}}{s(R_m)}$	$\frac{\overline{\hat{\gamma}_1}}{s(R_m)}$	$s(R_m)$	$s(\hat{\gamma}_1)$
1935-6/1968	0.0144	0.0131	0.0081	0.0059	0.0046	0.2148	0.1325	0.061	0.066
1935-45	0.0199	0.0197	0.0166	0.0033	0.0032	0.2225	0.1876	0.089	0.098
1946-55	0.0112	0.0103	0.0026	0.0088	0.0079	0.2375	0.0603	0.043	0.043
1956-6/68	0.0121	0.0096	0.0050	0.0057	0.0031	0.2402	0.1245	0.040	0.043
1935-40	0.0137	0.0136	0.0144	-0.0011	-0.0011	0.1260	0.1336	0.108	0.119
1941-45	0.0273	0.0271	0.0193	0.0086	0.0084	0.4702	0.3345	0.058	0.066
1946-50	0.0077	0.0070	0.0029	0.0051	0.0044	0.1350	0.0561	0.052	0.049
1951-55	0.0148	0.0136	0.0023	0.0126	0.0114	0.4163	0.0708	0.033	0.035
1956-60	0.0091	0.0071	-0.0058	0.0148	0.0128	0.2095	-0.1703	0.034	0.034
1961-6/68	0.0141	0.0112	0.0121	-0.0004	-0.0033	0.2583	0.2786	0.043	0.046

Table 4 *(Continued)*

The Behavior of the Market

Period	Statistic: $s(\hat{\gamma}_0)$	$s(R_f)$	$t(\overline{R_m})$	$t(\overline{R_m - R_f})$	$t(\overline{\hat{\gamma}_1})$	$t(\overline{\hat{\gamma}_0})$	$\rho_M(R_m)$	$\rho_M(R_m - R_f)$	$\rho_M(\hat{\gamma}_1)$	$\rho_M(\hat{\gamma}_0)$	$\rho_M(R_f)$
1935-6/1968	0.038	0.0012	4.73	4.30	2.45	3.09	-0.01	-0.01	0.01	0.19	0.99
1935-45	0.053	0.0001	2.57	2.56	1.95	0.72	-0.07	-0.07	-0.04	0.17	0.92
1946-55	0.026	0.0004	2.84	2.60	0.67	3.79	0.09	0.09	0.08	0.08	0.95
1956-6/68	0.030	0.0008	3.73	2.94	1.43	2.35	0.14	0.14	0.16	0.28	0.94
1935-40	0.066	0.0001	1.07	1.07	1.03	-0.14	-0.13	-0.13	-0.09	0.18	0.86
1941-45	0.031	0.0001	3.67	3.64	2.28	2.17	0.16	0.16	0.15	0.12	0.93
1946-50	0.030	0.0003	1.15	1.05	0.46	1.30	0.10	0.10	0.05	0.15	0.96
1951-55	0.019	0.0004	3.51	3.21	0.51	5.12	0.05	0.05	0.13	-0.13	0.88
1956-60	0.020	0.0006	2.08	1.61	-1.31	5.64	0.11	0.12	0.16	0.15	0.81
1961-6/68	0.033	0.0007	3.09	2.45	2.48	-0.12	0.14	0.14	0.11	0.26	0.97

Table 5

Components of the Variance of the $\hat{\gamma}_{it}$

Period	$s^2(\tilde{\gamma}_0)$	$s^2(\tilde{\gamma}_0)$	$\overline{s^2(\tilde{\phi}_0)}$	F	$s^2(\tilde{\gamma}_1)$	$s^2(\tilde{\gamma}_1)$	$\overline{s^2(\tilde{\phi}_1)}$	F
Panel A								
1935-6/1968	0.00104	0.00145	0.00041	3.54	0.00397	0.00440	0.00043	10.26
1935-45	0.00179	0.00282	0.00103	2.74	0.00854	0.00964	0.00110	8.80
1946-55	0.00057	0.00065	0.00009	7.45	0.00173	0.00182	0.00008	21.71
1956-6/68	0.00076	0.00088	0.00012	7.45	0.00169	0.00181	0.00012	15.40
1935-40	0.00272	0.00438	0.00167	2.63	0.01241	0.01421	0.00180	7.91
1941-45	0.00067	0.00093	0.00026	3.55	0.00404	0.00429	0.00025	16.88
1946-50	0.00083	0.00092	0.00009	10.30	0.00235	0.00244	0.00009	28.04
1951-55	0.00028	0.00036	0.00009	4.26	0.00115	0.00123	0.00008	15.26
1956-60	0.00031	0.00042	0.00010	4.13	0.00107	0.00116	0.00009	12.45
1961-6/68	0.00097	0.00110	0.00013	8.51	0.00200	0.00213	0.00013	15.94
Panel B								
1935-6/1968	0.00132	0.01710	0.01578	1.08	0.00634	0.07737	0.07103	1.09
1935-45	0.00154	0.04756	0.04602	1.03	0.00504	0.21238	0.20734	1.02
1946-55	0.00040	0.00119	0.00078	1.51	0.00609	0.00945	0.00337	2.81
1956-6/68	0.00207	0.00324	0.00117	2.77	0.00867	0.01389	0.00522	2.66
1935-40	0.00232	0.08530	0.08298	1.03	0.01224	0.38518	0.37294	1.03
1941-45	0.00117	0.00283	0.00166	1.71	-0.00062	0.00799	0.00862	0.93
1946-50	0.00061	0.00136	0.00075	1.82	0.00783	0.01109	0.00326	3.40
1951-55	0.00021	0.00103	0.00082	1.26	0.00441	0.00788	0.00347	2.27
1956-60	0.00052	0.00122	0.00070	1.74	0.00417	0.00730	0.00313	2.33
1961-6/68	0.00307	0.00455	0.00149	3.07	0.01173	0.01835	0.00662	2.77
Panel C								
1935-6/1968	0.00157	0.00244	0.00087	2.80	0.00350	0.00534	0.00184	2.91
1935-45	0.00248	0.00423	0.00175	2.42	0.00684	0.01055	0.00371	2.84
1946-55	0.00111	0.00143	0.00031	4.56	0.00248	0.00336	0.00088	3.83
1956-6/68	0.00113	0.00168	0.00054	3.08	0.00138	0.00233	0.00095	2.45
1935-40	0.00263	0.00502	0.00239	2.10	0.01138	0.01650	0.00512	3.22
1941-45	0.00235	0.00332	0.00097	3.42	0.00154	0.00357	0.00202	1.76
1946-50	0.00182	0.00214	0.00032	6.74	0.00378	0.00483	0.00106	4.58
1951-55	0.00039	0.00070	0.00031	2.27	0.00124	0.00194	0.00069	2.79
1956-60	0.00056	0.00111	0.00055	2.02	0.00090	0.00199	0.00109	1.82
1961-6/68	0.00146	0.00200	0.00054	3.70	0.00156	0.00242	0.00086	2.81
Panel D								
1935-6/1968	0.00546	0.02164	0.01618	1.34	0.01044	0.07785	0.06741	1.15
1935-45	0.01411	0.05951	0.04540	1.31	0.01598	0.21073	0.19475	1.08
1946-55	0.00010	0.00202	0.00193	1.05	0.00611	0.00947	0.00336	2.82
1956-6/68	0.00241	0.00427	0.00187	2.29	0.01000	0.01659	0.00658	2.52
1935-40	0.02452	0.10526	0.08074	1.30	0.03233	0.38208	0.34975	1.09
1941-45	0.00236	0.00535	0.00299	1.79	-0.00066	0.00808	0.00874	0.92
1946-50	-0.00021	0.00184	0.00205	0.90	0.00793	0.01120	0.00327	3.43
1951-55	0.00043	0.00224	0.00181	1.24	0.00437	0.00783	0.00346	2.26
1956-60	0.00099	0.00307	0.00208	1.48	0.00467	0.00822	0.00356	2.31
1961-6/68	0.00336	0.00508	0.00173	2.95	0.01364	0.02225	0.00860	2.59

Table 5 *(Continued)*

Components of the Variance of the $\hat{\gamma}_{it}$

Period	$s^2(\tilde{\gamma}_2)$	$s^2(\tilde{\gamma}_2)$	$\overline{s^2(\tilde{\phi}_2)}$	F	$s^2(\tilde{\gamma}_3)$	$s^2(\tilde{\gamma}_3)$	$\overline{s^2(\tilde{\phi}_3)}$	F
Panel A								
1935-6/1968								
1935-45								
1946-55								
1956-6/68								
1935-40								
1941-45								
1946-50								
1951-55								
1956-60								
1961-6/68								
Panel B								
1935-6/1968	0.00081	0.02009	0.01928	1.04				
1935-45	-0.00025	0.05617	0.05641	1.00				
1946-55	0.00083	0.00164	0.00081	2.03				
1956-6/68	0.00193	0.00331	0.00137	2.40				
1935-40	-0.00163	0.09974	0.10136	0.98				
1941-45	0.00218	0.00466	0.00248	1.88				
1946-50	0.00110	0.00187	0.00077	2.42				
1951-55	0.00057	0.00142	0.00084	1.68				
1956-60	0.00079	0.00160	0.00081	1.97				
1961-6/68	0.00272	0.00447	0.00175	2.56				
Panel C								
1935-6/1968					0.29136	0.7834	0.49206	1.59
1935-45					0.33363	0.7505	0.41686	1.80
1946-55					0.25862	0.6547	0.39606	1.65
1956-6/68					0.28375	0.9188	0.63503	1.45
1935-40					0.21433	0.5978	0.38352	1.56
1941-45					0.48970	0.9466	0.45687	2.07
1946-50					0.37681	0.7457	0.36885	2.02
1951-55					0.15051	0.5738	0.42328	1.36
1956-60					0.20660	0.9827	0.77612	1.27
1961-6/68					0.34274	0.8837	0.54096	1.63
Panel D								
1935-6/1968	0.00365	0.02214	0.01850	1.20	0.26071	0.8422	0.58152	1.45
1935-45	0.00842	0.06189	0.05347	1.16	0.32859	0.7585	0.42995	1.76
1946-55	0.00045	0.00156	0.00111	1.41	0.03322	0.5856	0.55235	1.06
1956-6/68	0.00223	0.00386	0.00163	2.37	0.38882	1.1270	0.73823	1.53
1935-40	0.01456	0.11045	0.09589	1.15	0.27821	0.6684	0.39022	1.71
1941-45	0.00191	0.00447	0.00256	1.75	0.40126	0.8789	0.47763	1.84
1946-50	0.00025	0.00137	0.00113	1.22	-0.07232	0.4757	0.54801	0.87
1951-55	0.00067	0.00177	0.00110	1.61	0.14741	0.7041	0.55670	1.26
1956-60	0.00098	0.00219	0.00121	1.81	0.39278	1.4201	1.02730	1.38
1961-6/68	0.00310	0.00500	0.00191	2.62	0.39653	0.9420	0.54551	1.73

Table 6

Shanken (1992) Adjustment

$$c = (\gamma_i / s(\gamma_i))^2$$

Period	$s(R_m)$	$c(\overline{\hat{\gamma}_0})$	$c(\overline{\hat{\gamma}_1})$	$c(\overline{\hat{\gamma}_2})$	$c(\overline{\hat{\gamma}_3})$	$c(\overline{\hat{\gamma}_0 - R_f})$	$t(\bar{\hat{\gamma}}_0)^*$	$t(\bar{\hat{\gamma}}_1)^*$	$t(\bar{\hat{\gamma}}_2)^*$	$t(\bar{\hat{\gamma}}_3)^*$	$t(\overline{\hat{\gamma}_0 - R_f})^*$
Panel A											
1935-6/1968	0.061	0.009	0.018			0.006	3.07	2.43			2.40
1935-45	0.089	0.001	0.035			0.001	0.72	1.91			0.69
1946-55	0.043	0.042	0.004			0.033	3.72	0.67			3.33
1956-6/68	0.040	0.020	0.015			0.006	2.33	1.42			1.28
1935-40	0.108	0.000	0.018			0.000	-0.14	1.02			-0.14
1941-45	0.058	0.022	0.112			0.021	2.15	2.16			2.10
1946-50	0.052	0.010	0.003			0.007	1.29	0.46			1.12
1951-55	0.033	0.149	0.005			0.122	4.77	0.51			4.36
1956-60	0.034	0.193	0.029			0.144	5.16	-1.29			4.53
1961-6/68	0.043	0.000	0.078			0.006	-0.12	2.39			-0.95
Panel B											
1935-6/1968	0.061	0.002	0.063	0.003		0.000	0.38	1.07	-0.50		0.19
1935-45	0.089	0.004	0.020	0.001		0.003	0.28	0.31	0.10		0.27
1946-55	0.043	0.000	0.283	0.054		0.002	-0.23	2.29	-2.64		-0.54
1956-6/68	0.040	0.004	0.086	0.007		0.000	0.56	1.16	-0.71		0.01
1935-40	0.108	0.000	0.022	0.000		0.000	-0.04	0.22	-0.03		-0.04
1941-45	0.058	0.052	0.021	0.010		0.050	1.87	0.71	0.66		1.84
1946-50	0.052	0.000	0.096	0.015		0.001	-0.23	1.13	-1.13		-0.37
1951-55	0.033	0.000	0.846	0.177		0.002	-0.10	1.93	-2.61		-0.39
1956-60	0.034	0.096	0.014	0.022		0.063	2.22	0.36	-0.97		1.81
1961-6/68	0.043	0.004	0.149	0.003		0.016	-0.37	1.10	-0.31		-0.77
Panel C											
1935-6/1968	0.061	0.011	0.021		0.05	0.007	2.53	2.40		-0.30	2.01
1935-45	0.089	0.002	0.035		0.00	0.002	0.67	1.82		0.07	0.65
1946-55	0.043	0.061	0.021		4.28	0.051	3.02	1.19		-0.53	2.77
1956-6/68	0.040	0.015	0.010		0.56	0.003	1.45	1.02		0.31	0.69
1935-40	0.108	0.000	0.018		0.00	0.000	0.04	0.95		-0.06	0.03
1941-45	0.058	0.019	0.108		0.10	0.018	1.06	2.34		0.14	1.03
1946-50	0.052	0.015	0.014		1.67	0.012	1.07	0.68		-0.37	0.96
1951-55	0.033	0.212	0.041		11.8	0.179	3.99	1.13		-0.32	3.71
1956-60	0.034	0.137	0.060		5.84	0.096	2.72	-1.39		0.24	2.33
1961-6/68	0.043	0.000	0.079		0.01	0.005	-0.05	2.27		-0.04	-0.66
Panel D											
1935-6/1968	0.061	0.001	0.052	0.003	0.38	0.000	0.23	0.98	-0.48	0.70	0.06
1935-45	0.089	0.006	0.017	0.001	0.00	0.005	0.31	0.29	0.13	-0.02	0.30
1946-55	0.043	0.001	0.267	0.054	0.07	0.003	-0.34	2.24	-2.73	0.16	-0.57
1956-6/68	0.040	0.000	0.055	0.010	5.52	0.005	-0.03	0.87	-0.77	0.42	-0.51
1935-40	0.108	0.000	0.014	0.000	0.02	0.000	0.00	0.17	-0.01	0.18	0.00
1941-45	0.058	0.062	0.029	0.012	0.17	0.060	1.48	0.84	0.72	-0.19	1.45
1946-50	0.052	0.004	0.097	0.021	0.50	0.006	-0.57	1.13	-1.55	0.34	-0.70
1951-55	0.033	0.000	0.771	0.153	0.16	0.001	0.06	1.88	-2.19	-0.11	-0.14
1956-60	0.034	0.029	0.002	0.035	19.3	0.012	0.79	0.12	-1.03	0.21	0.52
1961-6/68	0.043	0.009	0.114	0.003	1.71	0.026	-0.54	0.88	-0.30	0.34	-0.92

Table 7

Shanken (1992) & Campbell-Lo-MacKinlay Adjustment

$$\sigma_{\gamma_i}^2{}' = \sigma_{\gamma_i}^2 \cdot \left[1 + (\hat{\mu}_m - \hat{\gamma}_0)^2 / \hat{\sigma}_m^2\right] \qquad Z_{mt} = R_{mt} - R_{ft}$$

Period	$s(Z_m)$	$\overline{Z}_m$	$c(\gamma)$	$s(\overline{\hat{\gamma}_0})'$	$s(\overline{\hat{\gamma}_1})'$	$s(\overline{\hat{\gamma}_2})'$	$s(\overline{\hat{\gamma}_3})'$	$s(\overline{\hat{\gamma}_0 - R_f})'$	$t(\bar{\hat{\gamma}}_0)'$	$t(\bar{\hat{\gamma}}_1)'$	$t(\bar{\hat{\gamma}}_2)'$	$t(\bar{\hat{\gamma}}_3)'$	$t(\overline{\hat{\gamma}_0 - R_f})'$
Panel A													
1935-6/1968	0.061	0.013	1.014	0.038	0.067			0.038	3.06	2.43			2.39
1935-45	0.089	0.020	1.034	0.054	0.100			0.054	0.71	1.91			0.68
1946-55	0.043	0.010	1.001	0.026	0.043			0.026	3.79	0.67			3.39
1956-6/68	0.040	0.010	1.009	0.030	0.043			0.030	2.34	1.42			1.28
1935-40	0.108	0.014	1.018	0.067	0.120			0.067	-0.13	1.02			-0.14
1941-45	0.058	0.027	1.103	0.032	0.069			0.032	2.07	2.17			2.02
1946-50	0.052	0.007	1.001	0.030	0.049			0.030	1.30	0.46			1.12
1951-55	0.033	0.014	1.001	0.019	0.035			0.019	5.12	0.51			4.61
1956-60	0.034	0.007	1.052	0.021	0.035			0.021	5.50	-1.27			4.73
1961-6/68	0.043	0.011	1.072	0.034	0.048			0.034	-0.11	2.40			-0.92
Panel B													
1935-6/1968	0.061	0.013	1.030	0.133	0.282	0.144		0.133	0.38	1.09	-0.50		0.18
1935-45	0.089	0.020	1.026	0.221	0.467	0.240		0.221	0.28	0.31	0.10		0.27
1946-55	0.043	0.010	1.065	0.036	0.100	0.042		0.036	-0.23	2.52	-2.63		-0.52
1956-6/68	0.040	0.010	1.030	0.058	0.120	0.058		0.058	0.56	1.20	-0.70		0.01
1935-40	0.108	0.014	1.019	0.295	0.626	0.319		0.295	-0.04	0.22	-0.03		-0.04
1941-45	0.058	0.027	1.059	0.055	0.092	0.070		0.055	1.86	0.70	0.65		1.83
1946-50	0.052	0.007	1.024	0.037	0.107	0.044		0.037	-0.22	1.17	-1.12		-0.37
1951-55	0.033	0.014	1.182	0.035	0.097	0.041		0.035	-0.09	2.41	-2.60		-0.36
1956-60	0.034	0.007	1.010	0.035	0.086	0.040		0.035	2.31	0.37	-0.97		1.86
1961-6/68	0.043	0.011	1.102	0.071	0.142	0.070		0.071	-0.35	1.12	-0.30		-0.74
Panel C													
1935-6/1968	0.061	0.013	1.013	0.050	0.074		0.891	0.050	2.53	2.41		-0.31	2.01
1935-45	0.089	0.020	1.032	0.066	0.104		0.880	0.066	0.66	1.82		0.07	0.64
1946-55	0.043	0.010	1.000	0.038	0.058		0.809	0.038	3.11	1.20		-1.21	2.84
1956-6/68	0.040	0.010	1.014	0.041	0.049		0.965	0.041	1.45	1.02		0.38	0.69
1935-40	0.108	0.014	1.015	0.071	0.129		0.779	0.071	0.04	0.95		-0.06	0.03
1941-45	0.058	0.027	1.111	0.061	0.063		1.025	0.061	1.01	2.33		0.14	0.98
1946-50	0.052	0.007	1.000	0.046	0.070		0.864	0.046	1.08	0.68		-0.60	0.96
1951-55	0.033	0.014	1.002	0.026	0.044		0.758	0.027	4.39	1.15		-1.15	4.03
1956-60	0.034	0.007	1.025	0.034	0.045		1.004	0.034	2.87	-1.41		0.63	2.40
1961-6/68	0.043	0.011	1.069	0.046	0.051		0.972	0.046	-0.04	2.28		-0.04	-0.64
Panel D													
1935-6/1968	0.061	0.013	1.035	0.150	0.284	0.151	0.934	0.150	0.23	0.99	-0.47	0.81	0.05
1935-45	0.089	0.020	1.022	0.247	0.464	0.251	0.880	0.247	0.31	0.28	0.12	-0.02	0.30
1946-55	0.043	0.010	1.073	0.047	0.101	0.041	0.793	0.047	-0.33	2.44	-2.70	0.16	-0.56
1956-6/68	0.040	0.010	1.060	0.067	0.133	0.064	1.093	0.067	-0.03	0.86	-0.75	1.05	-0.49
1935-40	0.108	0.014	1.016	0.327	0.623	0.335	0.824	0.327	0.00	0.17	-0.01	0.18	0.00
1941-45	0.058	0.027	1.049	0.075	0.092	0.068	0.960	0.075	1.48	0.83	0.71	-0.20	1.46
1946-50	0.052	0.007	1.038	0.044	0.108	0.038	0.703	0.044	-0.56	1.16	-1.53	0.41	-0.68
1951-55	0.033	0.014	1.163	0.051	0.095	0.045	0.905	0.051	0.05	2.32	-2.18	-0.11	-0.13
1956-60	0.034	0.007	1.002	0.055	0.091	0.047	1.193	0.055	0.80	0.12	-1.05	0.97	0.52
1961-6/68	0.043	0.011	1.125	0.076	0.158	0.075	1.029	0.076	-0.51	0.88	-0.29	0.52	-0.88

Table 8

McElroy-Burmeister Approach to Gamma Estimation

	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\gamma}_3$	$t(\hat{\gamma}_1)$	$t(\hat{\gamma}_2)$	$t(\hat{\gamma}_3)$	McElroy's R^2	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\gamma}_3$	$t(\hat{\gamma}_1)$	$t(\hat{\gamma}_2)$	$t(\hat{\gamma}_3)$	McElroy's R^2
Period	**METHOD 1**							**METHOD 2**						
Panel A														
1935-6/1968	-0.0017			-1.92			0.6323	-0.0012			-0.81			0.4816
1935-45	-0.0009			-2.04			0.9521	0.0003			0.07			0.5829
1946-55	-0.0010			-5.43			0.9653	-0.0004			-0.55			0.8759
1956-6/68	-0.0024			-1.22			0.2661	-0.0008			-0.37			0.1961
1935-40	-0.0010			-1.43			0.9592	0.0012			0.24			0.7192
1941-45	-0.0012			-3.29			0.9727	0.0021			0.41			0.3636
1946-50	-0.0005			-1.92			0.9789	0.0005			0.61			0.9214
1951-55	-0.0013			-5.38			0.9642	0.0001			0.11			0.8760
1956-60	-0.0021			-6.80			0.9552	-0.0035			-4.41			0.8304
1961-6/68	-0.0035			-1.43			0.2674	-0.0006			-0.14			0.1224
Panel B														
1935-6/1968	0.0044	-0.0060		1.79	-2.64		0.6326	0.0047	-0.0059		1.61	-2.54		0.3920
1935-45	0.0055	-0.0060		1.02	-1.21		0.9522	0.0064	-0.0060		1.09	-1.13		0.6368
1946-55	0.0064	-0.0069		1.90	-2.20		0.9658	0.0077	-0.0060		1.25	-1.42		0.3851
1956-6/68	0.0012	-0.0038		0.28	-1.00		0.2660	0.0026	-0.0033		0.57	-0.81		0.1589
1935-40	0.0012	-0.0021		0.14	-0.27		0.9593	0.0039	-0.0026		0.38	-0.33		0.7057
1941-45	0.0051	-0.0055		1.20	-1.46		0.9739	0.0049	-0.0034		1.11	-0.66		0.5349
1946-50	-0.0007	0.0002		-0.14	0.04		0.9791	0.0014	0.0010		0.18	0.17		0.6791
1951-55	0.0089	-0.0095		3.41	-3.84		0.9711	0.0131	-0.0103		1.13	-1.12		0.1869
1956-60	0.0119	-0.0130		3.23	-3.76		0.9616	0.0085	-0.0096		2.28	-2.73		0.9600
1961-6/68	-0.0093	0.0070		-1.77	1.12		0.2677	-0.0044	0.0053		-0.62	0.76		0.0985
Panel C														
1935-6/1968	-0.0019		-0.0893	-2.03		-11.00	0.6311	-0.0013		-0.0941	-0.80		-10.47	0.4645
1935-45	-0.0010		-0.1177	-2.17		-5.23	0.9518	0.0002		-0.1097	0.05		-4.88	0.5858
1946-55	-0.0011		-0.0566	-5.69		-2.39	0.9653	0.0006		-0.0763	0.44		-3.08	0.6985
1956-6/68	-0.0024		-0.0492	-1.22		-2.64	0.2642	-0.0010		-0.0501	-0.46		-2.60	0.2038
1935-40	-0.0010		-0.1283	-1.45		-3.46	0.9586	0.0012		-0.1074	0.24		-3.00	0.7197
1941-45	-0.0013		-0.1085	-3.53		-2.23	0.9726	0.0022		-0.0861	0.42		-1.90	0.3676
1946-50	-0.0005		-0.0367	-1.95		-0.86	0.9788	0.0017		-0.0644	1.14		-1.39	0.8141
1951-55	-0.0014		-0.0749	-5.36		-1.49	0.9624	0.0019		-0.1061	1.47		-2.22	0.6450
1956-60	-0.0021		0.0007	-6.24		0.02	0.9565	-0.0045		-0.0036	-3.14		-0.09	0.6515
1961-6/68	-0.0037		-0.0657	-1.48		-2.53	0.2668	-0.0005		-0.0686	-0.13		-2.61	0.1216
Panel D														
1935-6/1968	0.0047	-0.0064	-0.0900	1.89	-2.80	-11.02	0.6314	0.0050	-0.0064	-0.0903	1.75	-2.74	-9.77	0.4247
1935-45	0.0060	-0.0065	-0.1184	1.08	-1.28	-5.27	0.9519	0.0067	-0.0065	-0.1119	1.13	-1.21	-4.98	0.6488
1946-55	0.0069	-0.0074	-0.0599	2.04	-2.36	-2.52	0.9658	0.0080	-0.0064	-0.0587	1.30	-1.51	-2.35	0.4115
1956-6/68	0.0011	-0.0038	-0.0490	0.26	-1.00	-2.62	0.2642	0.0023	-0.0036	-0.0410	0.52	-0.91	-2.12	0.1821
1935-40	0.0001	-0.0011	-0.1282	0.01	-0.13	-3.46	0.9587	0.0029	-0.0020	-0.1007	0.29	-0.25	-2.81	0.7590
1941-45	0.0059	-0.0063	-0.1162	1.41	-1.69	-2.39	0.9739	0.0057	-0.0038	-0.1036	1.25	-0.67	-2.27	0.4787
1946-50	-0.0008	0.0003	-0.0374	-0.16	0.06	-0.85	0.9790	0.0014	0.0006	-0.0270	0.18	0.10	-0.58	0.7275
1951-55	0.0097	-0.0103	-0.0924	3.84	-4.28	-1.75	0.9692	0.0139	-0.0109	-0.0825	1.20	-1.17	-1.62	0.1943
1956-60	0.0122	-0.0133	-0.0262	3.28	-3.83	-0.59	0.9618	0.0090	-0.0111	0.0091	1.94	-2.83	0.21	0.7997
1961-6/68	-0.0103	0.0080	-0.0678	-1.88	1.22	-2.53	0.2672	-0.0058	0.0063	-0.0570	-0.82	0.87	-2.10	0.1110

Table 9

Summary Results for the McElroy-Burmeister Regression

Portfolios	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX
									Period 1935 – 6/68											
										Panel A										
Method I																				
$\hat{\beta}$	0.601	0.668	0.719	0.710	0.828	0.822	0.961	0.922	0.926	0.965	1.028	1.058	1.007	1.106	1.115	1.149	1.137	1.306	1.335	1.326
$t(\hat{\beta})$	50.86	58.11	61.25	66.67	54.19	56.47	68.60	72.94	71.04	64.07	75.53	64.10	58.23	63.25	59.45	65.81	71.51	70.53	72.38	58.02
R^2	0.722	0.796	0.792	0.834	0.852	0.837	0.902	0.887	0.900	0.908	0.927	0.929	0.897	0.891	0.886	0.900	0.913	0.886	0.887	0.887
Method II																				
$\hat{\beta}$	0.600	0.667	0.718	0.709	0.827	0.821	0.960	0.921	0.925	0.963	1.026	1.056	1.005	1.104	1.113	1.147	1.135	1.304	1.333	1.324
$t(\hat{\beta})$	45.76	50.13	52.81	51.92	45.22	46.87	51.79	54.54	51.56	48.35	51.81	45.11	43.96	46.60	42.48	46.00	47.17	50.31	46.46	38.61
R^2	0.723	0.796	0.792	0.834	0.852	0.837	0.902	0.888	0.901	0.908	0.927	0.928	0.897	0.891	0.886	0.899	0.913	0.886	0.887	0.886
										Panel B										
Method I																				
$\hat{\beta}$	0.598	0.665	0.717	0.707	0.825	0.820	0.961	0.921	0.924	0.965	1.029	1.060	1.006	1.108	1.119	1.153	1.136	1.308	1.345	1.336
$t(\hat{\beta})$	50.80	57.44	59.95	65.59	53.21	54.38	66.87	71.57	70.77	62.53	74.15	62.10	56.76	61.79	57.58	64.71	70.28	66.70	70.12	55.52
R^2	0.724	0.796	0.792	0.834	0.852	0.837	0.902	0.888	0.901	0.908	0.927	0.929	0.897	0.891	0.887	0.900	0.913	0.885	0.889	0.888
Method II																				
$\hat{\beta}$	0.597	0.664	0.716	0.706	0.825	0.819	0.960	0.921	0.924	0.964	1.028	1.059	1.005	1.107	1.118	1.152	1.136	1.307	1.344	1.335
$t(\hat{\beta})$	39.52	39.10	40.75	38.14	35.19	36.55	38.72	39.54	37.88	36.08	38.00	33.96	33.36	35.48	32.79	35.00	36.09	37.75	35.16	30.46
R^2	0.724	0.795	0.792	0.834	0.852	0.837	0.902	0.887	0.900	0.908	0.927	0.929	0.897	0.891	0.887	0.900	0.913	0.886	0.888	0.888
										Panel C										
Method I																				
$\hat{\beta}$	0.607	0.666	0.722	0.709	0.824	0.825	0.954	0.924	0.924	0.964	1.027	1.056	1.008	1.108	1.107	1.150	1.132	1.305	1.332	1.322
$t(\hat{\beta})$	52.27	56.83	62.32	66.24	52.44	57.35	69.06	71.47	70.22	64.64	75.38	64.43	57.68	65.04	59.69	65.29	69.44	69.13	71.81	56.34
R^2	0.716	0.794	0.789	0.834	0.852	0.841	0.904	0.887	0.900	0.909	0.927	0.929	0.899	0.892	0.890	0.900	0.913	0.885	0.885	0.885
Method II																				
$\hat{\beta}$	0.606	0.664	0.721	0.708	0.823	0.823	0.952	0.922	0.922	0.962	1.024	1.053	1.006	1.106	1.104	1.147	1.129	1.302	1.328	1.318
$t(\hat{\beta})$	46.34	47.85	51.61	49.61	42.94	45.22	50.03	51.30	48.78	46.92	48.79	43.23	41.54	45.42	40.38	43.71	43.93	47.27	43.71	36.19
R^2	0.717	0.794	0.789	0.834	0.852	0.841	0.904	0.887	0.900	0.908	0.927	0.929	0.899	0.892	0.889	0.900	0.913	0.885	0.884	0.884
										Panel D										
Method I																				
$\hat{\beta}$	0.603	0.662	0.719	0.705	0.821	0.823	0.953	0.923	0.922	0.964	1.028	1.058	1.007	1.110	1.111	1.154	1.132	1.307	1.343	1.333
$t(\hat{\beta})$	52.12	56.08	60.78	65.09	51.38	55.19	67.18	70.13	70.03	62.84	73.95	62.15	56.11	63.31	57.75	64.00	68.10	65.33	69.24	53.69
R^2	0.718	0.793	0.789	0.834	0.852	0.841	0.904	0.887	0.900	0.908	0.927	0.929	0.899	0.892	0.890	0.900	0.913	0.884	0.887	0.886
Method II																				
$\hat{\beta}$	0.603	0.662	0.718	0.704	0.821	0.822	0.953	0.922	0.921	0.963	1.027	1.057	1.007	1.110	1.110	1.153	1.131	1.307	1.342	1.332
$t(\hat{\beta})$	42.51	41.09	43.99	41.65	37.14	38.81	42.32	42.91	41.73	39.99	42.06	37.22	35.77	39.49	35.62	38.41	39.49	41.34	38.99	32.90
R^2	0.718	0.793	0.789	0.834	0.852	0.841	0.903	0.887	0.900	0.908	0.927	0.929	0.899	0.892	0.890	0.900	0.913	0.885	0.887	0.886

```
**********************************************************************
* PROGRAM:     access.f - Sample program to read crsp daily and monthly stock
*                   files using random access programming
*
* DESCRIPTION: This program takes CRSP perm numbers from a user-created file
*            called perms.dat.  Retrieved information for each security
*            found is written to an output file called outperm.dat.
*
*            Perm numbers should be entered one to a line in the file
*            perms.dat in columns  1-5.
*
*            All securities with data in the monthly and daily databases
*            are listed in the files:
*
*            /dbases/crsp/doc/monthly-stock.listing
*            /dbases/crsp/doc/daily-stock.listing
*
*            These files can be used to locate perm numbers from the ticker
           symbol or the name of a security.

*            To search the files use the Unix "grep" command.
*            For example:
*
*            grep FORD /dbases/crsp/doc/monthly-stock.listing | more
*
*            This will print to the screen all companies with "FORD"
*            in their name.
*
* USAGE:       Change udopen to umopen and udclose to umclose for monthly
*            data where specified.
*
*            Add code for desired extraction or processing where
*            specified.  See the "Stock File User's Guide" and "Stock
*            File Programmer's Guide" for assistance.  These are
*            available as Microsoft Word documents in the /dbases/crsp/doc
*            directory.
*
*            Then, compile the program as follows:  f77crsp access.f
*
*            Then run the executable "a.out" generated from the compile
*            step by simply typing:  a.out
*
*********************************************************************
```

```
      program access1

      include '/dbases/crsp/include/us.txt'

      integer kperm
      open (unit=10,file='perms53.dat',status='old')

      open (unit=11,file='outperm.dat',status='unknown')

c---------------------------------------------------------------------------
      call umopen(nyseamex)

      call umcal(nyse)
      100 read (10,1000,end=900) kperm
      1000 format(i5)

      call usgetper(1,kperm,infos+returns,*900)

      if (kperm. ne . permno) goto 100

      call usgetper(1,permno,infos+returns,*900)

c     ********************************************
c     ***                                      ***
c     *** Insert your processing code here     ***
c     ***                                      ***
c     *** For example, the following do loop   ***
c     *** writes the cusip, calendar date and  ***
c     *** price for each date that the security ***
c     *** has price data in the database.      ***
c     ********************************************


      do j=350,541

      write(11,9001) permno,caldt(j),ret(j),ewretd(j)

      end do

 9001 format (i5,x,i8,x,f11.6,x,f11.6)
c     ********************************************
c     ***    End of user inserted code         ***
c     ********************************************
```

```
      goto 100                     ! get another perm number


c-----------------------------------------------------------------------
  900 call umclose
c-----------------------------------------------------------------------

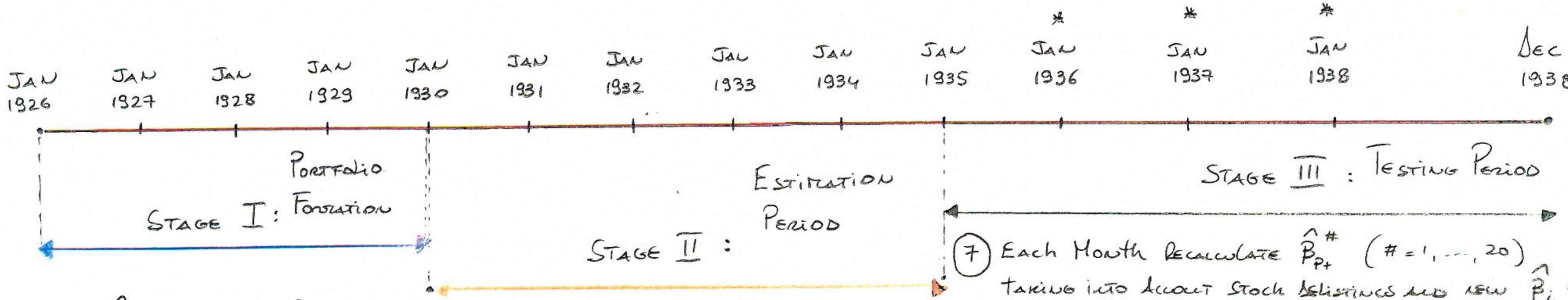
      close(unit=10)
      close(unit=11)

      stop
      end
```

Fama-MacBeth 1973

Paolo Pasquariello

0) Stock Selection



1) Estimate $\hat{\beta}_i$ of individual securities

2) Build 20 portfolios from the ranked $\hat{\beta}_i$: Portfolio formation happens here.

3) Individual $\hat{\beta}_i$s are estimated using this new time interval

4) 20 initial portfolio $\hat{\beta}^{\#}_{p0}$ are calculated: $\# = 1, \dots, 20$

5) Non-beta risk component $s(\hat{\varepsilon}_i)$ is computed for each security

6) 20 initial non-beta risk components $\bar{s}^{\#}_{p0}(\hat{\varepsilon}_i)$ are computed: $\# = 1, \dots, 20$. Also $R^{\#}_{pt}$ are calculated.

7) Each month recalculate $\hat{\beta}^{\#}_{pt}$ $(\# = 1, \dots, 20)$ taking into account stock delistings and new $\hat{\beta}_i$ estimate as in point ⑧.

8) In Jan 1936, Jan 1937, Jan 1938 update $\hat{\beta}_i$ *

9) Each month recalculate $\bar{s}^{\#}_{pt}(\hat{\varepsilon}_i)$ $(\# = 1, \dots, 20)$ taking into account same stock delistings and new regressions as in point ⑩.

10) In Jan 1936, Jan 1937, Jan 1938 update $s(\hat{\varepsilon}_i)$s

11) Points 7-10 permit to construct cross sections of $\hat{\beta}^{\#}_{pt}$ and $\hat{s}^{\#}_{pt}$ for each month in the subsample. Calculations of $R^{\#}_{pt}$ $(\# = 1, \dots, 20)$ are needed, as well as $(\hat{\beta}^{\#}_{pt})^2$.

12) Run Fama-MacBeth cross-sectional regression for each month in the subsample.

13) Repeat steps 0-12 for successive subperiods and use resulting time series of coefficients for tests of Fama-MacBeth hypothesis.

⓪ Data Selection:

Given a Selected Sub-period (e.g. Jan 1926 to Dec 1938), just the following stocks will be considered:

1. A stock whose Monthly Return is Available for the First Month of the Testing period AND
2. Monthly Returns ∃ for ALL 60 months of Estimation period AND
3. Monthly Returns ∃ for AT LEAST 48 months prior to the estimation period.

(1)

$$\hat{\beta}_i = \frac{\hat{cov}(R_i, R_m)}{\hat{\sigma}^2(R_m)}$$

$t =$ JAN 1926

$T =$ DEC 1929

$$\hat{\sigma}^2(R_m) = \sum_{t=1}^{T} \frac{(R_{mt} - \bar{R}_m)^2}{T-1} \qquad \bar{R}_m = \frac{1}{T}\sum_{t=1}^{T} R_{mt}$$

$$\hat{cov}(R_i, R_m) = \frac{\sum_{t=1}^{T} (R_{it} - \bar{R}_i)(R_{mt} - \bar{R}_m)}{T-1} = \frac{\sum_{t=1}^{T} R_{it} R_{mt} - T \bar{R}_i \bar{R}_m}{T-1}$$

$$\bar{R}_i = \frac{1}{T}\sum_{t=1}^{T} R_{it} \qquad T = 48 \qquad R_{mt} = \text{Equally-Weighted Index Return}$$

(2) If N is the # of securities selected for stage I, then build 20 portfolios composed by the following number of securities' betas:

		N even	N odd
1st	I_1	$Int(N/20) + \frac{1}{2}\left[N - 20\, Int\left(\frac{N}{20}\right)\right]$ betas	the same
2nd	I_2	$Int(N/20)$ betas	the same
⋮	⋮	⋮	⋮
19th	⋮	$Int(N/20)$ betas	the same
20th	I_{20}	$Int\left(\frac{N}{20}\right) + \frac{1}{2}\left[N - 20\, Int\left(\frac{N}{20}\right)\right]$ betas	$Int\left(\frac{N}{20}\right) + \frac{1}{2}\left[N - 20\, Int\left(\frac{N}{20}\right)\right] + 1$

the portfolios are equally weighted, so that:

$$\beta^{\#}_{Po} = \sum_{J=1}^{I_{\#}} i_J \hat{\beta}_J$$

$\# = 1, .., 20$

the betas entering in each portfolios are ranked from the lowest to the highest so that 20th portfolio is an equally-weighted portfolio of the highest beta securities and so on.

(3) thus we have:

$$\hat{\beta}_i = \frac{\widehat{cov}(R_i, R_m)}{\hat{\sigma}^2(R_m)}$$

AS IN (1) BUT NOW:

t = JAN 1930 T = DEC 1934 T = 60

(4) The Formula is the one described in (1):

$$\hat{\beta}^{\#}_{po} = \sum_{J=1}^{I_\#} i_J \hat{\beta}_J \quad \# = 1, \ldots, 20$$

$$i_J = 1/I_\#$$

USING THE NEW BETAS ESTIMATED IN (3) BUT THE SIZE PORTFOLIOS' COMPOSITIONS DEFINED IN (2)

(5) REGRESS: $R_{it} = a_i + b_i R_{mt} + \varepsilon_{it}$ t = 1, ..., T

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t = JAN 1930

CALCULATE: $\hat{\varepsilon}_{it} = R_{it} - \hat{a}_i^{OLS} - \hat{b}_i^{OLS} R_{mt}$

T = DEC 1934

CALCULATE: $$s(\hat{\varepsilon}_i) = \left[\frac{\sum_{t=1}^{T}(\hat{\varepsilon}_{it} - \bar{\hat{\varepsilon}}_i)^2}{T-1}\right]^{\frac{1}{2}}$$

$$\bar{\hat{\varepsilon}}_i = \frac{1}{T}\sum_{t=1}^{T}\hat{\varepsilon}_{it}$$

(6) As for portfolios' beta, calculate:

$$\bar{s}^{\#}_{p,o}(\hat{\varepsilon}_i) = \sum_{J=1}^{I^\#} i_J \, s(\hat{\varepsilon}_J)$$

$$i_J = \frac{1}{I^\#} \quad \# = 1, \ldots, 20$$

$$R^{\#}_{pt} = \sum_{J=1}^{I^\#} i_J R_{it}$$

$$i_J = \frac{1}{I^\#}$$

$\# = 1, \ldots, 20$

(7) EX. $t =$ JAN/31/1935 CALCULATE:

$$\hat{\beta}^{\#}_{Pt} = \sum_{J=1}^{I^{\#}(t)} i_J \hat{\beta}_J$$

$\# = 1, \ldots, 20$

$I_t \quad I^{\#}(t) \leq I^{\#}$

$$i_J = 1 / I^{\#}(t)$$

this $\hat{\beta}^{\#}_{Pt}$ may be different from $\hat{\beta}^{\#}_{PO}$ because of some stocks being delisted, thus dropping out of the portfolio, or because of new estimates for $\hat{\beta}_i$, as in point (8).

Note however that, apart from the delisting, the composition of the 20 portfolios remains unchanged.

(8) the update happens in $t =$ JAN 1936, JAN 1937, JAN 1938:

EX. $t =$ JAN 1936

$$\hat{\beta}_i = \frac{\hat{cov}(R_i, R_m)}{\hat{\sigma}^2(R_m)}$$

$$\hat{cov}(R_i, R_m) = \frac{\sum_{t=1}^{T} R_i R_m - T \bar{R}_i \bar{R}_m}{T-1}$$

$$\bar{R}_m = \frac{1}{T} \sum_{t=1}^{T} R_{mt}$$

$$\sigma^2(R_m) = \frac{\sum_{t=1}^{T} (R_{mt} - \bar{R}_m)^2}{T-1}$$

$$\bar{R}_i = \frac{1}{T} \sum_{t=1}^{T} R_{it}$$

AND $t =$ JAN 1930 $\quad T =$ DEC 1935

$$\hat{\beta}^{\#}_{Pt} = \sum_{J=1}^{I^{\#}(t)} i_J \hat{\beta}_J \qquad \# = 1, \ldots, 20 \qquad i_J = \frac{1}{I^{\#}(t)}$$

(9) As in point (7) you will calculate:

$$\bar{S}^{\#}_{pt}(\hat{\varepsilon}_i) = \sum_{J=1}^{I^{\#}(t)} i_J \, S(\hat{\varepsilon}_i) \qquad \# = 1, \ldots, 20$$

where $i_J = 1 / I^{\#}(t)$

Also $I^{\#}(t)$ changing every month because of possible delisting.
Also every year $S(\hat{\varepsilon}_i)$ are reestimated as in point (10).

(10) <u>the update happens in</u> $t =$ JAN 1936, JAN 1937, JAN 1938:

<u>EX.</u> $t =$ JAN 1936

Regress: $R_{it} = a_i + b_i R_{mt} + \varepsilon_{it}$ $\qquad t = 1, \ldots, T$

$t =$ JAN 1930

Calculate: $\hat{\varepsilon}_{it} = R_{it} - \hat{a}_i^{OLS} - \hat{b}_i^{OLS} R_{mt}$ $\qquad T =$ DEC 1935

Calculate: $$S(\hat{\varepsilon}_i) = \left[\frac{\sum_{t=1}^{T} \left(\hat{\varepsilon}_{it} - \hat{\bar{\varepsilon}}_i \right)^2}{T-1} \right]^{\frac{1}{2}}$$

$$\hat{\bar{\varepsilon}}_i = \frac{1}{T} \sum_{t=1}^{T} \hat{\varepsilon}_{it}$$

(11) More precisely we have:

t = Jan 1935

#	R_{pt}	$\hat{\beta}^{\#}_{p0}$	$\left(\hat{\beta}^{\#}_{p0}\right)^2$	$\bar{S}^{\#}_{p0}(\hat{\varepsilon}_i)$
1	.	.	.	.
2	.	.	.	.
⋮	⋮	⋮	⋮	⋮
19	.	.	.	.
20	.	.	.	.

t = Feb 1935

#	R_{pt}	$\hat{\beta}^{\#}_{pt-1}$	$\left(\hat{\beta}^{\#}_{pt-1}\right)^2$	$\bar{S}^{\#}_{pt-1}(\hat{\varepsilon}_i)$
1	.	.	.	.
2	.	.	.	.
⋮	⋮	⋮	⋮	⋮
19	.	.	.	.
20	.	.	.	.

etc up to t = Dec 1938. page 617

$\# = 1, \ldots, 20$

where:

$$R^{\#}_{pt} = \sum_{J=1}^{I^{\#}(t)} i_J R_{Jt}$$

$$i_J = \frac{1}{I^{\#}(t)}$$

$$\hat{B}^{\#\,2}_{pt-1} = \sum_{J=1}^{I^{\#}(t)} i_J \left[\hat{\beta}_J\right]^2 \quad \# = 1, \ldots, 20$$

$$i_J = \frac{1}{I^{\#}(t)}$$

(12) Using the cross sectional data described in (11), run the following regression for each t:

$$R_{pt} = \hat{\gamma}_{0t} + \hat{\gamma}_{1t}\hat{\beta}_{p\,t-1} + \hat{\gamma}_{2t}\hat{\beta}^{2}_{p\,t-1} + \hat{\gamma}_{3t}\bar{S}_{p,t-1}(\hat{\varepsilon}_i) + \hat{\eta}_{pt}$$

where:

$$\underset{(20\times 1)}{R_{pt}} = \begin{bmatrix} R^{1}_{pt} \\ \vdots \\ R^{20}_{pt} \end{bmatrix} \qquad \underset{(20\times 1)}{\hat{\beta}_{pt-1}} = \begin{bmatrix} \hat{\beta}^{1}_{pt-1} \\ \vdots \\ \hat{\beta}^{20}_{pt-1} \end{bmatrix} \qquad \underset{(20\times 1)}{\bar{S}_{p,t-1}(\hat{\varepsilon}_i)} = \begin{bmatrix} \bar{S}^{1}_{p,t-1}(\hat{\varepsilon}_i) \\ \vdots \\ \bar{S}^{20}_{pt-1}(\hat{\varepsilon}_i) \end{bmatrix}$$

And

$$\underset{(20\times 4)}{X_t} = \begin{bmatrix} \underline{1} & \hat{\beta}_{p,t-1} & \hat{\beta}^{2}_{p,t-1} & \bar{S}_{p,t-1}(\hat{\varepsilon}_i) \end{bmatrix}$$

$$\underset{4\times 1}{\hat{\gamma}_t} = \begin{bmatrix} \hat{\gamma}_{0t} \\ \hat{\gamma}_{1t} \\ \hat{\gamma}_{2t} \\ \hat{\gamma}_{3t} \end{bmatrix}$$

so that $\forall\, t$ the OLS estimates of the coefficients of interest are:

$$\hat{\gamma}^{OLS}_t = \left(X'_t X_t\right)^{-1} X'_t R_{pt} \qquad t = \text{Jan } 1935, \ldots, \text{Dec } 1938$$

Thus, with our estimated $\hat{\gamma}^{OLS}_t$ we build a time series for each of the coefficients of interest.

(13) For Replication of Fama-MacBeth Results, the following periods are selected:

(A)

	Stage 1 Portfolio Formation	Stage 2 Estimation Period	Stage 3 Testing Period
1	Jan 1926 - Dec 1929	Jan 1930 - Dec 1934	Jan 1935 - Dec 1938
2	Jan 1927 - Dec 1933	Jan 1934 - Dec 1938	Jan 1939 - Dec 1942
3	Jan 1931 - Dec 1937	Jan 1938 - Dec 1942	Jan 1943 - Dec 1946
4	Jan 1935 - Dec 1941	Jan 1942 - Dec 1946	Jan 1947 - Dec 1950
5	Jan 1939 - Dec 1945	Jan 1946 - Dec 1950	Jan 1951 - Dec 1954
6	Jan 1943 - Dec 1949	Jan 1950 - Dec 1954	Jan 1955 - Dec 1958
7	Jan 1947 - Dec 1953	Jan 1954 - Dec 1958	Jan 1959 - Dec 1962
8	Jan 1951 - Dec 1957	Jan 1958 - Dec 1962	Jan 1963 - Dec 1966
9	Jan 1955 - Dec 1961	Jan 1962 - Dec 1966	Jan 1967 - Jun 1968

points (0) + (13) To Replicate Table 1

(B) Table 2: It simply shows • $\hat{\beta}_{po}^{\#}$ for $\# = 1, \dots, 20$

for 4 of the 9 estimation periods: see (4) for it!

It also shows:

• $s\left(R_p^{\#}\right)$ = Sample Stdev of portfolio Returns $= \dfrac{\sum_{t=1}^{T}\left(R_{pt}^{\#} - \bar{R}_p^{\#}\right)^2}{T-1}$ $\qquad \bar{R}_p^{\#} = \dfrac{\sum_{t=1}^{T} R_{pt}^{\#}}{T}$

Ex: $t =$ Jan 1930 $\qquad \# = 1, \dots, 20$

$T =$ Dec 1934

• $s\left(\hat{\beta}_{po}^{\#}\right)$ = Standard Error of $\hat{\beta}_{p\,t-1}$ $= \left[\mathrm{Var}\left(\sum_{J=1}^{I^{\#}} i_J\, \hat{\beta}_i\right)\right]^{\frac{1}{2}} = \left[\sum_{J=1}^{I^{\#}} i_J^2\, \mathrm{Var}\left(\hat{\beta}_i\right)\right]^{\frac{1}{2}}$

• $\bar{S}_{p\,t-1}^{\#}(\hat{\varepsilon}_i) = \bar{S}_{po}^{\#}(\hat{\varepsilon}_i)$ $\qquad \mathrm{Var}\left[\hat{\beta}_i\right] = \left[\dfrac{s\left(\hat{\varepsilon}_i\right)}{\sqrt{T-1}\cdot s\left(R_m\right)}\right]^2$

• $s\left(R_m\right) = \left[\dfrac{\sum_{t=1}^{T}\left(R_{mt} - \bar{R}_m\right)^2}{T-1}\right]^{\frac{1}{2}}$ $\qquad t =$ Jan 1930, $T =$ Dec 1934

$s\left(\hat{\varepsilon}_i\right) =$ see (10) for the estimation period

- $s(\varepsilon_p^{\#})$ = Follow these steps: t = Jan 1930, T = Dec 1934

Regress: $R_{pt}^{\#} = \alpha_p^{\#} + \beta_p^{\#} R_{mt} + \varepsilon_{pt}^{\#}$ $\# = 1, \ldots, 20$

Calculate: $\hat{\varepsilon}_{pt}^{\#} = R_{pt}^{\#} - {}^{\#}\alpha_p^{OLS} - {}^{\#}\beta_{OLS}^{p} R_{mt}$

Calculate:

$$s(\hat{\varepsilon}_p^{\#}) = \left[\frac{\sum_{t=1}^{T} \left(\hat{\varepsilon}_{pt}^{\#} - \bar{\hat{\varepsilon}}_p^{\#} \right)^2}{T-1} \right] \qquad \bar{\hat{\varepsilon}}_p^{\#} = \frac{1}{T} \sum_{t=1}^{T} \hat{\varepsilon}_{pt}^{\#}$$

- $r(R_p^{\#}, R_m)^2$ = R^2 of the above regression =

$$= \frac{{}^{\#}\beta_p^{OLS\,2} \, VAR(R_m)}{VAR(R_p^{\#})} \qquad \beta_p^{*} = \frac{COV\left[R_{pt}^{\#}, R_{mt}\right]}{VAR(R_{mt})}$$

[or $s^2(\varepsilon_p^{\#}) = (1 - r^2)\, VAR(R_p^{\#})$]

(c) Table 3: Given the Time Series for $\hat{\gamma}_0$, $\hat{\gamma}_1$, $\hat{\gamma}_2$ and $\hat{\gamma}_3$, 10 subperiods are considered.

Four Versions of (12) are considered:

Panel A: $X_t = \left[1 \quad \hat{\beta}_{p\,t-1} \right]$

B $X_t = \left[1 \quad \hat{\beta}_{p\,t-1} \quad \hat{\beta}_{p\,t-1}^{2} \right]$

C $X_t = \left[1 \quad \hat{\beta}_{p\,t-1} \quad \bar{s}_{p\,t-1}(\varepsilon_i) \right]$

D $X_t = \left[1 \quad \hat{\beta}_{p\,t-1} \quad \hat{\beta}_{p\,t-1}^{2} \quad \bar{s}_{p\,t-1}(\varepsilon_i) \right]$

And for each model the following data are provided:

- $$\bar{\hat{\gamma}}_i = \frac{1}{T} \sum_{t=1}^{T} \hat{\gamma}_i$$

R_{Ft} = 1-month Treasury Bills

- $$\overline{\hat{\gamma}_0 - R_F} = \frac{1}{T} \sum_{t=1}^{T} \left[\hat{\gamma}_{0t} - R_{Ft} \right]$$

- $$s\left(\hat{\gamma}_i\right) = \left[\frac{\sum_{t=1}^{T} \left[\hat{\gamma}_{it} - \bar{\hat{\gamma}}_{it} \right]^2}{T-1} \right]^{\frac{1}{2}}$$

K = columns of Matrix X_t

- $$\bar{r}^2 = \frac{1}{T} \sum_{t=1}^{T} r_t^2$$

$$R_t^2 = \frac{\hat{\gamma}_t' X_t' M_0 X_t \hat{\gamma}_t}{R_{pt}' M_0 R_{pt}}$$

$$\underset{[20 \times 20]}{M_0} = \begin{bmatrix} 1 - \frac{1}{20} & & -\frac{1}{20} \\ & \ddots & \\ -\frac{1}{20} & & 1 - \frac{1}{20} \end{bmatrix}$$

$$r_t^2 = 1 - \frac{T-1}{T-K}\left(1 - R^2\right)$$

= ie R^2-adjusted

- $$s\left(r^2\right) = \left[\frac{\sum_{t=1}^{T} \left(r_t^2 - \bar{r}^2 \right)^2}{T-1} \right]^{\frac{1}{2}}$$

- $t\left(\hat{\gamma}_i\right) = \dfrac{\bar{\hat{\gamma}}_i}{s\left(\hat{\gamma}_i\right)/\sqrt{T}}$ $\qquad t\left(\overline{\gamma_0 - R_F}\right) = \dfrac{\left(\overline{\gamma_0 - R_F}\right)}{s\left(\hat{\gamma}_0 - R_F\right)/\sqrt{T}}$

- FIRST ORDER SERIAL AUTOCORRELATIONS:

CALCULATED OVER (-1) SAMPLE [0 – T-1]

$$\rho_M\left(\hat{\gamma}_i\right) = \rho\left(\hat{\gamma}_i - \bar{\hat{\gamma}}_i\right) = \frac{\operatorname{COV}\left[\left(\hat{\gamma}_{it} - \bar{\hat{\gamma}}_i\right), \left(\hat{\gamma}_{it-1} - \bar{\hat{\gamma}}_i\right)\right]}{\left[\operatorname{VAR}\left(\hat{\gamma}_{it} - \bar{\hat{\gamma}}_i\right) \cdot \operatorname{VAR}\left(\hat{\gamma}_{it-1} - \bar{\hat{\gamma}}_i\right)\right]^{\frac{1}{2}}}$$

$$\rho_0\left(\hat{\gamma}_i\right) = \frac{\operatorname{COV}\left(\hat{\gamma}_{it}, \hat{\gamma}_{it-1}\right)}{\left[\operatorname{VAR}\left(\hat{\gamma}_{it}\right) \operatorname{VAR}\left(\hat{\gamma}_{it-1}\right)\right]^{\frac{1}{2}}}$$

- $$\rho_0\left(\hat{\gamma}_0 - R_F\right) = \frac{\operatorname{COV}\left(\hat{\gamma}_{0t} - R_{Ft}, \hat{\gamma}_{0t-1} - R_{Ft-1}\right)}{\left[\operatorname{VAR}\left(\hat{\gamma}_{0t} - R_{Ft}\right) \cdot \operatorname{VAR}\left(\hat{\gamma}_{0t-1} - R_{Ft-1}\right)\right]^{\frac{1}{2}}}$$

- $$s\left(\hat{\gamma}_0 - R_F\right) = \left[\frac{\sum_{t=1}^{T}\left[\left(\hat{\gamma}_{0t} - R_{Ft}\right) - \left(\overline{\hat{\gamma}_0 - R_F}\right)\right]^2}{T-1}\right]^{\frac{1}{2}}$$

WHERE R_{Ft} = YIELD ON 1-MONTH TREASURY BILLS

(D) Table 4 :

- $\bar{R}_m = \frac{1}{T} \sum_{t=1}^{T} R_{mt}$ $\qquad \overline{R_m - R_F} = \frac{1}{T} \sum_{t=1}^{T} (R_{mt} - R_{Ft})$

- $\bar{\hat{\gamma}}_1, \bar{\hat{\gamma}}_0$ = From those of panel A

- $\bar{R}_F = \frac{1}{T} \sum_{t=1}^{T} R_{Ft}$ $\qquad S(R_m) = \left[\frac{\sum_{t=1}^{T} (R_{mt} - \bar{R}_m)^2}{T-1} \right]^{\frac{1}{2}}$

- $S(R_F) = \left[\frac{\sum_{t=1}^{T} (R_{Ft} - \bar{R}_F)^2}{T-1} \right]^{\frac{1}{2}}$

- $t(x) = \frac{\bar{x}}{S(x)/\sqrt{T}}$ $\qquad$ X = Any sample mean

- $\rho_M(x) = \frac{\mathrm{cov}\left([x_t - \bar{x}], [x_{t-1} - \bar{x}]\right)}{\left[\mathrm{Var}(x_t - \bar{x})\,\mathrm{Var}(x_{t-1} - \bar{x})\right]^{\frac{1}{2}}}$ $\qquad$ X = Any sample mean

  (calculated over the (-1) sample [0 - T-1])

(E) **Table 5**: For each of the Panel Analysis shown in Table 3:

- $$s^2(\hat{\gamma}_i) = \frac{\sum_{t=1}^{T} \left(\hat{\gamma}_i - \bar{\hat{\gamma}}_i\right)^2}{T-1}$$

- $s(\tilde{\hat{\phi}}_i) =$ Standard Error of $\hat{\gamma}_i$ from the Regression in step (12), by defining:

$$\hat{\eta}_t = R_{pt} - \hat{\gamma}_t' X_t \quad \text{From Regressions (12)}$$

$$s_t^2 = \frac{\hat{\eta}_t' \hat{\eta}_t}{T-k} \qquad k = \text{\# of columns of } X_t$$

$$\widehat{VAR}\left[\hat{\gamma}_t\right] = s^2(\tilde{\hat{\phi}}_t) = s_t^2 \left(\underset{(k \times m)}{X_t'} \underset{(m \times k)}{X_t}\right)^{-1}$$ so that Fama-MacBeth

Assume that:

$$\underset{(k \times 1)}{s(\tilde{\hat{\phi}})} = \left[\frac{1}{T} \sum_{t=1}^{T} s^2(\tilde{\hat{\phi}}_t)_{kk}\right]^{\frac{1}{2}} = \underset{(k \times 1)}{\overline{s(\tilde{\hat{\phi}})}}$$ where $s(\tilde{\hat{\phi}}_i)$ is the ith element of that vector

- $$s^2(\tilde{\gamma}_i) = s^2(\hat{\gamma}_i) - s^2(\tilde{\hat{\phi}}_i)$$

- $$F = s^2(\hat{\gamma}_i) \Big/ s^2(\tilde{\hat{\phi}}_i)$$ with $\begin{cases} T-1 \text{ DF Numerator} \\ T(20-k) \text{ DF Denominator} \end{cases}$

Hypothesis to Test:

C 1 Linearity : $E[\hat{\gamma}_{2t}] = 0$

C 2 No systematic Effects of Non-Beta Risk : $E[\hat{\gamma}_{3t}] = 0$

C 3 Positive Expected Return-Risk Trade-off : $E[\gamma_{1t}] = E[\hat{R}_{mt}] - E[\hat{R}_{Ft}] > 0$

SL Sharpe-Lintner : $E[\hat{\gamma}_{0t}] = R_{Ft}$

ME Market Efficiency : $\hat{\gamma}_{3t}$ $\hat{\gamma}_{2t}$ $[\hat{\gamma}_{1t} - (E(\hat{R}_{mt}) - E(\hat{R}_{Ft}))]$

$\hat{\gamma}_{0t} - E[\hat{R}_{0t}]$ and $\hat{\eta}_{it}$ are

Fair Game

Reject C2 when $t(\hat{\bar{\gamma}}_2)$ is large Table 3

Reject C_1 when $t(\bar{\hat{\gamma}}_3)$ is large Table 3

Accept C3 when $t(\hat{\bar{\gamma}}_1)$ is large Table 3

Accept ME when Serial Correlations are not statistically significant (STDEV $\approx S(\hat{\rho})/\sqrt{T}$) and have low explanatory power $= \rho^2_{0,M}$

REJECT SL when $\left[\hat{\gamma}_1 - \left(\overline{R_m - R_F}\right)\right]$ is STATISTICALLY LARGE (page 627)

when $\left\{ \begin{array}{l} \overline{\hat{\gamma}_0 - R_F} \text{ is positive} \\ + \left(\hat{\gamma}_0 - R_F\right) \text{ is LARGE} \end{array} \right.$

FIRST TRY: FAMA-McBeth is used for the initial values of NLOLS. Then a ITNLGLS is performed
----
PANEL A **

ok!!!!

```
calc;T=90;NCF=21;FROM=313;TO=402$
read;Nobs=1000;Nvar=22;file=a:/panelA35-68.wks;format=wks$
samp;1-NCF$
matr;BEGIN=x31$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
    ;start=BEGIN
    ;Labels=gamma1,20_beta
    ;Fn1=beta1*(gamma1+x21)
    ;Fn2=beta2*(gamma1+x21)
    ;Fn3=beta3*(gamma1+x21)
    ;Fn4=beta4*(gamma1+x21)
    ;Fn5=beta5*(gamma1+x21)
    ;Fn6=beta6*(gamma1+x21)
    ;Fn7=beta7*(gamma1+x21)
    ;Fn8=beta8*(gamma1+x21)
    ;Fn9=beta9*(gamma1+x21)
    ;Fn10=beta10*(gamma1+x21)
    ;Fn11=beta11*(gamma1+x21)
    ;Fn12=beta12*(gamma1+x21)
    ;Fn13=beta13*(gamma1+x21)
    ;Fn14=beta14*(gamma1+x21)
    ;Fn15=beta15*(gamma1+x21)
    ;Fn16=beta16*(gamma1+x21)
    ;Fn17=beta17*(gamma1+x21)
    ;Fn18=beta18*(gamma1+x21)
    ;Fn19=beta19*(gamma1+x21)
    ;Fn20=beta20*(gamma1+x21)
    ;SIGMA=I$
matr;EX=[B(1)]+x21$
matr;E1=Init(T,1,0);E1=x1-EX*B(2)$
matr;E2=Init(T,1,0);E2=x2-EX*B(3)$
matr;E3=Init(T,1,0);E3=x3-EX*B(4)$
matr;E4=Init(T,1,0);E4=x4-EX*B(5)$
matr;E5=Init(T,1,0);E5=x5-EX*B(6)$
matr;E6=Init(T,1,0);E6=x6-EX*B(7)$
matr;E7=Init(T,1,0);E7=x7-EX*B(8)$
matr;E8=Init(T,1,0);E8=x8-EX*B(9)$
matr;E9=Init(T,1,0);E9=x9-EX*B(10)$
matr;E10=Init(T,1,0);E10=x10-EX*B(11)$
matr;E11=Init(T,1,0);E11=x11-EX*B(12)$
matr;E12=Init(T,1,0);E12=x12-EX*B(13)$
matr;E13=Init(T,1,0);E13=x13-EX*B(14)$
matr;E14=Init(T,1,0);E14=x14-EX*B(15)$
matr;E15=Init(T,1,0);E15=x15-EX*B(16)$
matr;E16=Init(T,1,0);E16=x16-EX*B(17)$
matr;E17=Init(T,1,0);E17=x17-EX*B(18)$
matr;E18=Init(T,1,0);E18=x18-EX*B(19)$
matr;E19=Init(T,1,0);E19=x19-EX*B(20)$
matr;E20=Init(T,1,0);E20=x20-EX*B(21)$
matr;BIGE1=[E1,E2,E3,E4,E5,E6,E7,E8,E9,E10]$
matr;BIGE2=[E11,E12,E13,E14,E15,E16,E17,E18,E19,E20]$
matr;BIGE=[BIGE1,BIGE2]$
matr;SIGMA1=BIGE'BIGE*<T>$
```

```
samp;1-NCF$
matr;BEGIN2=B$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
    ;start=BEGIN2
    ;Labels=gamma1,20_beta
    ;Fn1=beta1*(gamma1+x21)
    ;Fn2=beta2*(gamma1+x21)
    ;Fn3=beta3*(gamma1+x21)
    ;Fn4=beta4*(gamma1+x21)
    ;Fn5=beta5*(gamma1+x21)
    ;Fn6=beta6*(gamma1+x21)
    ;Fn7=beta7*(gamma1+x21)
    ;Fn8=beta8*(gamma1+x21)
    ;Fn9=beta9*(gamma1+x21)
    ;Fn10=beta10*(gamma1+x21)
    ;Fn11=beta11*(gamma1+x21)
    ;Fn12=beta12*(gamma1+x21)
    ;Fn13=beta13*(gamma1+x21)
    ;Fn14=beta14*(gamma1+x21)
    ;Fn15=beta15*(gamma1+x21)
    ;Fn16=beta16*(gamma1+x21)
    ;Fn17=beta17*(gamma1+x21)
    ;Fn18=beta18*(gamma1+x21)
    ;Fn19=beta19*(gamma1+x21)
    ;Fn20=beta20*(gamma1+x21)
    ;SIGMA=SIGMA1$
crea;Paolo=B$
matr;VARI=[VARB(1,1)/VARB(2,2)/VARB(3,3)/VARB(4,4)/VARB(5,5)/VARB(6,6)/VARB
(7,7)/VARB(8,8)/VARB(9,9)/VARB(10,10)]$
matr;VARII=[VARB(11,11)/VARB(12,12)/VARB(13,13)/VARB(14,14)/VARB(15,15)/VARB
(16,16)/VARB(17,17)/VARB(18,18)/VARB(19,19)/VARB(20,20)]$
matr;VARIII=[VARB(21,21)]$
matr;VARIV=[VARI/VARII/VARIII]$
crea;Pasqua=VARIV$
writ;Paolo,Pasqua;File=a:\outputA61-68.wks;format=wks$




************************************************************************
METHOD II


calc;T=90;NCF=21;FROM=313;TO=402$
read;Nobs=1000;Nvar=31;file=a:/panelA35-68.wks;format=wks$
samp;1-NCF$
matr;B1=x31$
samp;FROM-TO$
matr;EX=[B1(1)]+x21$
matr;E1=Init(T,1,0);E1=x1-EX*B1(2)$
matr;E2=Init(T,1,0);E2=x2-EX*B1(3)$
matr;E3=Init(T,1,0);E3=x3-EX*B1(4)$
matr;E4=Init(T,1,0);E4=x4-EX*B1(5)$
matr;E5=Init(T,1,0);E5=x5-EX*B1(6)$
matr;E6=Init(T,1,0);E6=x6-EX*B1(7)$
matr;E7=Init(T,1,0);E7=x7-EX*B1(8)$
matr;E8=Init(T,1,0);E8=x8-EX*B1(9)$
matr;E9=Init(T,1,0);E9=x9-EX*B1(10)$
matr;E10=Init(T,1,0);E10=x10-EX*B1(11)$
matr;E11=Init(T,1,0);E11=x11-EX*B1(12)$
```

```
matr;E12=Init(T,1,0);E12=x12-EX*B1(13)$
matr;E13=Init(T,1,0);E13=x13-EX*B1(14)$
matr;E14=Init(T,1,0);E14=x14-EX*B1(15)$
matr;E15=Init(T,1,0);E15=x15-EX*B1(16)$
matr;E16=Init(T,1,0);E16=x16-EX*B1(17)$
matr;E17=Init(T,1,0);E17=x17-EX*B1(18)$
matr;E18=Init(T,1,0);E18=x18-EX*B1(19)$
matr;E19=Init(T,1,0);E19=x19-EX*B1(20)$
matr;E20=Init(T,1,0);E20=x20-EX*B1(21)$
matr;BIGEI=[E1,E2,E3,E4,E5,E6,E7,E8,E9,E10];BIGEII=
[E11,E12,E13,E14,E15,E16,E17,E18,E19,E20];BIGE=[BIGEI,BIGEII];SIGMA1=BIGE'BIGE*
<T>$
matr;BEGIN2=B1$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
    ;start=BEGIN2
    ;Labels=gamma1,20_beta
    ;Fn1=beta1*(gamma1+x21)
    ;Fn2=beta2*(gamma1+x21)
    ;Fn3=beta3*(gamma1+x21)
    ;Fn4=beta4*(gamma1+x21)
    ;Fn5=beta5*(gamma1+x21)
    ;Fn6=beta6*(gamma1+x21)
    ;Fn7=beta7*(gamma1+x21)
    ;Fn8=beta8*(gamma1+x21)
    ;Fn9=beta9*(gamma1+x21)
    ;Fn10=beta10*(gamma1+x21)
    ;Fn11=beta11*(gamma1+x21)
    ;Fn12=beta12*(gamma1+x21)
    ;Fn13=beta13*(gamma1+x21)
    ;Fn14=beta14*(gamma1+x21)
    ;Fn15=beta15*(gamma1+x21)
    ;Fn16=beta16*(gamma1+x21)
    ;Fn17=beta17*(gamma1+x21)
    ;Fn18=beta18*(gamma1+x21)
    ;Fn19=beta19*(gamma1+x21)
    ;Fn20=beta20*(gamma1+x21)
    ;SIGMA=SIGMA1$
crea;Paolo=B$
matr;VARI=[VARB(1,1)/VARB(2,2)/VARB(3,3)/VARB(4,4)/VARB(5,5)/VARB(6,6)/VARB
(7,7)/VARB(8,8)/VARB(9,9)/VARB(10,10)]$
matr;VARII=[VARB(11,11)/VARB(12,12)/VARB(13,13)/VARB(14,14)/VARB(15,15)/VARB
(16,16)/VARB(17,17)/VARB(18,18)/VARB(19,19)/VARB(20,20)]$
matr;VARIII=[VARB(21,21)]$
matr;VARIV=[VARI/VARII/VARIII]$
crea;Pasqua=VARIV$
writ;Paolo,Pasqua;File=a:\outputA261-68.wks;format=wks$


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FIRST TRY: FAMA-McBeth is used for the initial values of NLOLS. Then a ITNLGLS is performed

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PANEL B *****************************************************************

ok!!!!

calc;T=60;NCF=22;FROM=253;TO=312$
read;Nobs=1000;Nvar=31;file=a:/panelB35-68.wks;format=wks$
samp;1-NCF$
matr;BEGIN=x30$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x20
    ;start=BEGIN
    ;Labels=gamma1,gamma2,20_beta
    ;Fn1=beta1*(gamma1+x21)+gamma2*(beta1^2)
    ;Fn2=beta2*(gamma1+x21)+gamma2*(beta2^2)
    ;Fn3=beta3*(gamma1+x21)+gamma2*(beta3^2)
    ;Fn4=beta4*(gamma1+x21)+gamma2*(beta4^2)
    ;Fn5=beta5*(gamma1+x21)+gamma2*(beta5^2)
    ;Fn6=beta6*(gamma1+x21)+gamma2*(beta6^2)
    ;Fn7=beta7*(gamma1+x21)+gamma2*(beta7^2)
    ;Fn8=beta8*(gamma1+x21)+gamma2*(beta8^2)
    ;Fn9=beta9*(gamma1+x21)+gamma2*(beta9^2)
    ;Fn10=beta10*(gamma1+x21)+gamma2*(beta10^2)
    ;Fn11=beta11*(gamma1+x21)+gamma2*(beta11^2)
    ;Fn12=beta12*(gamma1+x21)+gamma2*(beta12^2)
    ;Fn13=beta13*(gamma1+x21)+gamma2*(beta13^2)
    ;Fn14=beta14*(gamma1+x21)+gamma2*(beta14^2)
    ;Fn15=beta15*(gamma1+x21)+gamma2*(beta15^2)
    ;Fn16=beta16*(gamma1+x21)+gamma2*(beta16^2)
    ;Fn17=beta17*(gamma1+x21)+gamma2*(beta17^2)
    ;Fn18=beta18*(gamma1+x21)+gamma2*(beta18^2)
    ;Fn19=beta19*(gamma1+x21)+gamma2*(beta19^2)
    ;Fn20=beta20*(gamma1+x21)+gamma2*(beta20^2)
    ;SIGMA=I$
samp;1-NCF$
matr;BI=Diag(B)$
matr;BISQ=BI^{2}$
matr;BSQ=BISQ*ONE$
samp;FROM-TO$
matr;NEWB=B(1)*ONE$
matr;EX=Msum(NEWB,x21)$
matr;BSQ1=ONE*BSQ(3);EX1=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(4);EX2=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(5);EX3=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(6);EX4=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(7);EX5=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(8);EX6=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(9);EX7=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(10);EX8=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(11);EX9=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(12);EX10=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(13);EX11=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(14);EX12=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(15);EX13=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(16);EX14=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(17);EX15=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(18);EX16=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(19);EX17=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(20);EX18=[EX,BSQ1]$
```

```
matr;BSQ1=ONE*BSQ(21);EX19=[EX,BSQ1]$
matr;BSQ1=ONE*BSQ(22);EX20=[EX,BSQ1]$
samp;FROM-TO$
matr;R1=x1;R2=x2;R3=x3;R4=x4;R5=x5;R6=x6;R7=x7;R8=x8;R9=x9;R10=x10$
matr;R11=x11;R12=x12;R13=x13;R14=x14;R15=x15;R16=x16;R17=x17;R18=x18;R19
=x19;R20=x20$
matr;RM=x21$
matr;E1=Init(T,1,0);CF1=[B(3),B(2)];E1=R1-EX1*CF1'$
matr;E2=Init(T,1,0);CF1=[B(4),B(2)];E2=R2-EX2*CF1'$
matr;E3=Init(T,1,0);CF1=[B(5),B(2)];E3=R3-EX3*CF1'$
matr;E4=Init(T,1,0);CF1=[B(6),B(2)];E4=R4-EX4*CF1'$
matr;E5=Init(T,1,0);CF1=[B(7),B(2)];E5=R5-EX5*CF1'$
matr;E6=Init(T,1,0);CF1=[B(8),B(2)];E6=R6-EX6*CF1'$
matr;E7=Init(T,1,0);CF1=[B(9),B(2)];E7=R7-EX7*CF1'$
matr;E8=Init(T,1,0);CF1=[B(10),B(2)];E8=R8-EX8*CF1'$
matr;E9=Init(T,1,0);CF1=[B(11),B(2)];E9=R9-EX9*CF1'$
matr;E10=Init(T,1,0);CF1=[B(12),B(2)];E10=R10-EX10*CF1'$
matr;E11=Init(T,1,0);CF1=[B(13),B(2)];E11=R11-EX11*CF1'$
matr;E12=Init(T,1,0);CF1=[B(14),B(2)];E12=R12-EX12*CF1'$
matr;E13=Init(T,1,0);CF1=[B(15),B(2)];E13=R13-EX13*CF1'$
matr;E14=Init(T,1,0);CF1=[B(16),B(2)];E14=R14-EX14*CF1'$
matr;E15=Init(T,1,0);CF1=[B(17),B(2)];E15=R15-EX15*CF1'$
matr;E16=Init(T,1,0);CF1=[B(18),B(2)];E16=R16-EX16*CF1'$
matr;E17=Init(T,1,0);CF1=[B(19),B(2)];E17=R17-EX17*CF1'$
matr;E18=Init(T,1,0);CF1=[B(20),B(2)];E18=R18-EX18*CF1'$
matr;E19=Init(T,1,0);CF1=[B(21),B(2)];E19=R19-EX19*CF1'$
matr;E20=Init(T,1,0);CF1=[B(22),B(2)];E20=R20-EX20*CF1'$
matr;BIGE1=[E1,E2,E3,E4,E5,E6,E7,E8,E9,E10]$
matr;BIGE2=[E11,E12,E13,E14,E15,E16,E17,E18,E19,E20]$
matr;BIGE=[BIGE1,BIGE2]$
matr;SIGMA1=BIGE'BIGE*<T>$
samp;1-NCF$
matr;BEGIN2=B$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
    ;start=BEGIN2
    ;Labels=gamma1,gamma2,20_beta
    ;Fn1=beta1*(gamma1+x21)+gamma2*(beta1^2)
    ;Fn2=beta2*(gamma1+x21)+gamma2*(beta2^2)
    ;Fn3=beta3*(gamma1+x21)+gamma2*(beta3^2)
    ;Fn4=beta4*(gamma1+x21)+gamma2*(beta4^2)
    ;Fn5=beta5*(gamma1+x21)+gamma2*(beta5^2)
    ;Fn6=beta6*(gamma1+x21)+gamma2*(beta6^2)
    ;Fn7=beta7*(gamma1+x21)+gamma2*(beta7^2)
    ;Fn8=beta8*(gamma1+x21)+gamma2*(beta8^2)
    ;Fn9=beta9*(gamma1+x21)+gamma2*(beta9^2)
    ;Fn10=beta10*(gamma1+x21)+gamma2*(beta10^2)
    ;Fn11=beta11*(gamma1+x21)+gamma2*(beta11^2)
    ;Fn12=beta12*(gamma1+x21)+gamma2*(beta12^2)
    ;Fn13=beta13*(gamma1+x21)+gamma2*(beta13^2)
    ;Fn14=beta14*(gamma1+x21)+gamma2*(beta14^2)
    ;Fn15=beta15*(gamma1+x21)+gamma2*(beta15^2)
    ;Fn16=beta16*(gamma1+x21)+gamma2*(beta16^2)
    ;Fn17=beta17*(gamma1+x21)+gamma2*(beta17^2)
    ;Fn18=beta18*(gamma1+x21)+gamma2*(beta18^2)
    ;Fn19=beta19*(gamma1+x21)+gamma2*(beta19^2)
    ;Fn20=beta20*(gamma1+x21)+gamma2*(beta20^2)
    ;SIGMA=SIGMA1;Tlg=1.D-4$
crea;Paolo=B$
matr;VARI=[VARB(1,1)/VARB(2,2)/VARB(3,3)/VARB(4,4)/VARB(5,5)/VARB(6,6)/VARB
(7,7)/VARB(8,8)/VARB(9,9)/VARB(10,10)]$
matr;VARII=[VARB(11,11)/VARB(12,12)/VARB(13,13)/VARB(14,14)/VARB(15,15)/VARB
```

```
(16,16)/VARB(17,17)/VARB(18,18)/VARB(19,19)/VARB(20,20)]$
matr;VARIII=[VARB(21,21)/VARB(22,22)]$
matr;VARIV=[VARI/VARII/VARIII]$
crea;Pasqua=VARIV$
writ;Paolo,Pasqua;File=a:\outputB56-60.wks;format=wks$




SECOND TRY: FMcBeth is used to generate the initial SIGMA
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PANEL B *******************************************************************

calc;T=60;NCF=22;FROM=253;TO=312$
read;Nobs=1000;Nvar=31;file=a:/panelB35-68.wks;format=wks$
samp;1-NCF$
matr;B1=x30$
matr;B1I=Diag(B1)$
matr;B1ISQ=B1I^{2}$
matr;B1SQ=B1ISQ*ONE$
samp;FROM-TO$
matr;NEWB1=B1(1)*ONE$
matr;EX=Msum(NEWB1,x21)$
matr;B1SQ1=ONE*B1SQ(3);EX1=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(4);EX2=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(5);EX3=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(6);EX4=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(7);EX5=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(8);EX6=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(9);EX7=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(10);EX8=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(11);EX9=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(12);EX10=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(13);EX11=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(14);EX12=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(15);EX13=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(16);EX14=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(17);EX15=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(18);EX16=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(19);EX17=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(20);EX18=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(21);EX19=[EX,B1SQ1]$
matr;B1SQ1=ONE*B1SQ(22);EX20=[EX,B1SQ1]$
samp;FROM-TO$
matr;R1=x1;R2=x2;R3=x3;R4=x4;R5=x5;R6=x6;R7=x7;R8=x8;R9=x9;R10=x10$
matr;R11=x11;R12=x12;R13=x13;R14=x14;R15=x15;R16=x16;R17=x17;R18=x18;R19
=x19;R20=x20$
matr;RM=x21$
matr;E1=Init(T,1,0);CF1=[B1(3),B1(2)];E1=R1-EX1*CF1'$
matr;E2=Init(T,1,0);CF1=[B1(4),B1(2)];E2=R2-EX2*CF1'$
matr;E3=Init(T,1,0);CF1=[B1(5),B1(2)];E3=R3-EX3*CF1'$
matr;E4=Init(T,1,0);CF1=[B1(6),B1(2)];E4=R4-EX4*CF1'$
matr;E5=Init(T,1,0);CF1=[B1(7),B1(2)];E5=R5-EX5*CF1'$
matr;E6=Init(T,1,0);CF1=[B1(8),B1(2)];E6=R6-EX6*CF1'$
matr;E7=Init(T,1,0);CF1=[B1(9),B1(2)];E7=R7-EX7*CF1'$
matr;E8=Init(T,1,0);CF1=[B1(10),B1(2)];E8=R8-EX8*CF1'$
matr;E9=Init(T,1,0);CF1=[B1(11),B1(2)];E9=R9-EX9*CF1'$
matr;E10=Init(T,1,0);CF1=[B1(12),B1(2)];E10=R10-EX10*CF1'$
matr;E11=Init(T,1,0);CF1=[B1(13),B1(2)];E11=R11-EX11*CF1'$
matr;E12=Init(T,1,0);CF1=[B1(14),B1(2)];E12=R12-EX12*CF1'$
matr;E13=Init(T,1,0);CF1=[B1(15),B1(2)];E13=R13-EX13*CF1'$
matr;E14=Init(T,1,0);CF1=[B1(16),B1(2)];E14=R14-EX14*CF1'$
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matr;E15=Init(T,1,0);CF1=[B1(17),B1(2)];E15=R15-EX15*CF1'$
matr;E16=Init(T,1,0);CF1=[B1(18),B1(2)];E16=R16-EX16*CF1'$
matr;E17=Init(T,1,0);CF1=[B1(19),B1(2)];E17=R17-EX17*CF1'$
matr;E18=Init(T,1,0);CF1=[B1(20),B1(2)];E18=R18-EX18*CF1'$
matr;E19=Init(T,1,0);CF1=[B1(21),B1(2)];E19=R19-EX19*CF1'$
matr;E20=Init(T,1,0);CF1=[B1(22),B1(2)];E20=R20-EX20*CF1'$
matr;BIGE1=[E1,E2,E3,E4,E5,E6,E7,E8,E9,E10]$
matr;BIGE2=[E11,E12,E13,E14,E15,E16,E17,E18,E19,E20]$
matr;BIGE=[BIGE1,BIGE2]$
matr;SIGMA1=BIGE'BIGE*<T>$
samp;1-NCF$
matr;BEGIN2=B1$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
    ;start=BEGIN2
    ;Labels=gamma1,gamma2,20_beta
    ;Fn1=beta1*(gamma1+x21)+gamma2*(beta1^2)
    ;Fn2=beta2*(gamma1+x21)+gamma2*(beta2^2)
    ;Fn3=beta3*(gamma1+x21)+gamma2*(beta3^2)
    ;Fn4=beta4*(gamma1+x21)+gamma2*(beta4^2)
    ;Fn5=beta5*(gamma1+x21)+gamma2*(beta5^2)
    ;Fn6=beta6*(gamma1+x21)+gamma2*(beta6^2)
    ;Fn7=beta7*(gamma1+x21)+gamma2*(beta7^2)
    ;Fn8=beta8*(gamma1+x21)+gamma2*(beta8^2)
    ;Fn9=beta9*(gamma1+x21)+gamma2*(beta9^2)
    ;Fn10=beta10*(gamma1+x21)+gamma2*(beta10^2)
    ;Fn11=beta11*(gamma1+x21)+gamma2*(beta11^2)
    ;Fn12=beta12*(gamma1+x21)+gamma2*(beta12^2)
    ;Fn13=beta13*(gamma1+x21)+gamma2*(beta13^2)
    ;Fn14=beta14*(gamma1+x21)+gamma2*(beta14^2)
    ;Fn15=beta15*(gamma1+x21)+gamma2*(beta15^2)
    ;Fn16=beta16*(gamma1+x21)+gamma2*(beta16^2)
    ;Fn17=beta17*(gamma1+x21)+gamma2*(beta17^2)
    ;Fn18=beta18*(gamma1+x21)+gamma2*(beta18^2)
    ;Fn19=beta19*(gamma1+x21)+gamma2*(beta19^2)
    ;Fn20=beta20*(gamma1+x21)+gamma2*(beta20^2)
    ;SIGMA=SIGMA1$
crea;Paolo=B$
matr;VARI=[VARB(1,1)/VARB(2,2)/VARB(3,3)/VARB(4,4)/VARB(5,5)/VARB(6,6)/VARB
(7,7)/VARB(8,8)/VARB(9,9)/VARB(10,10)]$
matr;VARII=[VARB(11,11)/VARB(12,12)/VARB(13,13)/VARB(14,14)/VARB(15,15)/VARB
(16,16)/VARB(17,17)/VARB(18,18)/VARB(19,19)/VARB(20,20)]$
matr;VARIII=[VARB(21,21)/VARB(22,22)]$
matr;VARIV=[VARI/VARII/VARIII]$
crea;Pasqua=VARIV$
writ;Paolo,Pasqua;File=a:\outputB256-60.wks;format=wks$


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FIRST TRY: FAMA-McBeth is used for the initial values of NLOLS. Then a ITNLGLS is performed

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PANEL C ********************************************************************

ok!!!!

calc;T=60;NCF=22;FROM=252;TO=311$
read;Nobs=1000;Nvar=52;file=a:/panelC2-35-68.wks;format=wks$
samp;1-NCF$
matr;BEGIN=x30$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x20
     ;start=BEGIN
     ;Labels=gamma1,gamma3,20_beta
     ;Fn1=beta1*(gamma1+x21)+gamma3*(x32-beta1*x52)
     ;Fn2=beta2*(gamma1+x21)+gamma3*(x33-beta2*x52)
     ;Fn3=beta3*(gamma1+x21)+gamma3*(x34-beta3*x52)
     ;Fn4=beta4*(gamma1+x21)+gamma3*(x35-beta4*x52)
     ;Fn5=beta5*(gamma1+x21)+gamma3*(x36-beta5*x52)
     ;Fn6=beta6*(gamma1+x21)+gamma3*(x37-beta6*x52)
     ;Fn7=beta7*(gamma1+x21)+gamma3*(x38-beta7*x52)
     ;Fn8=beta8*(gamma1+x21)+gamma3*(x39-beta8*x52)
     ;Fn9=beta9*(gamma1+x21)+gamma3*(x40-beta9*x52)
     ;Fn10=beta10*(gamma1+x21)+gamma3*(x41-beta10*x52)
     ;Fn11=beta11*(gamma1+x21)+gamma3*(x42-beta11*x52)
     ;Fn12=beta12*(gamma1+x21)+gamma3*(x43-beta12*x52)
     ;Fn13=beta13*(gamma1+x21)+gamma3*(x44-beta13*x52)
     ;Fn14=beta14*(gamma1+x21)+gamma3*(x45-beta14*x52)
     ;Fn15=beta15*(gamma1+x21)+gamma3*(x46-beta15*x52)
     ;Fn16=beta16*(gamma1+x21)+gamma3*(x47-beta16*x52)
     ;Fn17=beta17*(gamma1+x21)+gamma3*(x48-beta17*x52)
     ;Fn18=beta18*(gamma1+x21)+gamma3*(x49-beta18*x52)
     ;Fn19=beta19*(gamma1+x21)+gamma3*(x50-beta19*x52)
     ;Fn20=beta20*(gamma1+x21)+gamma3*(x51-beta20*x52)
     ;SIGMA=I$
samp;FROM-TO$
matr;NEWB=B(1)*ONE$
matr;EX=Msum(NEWB,x21)$
matr;EXX1=x32-B(3)*x52;EX1=[EX,EXX1]$
matr;EXX1=x33-B(4)*x52;EX2=[EX,EXX1]$
matr;EXX1=x34-B(5)*x52;EX3=[EX,EXX1]$
matr;EXX1=x35-B(6)*x52;EX4=[EX,EXX1]$
matr;EXX1=x36-B(7)*x52;EX5=[EX,EXX1]$
matr;EXX1=x37-B(8)*x52;EX6=[EX,EXX1]$
matr;EXX1=x38-B(9)*x52;EX7=[EX,EXX1]$
matr;EXX1=x39-B(10)*x52;EX8=[EX,EXX1]$
matr;EXX1=x40-B(11)*x52;EX9=[EX,EXX1]$
matr;EXX1=x41-B(12)*x52;EX10=[EX,EXX1]$
matr;EXX1=x42-B(13)*x52;EX11=[EX,EXX1]$
matr;EXX1=x43-B(14)*x52;EX12=[EX,EXX1]$
matr;EXX1=x44-B(15)*x52;EX13=[EX,EXX1]$
matr;EXX1=x45-B(16)*x52;EX14=[EX,EXX1]$
matr;EXX1=x46-B(17)*x52;EX15=[EX,EXX1]$
matr;EXX1=x47-B(18)*x52;EX16=[EX,EXX1]$
matr;EXX1=x48-B(19)*x52;EX17=[EX,EXX1]$
matr;EXX1=x49-B(20)*x52;EX18=[EX,EXX1]$
matr;EXX1=x50-B(21)*x52;EX19=[EX,EXX1]$
matr;EXX1=x51-B(22)*x52;EX20=[EX,EXX1]$
samp;FROM-TO$
matr;R1=x1;R2=x2;R3=x3;R4=x4;R5=x5;R6=x6;R7=x7;R8=x8;R9=x9;R10=x10$
```

```
matr;R11=x11;R12=x12;R13=x13;R14=x14;R15=x15;R16=x16;R17=x17;R18=x18;R19
=x19;R20=x20$
matr;RM=x21$
matr;E1=Init(T,1,0);CF1=[B(3),B(2)];E1=R1-EX1*CF1'$
matr;E2=Init(T,1,0);CF1=[B(4),B(2)];E2=R2-EX2*CF1'$
matr;E3=Init(T,1,0);CF1=[B(5),B(2)];E3=R3-EX3*CF1'$
matr;E4=Init(T,1,0);CF1=[B(6),B(2)];E4=R4-EX4*CF1'$
matr;E5=Init(T,1,0);CF1=[B(7),B(2)];E5=R5-EX5*CF1'$
matr;E6=Init(T,1,0);CF1=[B(8),B(2)];E6=R6-EX6*CF1'$
matr;E7=Init(T,1,0);CF1=[B(9),B(2)];E7=R7-EX7*CF1'$
matr;E8=Init(T,1,0);CF1=[B(10),B(2)];E8=R8-EX8*CF1'$
matr;E9=Init(T,1,0);CF1=[B(11),B(2)];E9=R9-EX9*CF1'$
matr;E10=Init(T,1,0);CF1=[B(12),B(2)];E10=R10-EX10*CF1'$
matr;E11=Init(T,1,0);CF1=[B(13),B(2)];E11=R11-EX11*CF1'$
matr;E12=Init(T,1,0);CF1=[B(14),B(2)];E12=R12-EX12*CF1'$
matr;E13=Init(T,1,0);CF1=[B(15),B(2)];E13=R13-EX13*CF1'$
matr;E14=Init(T,1,0);CF1=[B(16),B(2)];E14=R14-EX14*CF1'$
matr;E15=Init(T,1,0);CF1=[B(17),B(2)];E15=R15-EX15*CF1'$
matr;E16=Init(T,1,0);CF1=[B(18),B(2)];E16=R16-EX16*CF1'$
matr;E17=Init(T,1,0);CF1=[B(19),B(2)];E17=R17-EX17*CF1'$
matr;E18=Init(T,1,0);CF1=[B(20),B(2)];E18=R18-EX18*CF1'$
matr;E19=Init(T,1,0);CF1=[B(21),B(2)];E19=R19-EX19*CF1'$
matr;E20=Init(T,1,0);CF1=[B(22),B(2)];E20=R20-EX20*CF1'$
matr;BIGE1=[E1,E2,E3,E4,E5,E6,E7,E8,E9,E10]$
matr;BIGE2=[E11,E12,E13,E14,E15,E16,E17,E18,E19,E20]$
matr;BIGE=[BIGE1,BIGE2]$
matr;SIGMA1=BIGE'BIGE*<T>$
samp;1-NCF$
matr;BEGIN2=B$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
    ;start=BEGIN2
    ;Labels=gamma1,gamma3,20_beta
    ;Fn1=beta1*(gamma1+x21)+gamma3*(x32-beta1*x52)
    ;Fn2=beta2*(gamma1+x21)+gamma3*(x33-beta2*x52)
    ;Fn3=beta3*(gamma1+x21)+gamma3*(x34-beta3*x52)
    ;Fn4=beta4*(gamma1+x21)+gamma3*(x35-beta4*x52)
    ;Fn5=beta5*(gamma1+x21)+gamma3*(x36-beta5*x52)
    ;Fn6=beta6*(gamma1+x21)+gamma3*(x37-beta6*x52)
    ;Fn7=beta7*(gamma1+x21)+gamma3*(x38-beta7*x52)
    ;Fn8=beta8*(gamma1+x21)+gamma3*(x39-beta8*x52)
    ;Fn9=beta9*(gamma1+x21)+gamma3*(x40-beta9*x52)
    ;Fn10=beta10*(gamma1+x21)+gamma3*(x41-beta10*x52)
    ;Fn11=beta11*(gamma1+x21)+gamma3*(x42-beta11*x52)
    ;Fn12=beta12*(gamma1+x21)+gamma3*(x43-beta12*x52)
    ;Fn13=beta13*(gamma1+x21)+gamma3*(x44-beta13*x52)
    ;Fn14=beta14*(gamma1+x21)+gamma3*(x45-beta14*x52)
    ;Fn15=beta15*(gamma1+x21)+gamma3*(x46-beta15*x52)
    ;Fn16=beta16*(gamma1+x21)+gamma3*(x47-beta16*x52)
    ;Fn17=beta17*(gamma1+x21)+gamma3*(x48-beta17*x52)
    ;Fn18=beta18*(gamma1+x21)+gamma3*(x49-beta18*x52)
    ;Fn19=beta19*(gamma1+x21)+gamma3*(x50-beta19*x52)
    ;Fn20=beta20*(gamma1+x21)+gamma3*(x51-beta20*x52)
    ;SIGMA=SIGMA1;Tlg=1.D-4$
crea;Paolo=B$
matr;VARI=[VARB(1,1)/VARB(2,2)/VARB(3,3)/VARB(4,4)/VARB(5,5)/VARB(6,6)/VARB
(7,7)/VARB(8,8)/VARB(9,9)/VARB(10,10)]$
matr;VARII=[VARB(11,11)/VARB(12,12)/VARB(13,13)/VARB(14,14)/VARB(15,15)/VARB
(16,16)/VARB(17,17)/VARB(18,18)/VARB(19,19)/VARB(20,20)]$
matr;VARIII=[VARB(21,21)/VARB(22,22)]$
matr;VARIV=[VARI/VARII/VARIII]$
crea;Pasqua=VARIV$
```

```
writ;Paolo,Pasqua;File=a:\outputC56-60.wks;format=wks$




SECOND TRY: FMcBeth is used to generate the initial SIGMA
--------------------------------------------------------------------------------
------------
PANEL B *****************************************************************

calc;T=60;NCF=22;FROM=252;TO=311$
read;Nobs=1000;Nvar=52;file=a:/panelC2-35-68.wks;format=wks$
samp;1-NCF$
matr;B1=x30$
samp;FROM-TO$
matr;NEWB1=B1(1)*ONE$
matr;EX=Msum(NEWB1,x21)$
matr;EXX1=x32-B1(3)*x52;EX1=[EX,EXX1]$
matr;EXX1=x33-B1(4)*x52;EX2=[EX,EXX1]$
matr;EXX1=x34-B1(5)*x52;EX3=[EX,EXX1]$
matr;EXX1=x35-B1(6)*x52;EX4=[EX,EXX1]$
matr;EXX1=x36-B1(7)*x52;EX5=[EX,EXX1]$
matr;EXX1=x37-B1(8)*x52;EX6=[EX,EXX1]$
matr;EXX1=x38-B1(9)*x52;EX7=[EX,EXX1]$
matr;EXX1=x39-B1(10)*x52;EX8=[EX,EXX1]$
matr;EXX1=x40-B1(11)*x52;EX9=[EX,EXX1]$
matr;EXX1=x41-B1(12)*x52;EX10=[EX,EXX1]$
matr;EXX1=x42-B1(13)*x52;EX11=[EX,EXX1]$
matr;EXX1=x43-B1(14)*x52;EX12=[EX,EXX1]$
matr;EXX1=x44-B1(15)*x52;EX13=[EX,EXX1]$
matr;EXX1=x45-B1(16)*x52;EX14=[EX,EXX1]$
matr;EXX1=x46-B1(17)*x52;EX15=[EX,EXX1]$
matr;EXX1=x47-B1(18)*x52;EX16=[EX,EXX1]$
matr;EXX1=x48-B1(19)*x52;EX17=[EX,EXX1]$
matr;EXX1=x49-B1(20)*x52;EX18=[EX,EXX1]$
matr;EXX1=x50-B1(21)*x52;EX19=[EX,EXX1]$
matr;EXX1=x51-B1(22)*x52;EX20=[EX,EXX1]$
samp;FROM-TO$
matr;R1=x1;R2=x2;R3=x3;R4=x4;R5=x5;R6=x6;R7=x7;R8=x8;R9=x9;R10=x10$
matr;R11=x11;R12=x12;R13=x13;R14=x14;R15=x15;R16=x16;R17=x17;R18=x18;R19
=x19;R20=x20$
matr;RM=x21$
matr;E1=Init(T,1,0);CF1=[B1(3),B1(2)];E1=R1-EX1*CF1'$
matr;E2=Init(T,1,0);CF1=[B1(4),B1(2)];E2=R2-EX2*CF1'$
matr;E3=Init(T,1,0);CF1=[B1(5),B1(2)];E3=R3-EX3*CF1'$
matr;E4=Init(T,1,0);CF1=[B1(6),B1(2)];E4=R4-EX4*CF1'$
matr;E5=Init(T,1,0);CF1=[B1(7),B1(2)];E5=R5-EX5*CF1'$
matr;E6=Init(T,1,0);CF1=[B1(8),B1(2)];E6=R6-EX6*CF1'$
matr;E7=Init(T,1,0);CF1=[B1(9),B1(2)];E7=R7-EX7*CF1'$
matr;E8=Init(T,1,0);CF1=[B1(10),B1(2)];E8=R8-EX8*CF1'$
matr;E9=Init(T,1,0);CF1=[B1(11),B1(2)];E9=R9-EX9*CF1'$
matr;E10=Init(T,1,0);CF1=[B1(12),B1(2)];E10=R10-EX10*CF1'$
matr;E11=Init(T,1,0);CF1=[B1(13),B1(2)];E11=R11-EX11*CF1'$
matr;E12=Init(T,1,0);CF1=[B1(14),B1(2)];E12=R12-EX12*CF1'$
matr;E13=Init(T,1,0);CF1=[B1(15),B1(2)];E13=R13-EX13*CF1'$
matr;E14=Init(T,1,0);CF1=[B1(16),B1(2)];E14=R14-EX14*CF1'$
matr;E15=Init(T,1,0);CF1=[B1(17),B1(2)];E15=R15-EX15*CF1'$
matr;E16=Init(T,1,0);CF1=[B1(18),B1(2)];E16=R16-EX16*CF1'$
matr;E17=Init(T,1,0);CF1=[B1(19),B1(2)];E17=R17-EX17*CF1'$
matr;E18=Init(T,1,0);CF1=[B1(20),B1(2)];E18=R18-EX18*CF1'$
matr;E19=Init(T,1,0);CF1=[B1(21),B1(2)];E19=R19-EX19*CF1'$
matr;E20=Init(T,1,0);CF1=[B1(22),B1(2)];E20=R20-EX20*CF1'$
matr;BIGE1=[E1,E2,E3,E4,E5,E6,E7,E8,E9,E10]$
```

```
matr;BIGE2=[E11,E12,E13,E14,E15,E16,E17,E18,E19,E20]$
matr;BIGE=[BIGE1,BIGE2]$
matr;SIGMA1=BIGE'BIGE*<T>$
samp;1-NCF$
matr;BEGIN2=B1$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
     ;start=BEGIN2
     ;Labels=gamma1,gamma3,20_beta
     ;Fn1=beta1*(gamma1+x21)+gamma3*(x32-beta1*x52)
     ;Fn2=beta2*(gamma1+x21)+gamma3*(x33-beta2*x52)
     ;Fn3=beta3*(gamma1+x21)+gamma3*(x34-beta3*x52)
     ;Fn4=beta4*(gamma1+x21)+gamma3*(x35-beta4*x52)
     ;Fn5=beta5*(gamma1+x21)+gamma3*(x36-beta5*x52)
     ;Fn6=beta6*(gamma1+x21)+gamma3*(x37-beta6*x52)
     ;Fn7=beta7*(gamma1+x21)+gamma3*(x38-beta7*x52)
     ;Fn8=beta8*(gamma1+x21)+gamma3*(x39-beta8*x52)
     ;Fn9=beta9*(gamma1+x21)+gamma3*(x40-beta9*x52)
     ;Fn10=beta10*(gamma1+x21)+gamma3*(x41-beta10*x52)
     ;Fn11=beta11*(gamma1+x21)+gamma3*(x42-beta11*x52)
     ;Fn12=beta12*(gamma1+x21)+gamma3*(x43-beta12*x52)
     ;Fn13=beta13*(gamma1+x21)+gamma3*(x44-beta13*x52)
     ;Fn14=beta14*(gamma1+x21)+gamma3*(x45-beta14*x52)
     ;Fn15=beta15*(gamma1+x21)+gamma3*(x46-beta15*x52)
     ;Fn16=beta16*(gamma1+x21)+gamma3*(x47-beta16*x52)
     ;Fn17=beta17*(gamma1+x21)+gamma3*(x48-beta17*x52)
     ;Fn18=beta18*(gamma1+x21)+gamma3*(x49-beta18*x52)
     ;Fn19=beta19*(gamma1+x21)+gamma3*(x50-beta19*x52)
     ;Fn20=beta20*(gamma1+x21)+gamma3*(x51-beta20*x52)
     ;SIGMA=SIGMA1$
crea;Paolo=B$
matr;VARI=[VARB(1,1)/VARB(2,2)/VARB(3,3)/VARB(4,4)/VARB(5,5)/VARB(6,6)/VARB
(7,7)/VARB(8,8)/VARB(9,9)/VARB(10,10)]$
matr;VARII=[VARB(11,11)/VARB(12,12)/VARB(13,13)/VARB(14,14)/VARB(15,15)/VARB
(16,16)/VARB(17,17)/VARB(18,18)/VARB(19,19)/VARB(20,20)]$
matr;VARIII=[VARB(21,21)/VARB(22,22)]$
matr;VARIV=[VARI/VARII/VARIII]$
crea;Pasqua=VARIV$
writ;Paolo,Pasqua;File=a:\outputC256-60.wks;format=wks$


*******************************************************************************
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```

FIRST TRY: FAMA-McBeth is used for the initial values of NLOLS. Then a ITNLGLS is performed
----
PANEL D ***

ok!!!!

```
calc;T=60;NCF=23;FROM=252;TO=311$
read;Nobs=1000;Nvar=52;file=a:/panelD2-35-68.wks;format=wks$
samp;1-NCF$
matr;BEGIN=x30$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
    ;start=BEGIN
    ;Labels=gamma1,gamma2,gamma3,20_beta
    ;Fn1=beta1*(gamma1+x21)+gamma2*(beta1^2)+gamma3*(x32-beta1*x52)
    ;Fn2=beta2*(gamma1+x21)+gamma2*(beta2^2)+gamma3*(x33-beta2*x52)
    ;Fn3=beta3*(gamma1+x21)+gamma2*(beta3^2)+gamma3*(x34-beta3*x52)
    ;Fn4=beta4*(gamma1+x21)+gamma2*(beta4^2)+gamma3*(x35-beta4*x52)
    ;Fn5=beta5*(gamma1+x21)+gamma2*(beta5^2)+gamma3*(x36-beta5*x52)
    ;Fn6=beta6*(gamma1+x21)+gamma2*(beta6^2)+gamma3*(x37-beta6*x52)
    ;Fn7=beta7*(gamma1+x21)+gamma2*(beta7^2)+gamma3*(x38-beta7*x52)
    ;Fn8=beta8*(gamma1+x21)+gamma2*(beta8^2)+gamma3*(x39-beta8*x52)
    ;Fn9=beta9*(gamma1+x21)+gamma2*(beta9^2)+gamma3*(x40-beta9*x52)
    ;Fn10=beta10*(gamma1+x21)+gamma2*(beta10^2)+gamma3*(x41-beta10*x52)
    ;Fn11=beta11*(gamma1+x21)+gamma2*(beta11^2)+gamma3*(x42-beta11*x52)
    ;Fn12=beta12*(gamma1+x21)+gamma2*(beta12^2)+gamma3*(x43-beta12*x52)
    ;Fn13=beta13*(gamma1+x21)+gamma2*(beta13^2)+gamma3*(x44-beta13*x52)
    ;Fn14=beta14*(gamma1+x21)+gamma2*(beta14^2)+gamma3*(x45-beta14*x52)
    ;Fn15=beta15*(gamma1+x21)+gamma2*(beta15^2)+gamma3*(x46-beta15*x52)
    ;Fn16=beta16*(gamma1+x21)+gamma2*(beta16^2)+gamma3*(x47-beta16*x52)
    ;Fn17=beta17*(gamma1+x21)+gamma2*(beta17^2)+gamma3*(x48-beta17*x52)
    ;Fn18=beta18*(gamma1+x21)+gamma2*(beta18^2)+gamma3*(x49-beta18*x52)
    ;Fn19=beta19*(gamma1+x21)+gamma2*(beta19^2)+gamma3*(x50-beta19*x52)
    ;Fn20=beta20*(gamma1+x21)+gamma2*(beta20^2)+gamma3*(x51-beta20*x52)
    ;SIGMA=I$
samp;1-NCF$
matr;BI=Diag(B)$
matr;BISQ=BI^{2}$
matr;BSQ=BISQ*ONE$
samp;FROM-TO$
matr;NEWB=B(1)*ONE$
matr;EX=Msum(NEWB,x21)$
matr;EXX1=x32-B(4)*x52;BSQ1=ONE*BSQ(4);EX1=[EX,BSQ1,EXX1]$
matr;EXX1=x33-B(5)*x52;BSQ1=ONE*BSQ(5);EX2=[EX,BSQ1,EXX1]$
matr;EXX1=x34-B(6)*x52;BSQ1=ONE*BSQ(6);EX3=[EX,BSQ1,EXX1]$
matr;EXX1=x35-B(7)*x52;BSQ1=ONE*BSQ(7);EX4=[EX,BSQ1,EXX1]$
matr;EXX1=x36-B(8)*x52;BSQ1=ONE*BSQ(8);EX5=[EX,BSQ1,EXX1]$
matr;EXX1=x37-B(9)*x52;BSQ1=ONE*BSQ(9);EX6=[EX,BSQ1,EXX1]$
matr;EXX1=x38-B(10)*x52;BSQ1=ONE*BSQ(10);EX7=[EX,BSQ1,EXX1]$
matr;EXX1=x39-B(11)*x52;BSQ1=ONE*BSQ(11);EX8=[EX,BSQ1,EXX1]$
matr;EXX1=x40-B(12)*x52;BSQ1=ONE*BSQ(12);EX9=[EX,BSQ1,EXX1]$
matr;EXX1=x41-B(13)*x52;BSQ1=ONE*BSQ(13);EX10=[EX,BSQ1,EXX1]$
matr;EXX1=x42-B(14)*x52;BSQ1=ONE*BSQ(14);EX11=[EX,BSQ1,EXX1]$
matr;EXX1=x43-B(15)*x52;BSQ1=ONE*BSQ(15);EX12=[EX,BSQ1,EXX1]$
matr;EXX1=x44-B(16)*x52;BSQ1=ONE*BSQ(16);EX13=[EX,BSQ1,EXX1]$
matr;EXX1=x45-B(17)*x52;BSQ1=ONE*BSQ(17);EX14=[EX,BSQ1,EXX1]$
matr;EXX1=x46-B(18)*x52;BSQ1=ONE*BSQ(18);EX15=[EX,BSQ1,EXX1]$
matr;EXX1=x47-B(19)*x52;BSQ1=ONE*BSQ(19);EX16=[EX,BSQ1,EXX1]$
matr;EXX1=x48-B(20)*x52;BSQ1=ONE*BSQ(20);EX17=[EX,BSQ1,EXX1]$
matr;EXX1=x49-B(21)*x52;BSQ1=ONE*BSQ(21);EX18=[EX,BSQ1,EXX1]$
```

```
matr;EXX1=x50-B(22)*x52;BSQ1=ONE*BSQ(22);EX19=[EX,BSQ1,EXX1]$
matr;EXX1=x51-B(23)*x52;BSQ1=ONE*BSQ(23);EX20=[EX,BSQ1,EXX1]$
samp;FROM-TO$
matr;R1=x1;R2=x2;R3=x3;R4=x4;R5=x5;R6=x6;R7=x7;R8=x8;R9=x9;R10=x10$
matr;R11=x11;R12=x12;R13=x13;R14=x14;R15=x15;R16=x16;R17=x17;R18=x18;R19
=x19;R20=x20$
matr;RM=x21$
matr;E1=Init(T,1,0);CF1=[B(4),B(2),B(3)];E1=R1-EX1*CF1'$
matr;E2=Init(T,1,0);CF1=[B(5),B(2),B(3)];E2=R2-EX2*CF1'$
matr;E3=Init(T,1,0);CF1=[B(6),B(2),B(3)];E3=R3-EX3*CF1'$
matr;E4=Init(T,1,0);CF1=[B(7),B(2),B(3)];E4=R4-EX4*CF1'$
matr;E5=Init(T,1,0);CF1=[B(8),B(2),B(3)];E5=R5-EX5*CF1'$
matr;E6=Init(T,1,0);CF1=[B(9),B(2),B(3)];E6=R6-EX6*CF1'$
matr;E7=Init(T,1,0);CF1=[B(10),B(2),B(3)];E7=R7-EX7*CF1'$
matr;E8=Init(T,1,0);CF1=[B(11),B(2),B(3)];E8=R8-EX8*CF1'$
matr;E9=Init(T,1,0);CF1=[B(12),B(2),B(3)];E9=R9-EX9*CF1'$
matr;E10=Init(T,1,0);CF1=[B(13),B(2),B(3)];E10=R10-EX10*CF1'$
matr;E11=Init(T,1,0);CF1=[B(14),B(2),B(3)];E11=R11-EX11*CF1'$
matr;E12=Init(T,1,0);CF1=[B(15),B(2),B(3)];E12=R12-EX12*CF1'$
matr;E13=Init(T,1,0);CF1=[B(16),B(2),B(3)];E13=R13-EX13*CF1'$
matr;E14=Init(T,1,0);CF1=[B(17),B(2),B(3)];E14=R14-EX14*CF1'$
matr;E15=Init(T,1,0);CF1=[B(18),B(2),B(3)];E15=R15-EX15*CF1'$
matr;E16=Init(T,1,0);CF1=[B(19),B(2),B(3)];E16=R16-EX16*CF1'$
matr;E17=Init(T,1,0);CF1=[B(20),B(2),B(3)];E17=R17-EX17*CF1'$
matr;E18=Init(T,1,0);CF1=[B(21),B(2),B(3)];E18=R18-EX18*CF1'$
matr;E19=Init(T,1,0);CF1=[B(22),B(2),B(3)];E19=R19-EX19*CF1'$
matr;E20=Init(T,1,0);CF1=[B(23),B(2),B(3)];E20=R20-EX20*CF1'$
matr;BIGE1=[E1,E2,E3,E4,E5,E6,E7,E8,E9,E10]$
matr;BIGE2=[E11,E12,E13,E14,E15,E16,E17,E18,E19,E20]$
matr;BIGE=[BIGE1,BIGE2]$
matr;SIGMA1=BIGE'BIGE*<T>$
samp;1-NCF$
matr;BEGIN2=B$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
    ;start=BEGIN2
    ;Labels=gamma1,gamma2,gamma3,20_beta
    ;Fn1=beta1*(gamma1+x21)+gamma2*(beta1^2)+gamma3*(x32-beta1*x52)
    ;Fn2=beta2*(gamma1+x21)+gamma2*(beta2^2)+gamma3*(x33-beta2*x52)
    ;Fn3=beta3*(gamma1+x21)+gamma2*(beta3^2)+gamma3*(x34-beta3*x52)
    ;Fn4=beta4*(gamma1+x21)+gamma2*(beta4^2)+gamma3*(x35-beta4*x52)
    ;Fn5=beta5*(gamma1+x21)+gamma2*(beta5^2)+gamma3*(x36-beta5*x52)
    ;Fn6=beta6*(gamma1+x21)+gamma2*(beta6^2)+gamma3*(x37-beta6*x52)
    ;Fn7=beta7*(gamma1+x21)+gamma2*(beta7^2)+gamma3*(x38-beta7*x52)
    ;Fn8=beta8*(gamma1+x21)+gamma2*(beta8^2)+gamma3*(x39-beta8*x52)
    ;Fn9=beta9*(gamma1+x21)+gamma2*(beta9^2)+gamma3*(x40-beta9*x52)
    ;Fn10=beta10*(gamma1+x21)+gamma2*(beta10^2)+gamma3*(x41-beta10*x52)
    ;Fn11=beta11*(gamma1+x21)+gamma2*(beta11^2)+gamma3*(x42-beta11*x52)
    ;Fn12=beta12*(gamma1+x21)+gamma2*(beta12^2)+gamma3*(x43-beta12*x52)
    ;Fn13=beta13*(gamma1+x21)+gamma2*(beta13^2)+gamma3*(x44-beta13*x52)
    ;Fn14=beta14*(gamma1+x21)+gamma2*(beta14^2)+gamma3*(x45-beta14*x52)
    ;Fn15=beta15*(gamma1+x21)+gamma2*(beta15^2)+gamma3*(x46-beta15*x52)
    ;Fn16=beta16*(gamma1+x21)+gamma2*(beta16^2)+gamma3*(x47-beta16*x52)
    ;Fn17=beta17*(gamma1+x21)+gamma2*(beta17^2)+gamma3*(x48-beta17*x52)
    ;Fn18=beta18*(gamma1+x21)+gamma2*(beta18^2)+gamma3*(x49-beta18*x52)
    ;Fn19=beta19*(gamma1+x21)+gamma2*(beta19^2)+gamma3*(x50-beta19*x52)
    ;Fn20=beta20*(gamma1+x21)+gamma2*(beta20^2)+gamma3*(x51-beta20*x52)
    ;SIGMA=SIGMA1;Tlg=1.D-4$
crea;Paolo=B$
matr;VARI=[VARB(1,1)/VARB(2,2)/VARB(3,3)/VARB(4,4)/VARB(5,5)/VARB(6,6)/VARB
(7,7)/VARB(8,8)/VARB(9,9)/VARB(10,10)]$
matr;VARII=[VARB(11,11)/VARB(12,12)/VARB(13,13)/VARB(14,14)/VARB(15,15)/VARB
```

```
(16,16)/VARB(17,17)/VARB(18,18)/VARB(19,19)/VARB(20,20)]$
matr;VARIII=[VARB(21,21)/VARB(22,22)/VARB(23,23)]$
matr;VARIV=[VARI/VARII/VARIII]$
crea;Pasqua=VARIV$
writ;Paolo,Pasqua;File=a:\outputD56-60.wks;format=wks$
```

SECOND TRY: FMcBeth is used to generate the initial SIGMA

PANEL B **

```
calc;T=60;NCF=23;FROM=252;TO=311$
read;Nobs=1000;Nvar=52;file=a:/panelD2-35-68.wks;format=wks$
samp;1-NCF$
matr;B1=x30$
matr;B1I=Diag(B1)$
matr;B1ISQ=B1I^{2}$
matr;B1SQ=B1ISQ*ONE$
samp;FROM-TO$
matr;NEWB1=B1(1)*ONE$
matr;EX=Msum(NEWB1,x21)$
matr;EXX1=x32-B1(4)*x52;B1SQ1=ONE*B1SQ(4);EX1=[EX,B1SQ1,EXX1]$
matr;EXX1=x33-B1(5)*x52;B1SQ1=ONE*B1SQ(5);EX2=[EX,B1SQ1,EXX1]$
matr;EXX1=x34-B1(6)*x52;B1SQ1=ONE*B1SQ(6);EX3=[EX,B1SQ1,EXX1]$
matr;EXX1=x35-B1(7)*x52;B1SQ1=ONE*B1SQ(7);EX4=[EX,B1SQ1,EXX1]$
matr;EXX1=x36-B1(8)*x52;B1SQ1=ONE*B1SQ(8);EX5=[EX,B1SQ1,EXX1]$
matr;EXX1=x37-B1(9)*x52;B1SQ1=ONE*B1SQ(9);EX6=[EX,B1SQ1,EXX1]$
matr;EXX1=x38-B1(10)*x52;B1SQ1=ONE*B1SQ(10);EX7=[EX,B1SQ1,EXX1]$
matr;EXX1=x39-B1(11)*x52;B1SQ1=ONE*B1SQ(11);EX8=[EX,B1SQ1,EXX1]$
matr;EXX1=x40-B1(12)*x52;B1SQ1=ONE*B1SQ(12);EX9=[EX,B1SQ1,EXX1]$
matr;EXX1=x41-B1(13)*x52;B1SQ1=ONE*B1SQ(13);EX10=[EX,B1SQ1,EXX1]$
matr;EXX1=x42-B1(14)*x52;B1SQ1=ONE*B1SQ(14);EX11=[EX,B1SQ1,EXX1]$
matr;EXX1=x43-B1(15)*x52;B1SQ1=ONE*B1SQ(15);EX12=[EX,B1SQ1,EXX1]$
matr;EXX1=x44-B1(16)*x52;B1SQ1=ONE*B1SQ(16);EX13=[EX,B1SQ1,EXX1]$
matr;EXX1=x45-B1(17)*x52;B1SQ1=ONE*B1SQ(17);EX14=[EX,B1SQ1,EXX1]$
matr;EXX1=x46-B1(18)*x52;B1SQ1=ONE*B1SQ(18);EX15=[EX,B1SQ1,EXX1]$
matr;EXX1=x47-B1(19)*x52;B1SQ1=ONE*B1SQ(19);EX16=[EX,B1SQ1,EXX1]$
matr;EXX1=x48-B1(20)*x52;B1SQ1=ONE*B1SQ(20);EX17=[EX,B1SQ1,EXX1]$
matr;EXX1=x49-B1(21)*x52;B1SQ1=ONE*B1SQ(21);EX18=[EX,B1SQ1,EXX1]$
matr;EXX1=x50-B1(22)*x52;B1SQ1=ONE*B1SQ(22);EX19=[EX,B1SQ1,EXX1]$
matr;EXX1=x51-B1(23)*x52;B1SQ1=ONE*B1SQ(23);EX20=[EX,B1SQ1,EXX1]$
samp;FROM-TO$
matr;R1=x1;R2=x2;R3=x3;R4=x4;R5=x5;R6=x6;R7=x7;R8=x8;R9=x9;R10=x10$
matr;R11=x11;R12=x12;R13=x13;R14=x14;R15=x15;R16=x16;R17=x17;R18=x18;R19
=x19;R20=x20$
matr;RM=x21$
matr;E1=Init(T,1,0);CF1=[B1(4),B1(2),B1(3)];E1=R1-EX1*CF1'$
matr;E2=Init(T,1,0);CF1=[B1(5),B1(2),B1(3)];E2=R2-EX2*CF1'$
matr;E3=Init(T,1,0);CF1=[B1(6),B1(2),B1(3)];E3=R3-EX3*CF1'$
matr;E4=Init(T,1,0);CF1=[B1(7),B1(2),B1(3)];E4=R4-EX4*CF1'$
matr;E5=Init(T,1,0);CF1=[B1(8),B1(2),B1(3)];E5=R5-EX5*CF1'$
matr;E6=Init(T,1,0);CF1=[B1(9),B1(2),B1(3)];E6=R6-EX6*CF1'$
matr;E7=Init(T,1,0);CF1=[B1(10),B1(2),B1(3)];E7=R7-EX7*CF1'$
matr;E8=Init(T,1,0);CF1=[B1(11),B1(2),B1(3)];E8=R8-EX8*CF1'$
matr;E9=Init(T,1,0);CF1=[B1(12),B1(2),B1(3)];E9=R9-EX9*CF1'$
matr;E10=Init(T,1,0);CF1=[B1(13),B1(2),B1(3)];E10=R10-EX10*CF1'$
matr;E11=Init(T,1,0);CF1=[B1(14),B1(2),B1(3)];E11=R11-EX11*CF1'$
matr;E12=Init(T,1,0);CF1=[B1(15),B1(2),B1(3)];E12=R12-EX12*CF1'$
matr;E13=Init(T,1,0);CF1=[B1(16),B1(2),B1(3)];E13=R13-EX13*CF1'$
matr;E14=Init(T,1,0);CF1=[B1(17),B1(2),B1(3)];E14=R14-EX14*CF1'$
```

```
matr;E15=Init(T,1,0);CF1=[B1(18),B1(2),B1(3)];E15=R15-EX15*CF1'$
matr;E16=Init(T,1,0);CF1=[B1(19),B1(2),B1(3)];E16=R16-EX16*CF1'$
matr;E17=Init(T,1,0);CF1=[B1(20),B1(2),B1(3)];E17=R17-EX17*CF1'$
matr;E18=Init(T,1,0);CF1=[B1(21),B1(2),B1(3)];E18=R18-EX18*CF1'$
matr;E19=Init(T,1,0);CF1=[B1(22),B1(2),B1(3)];E19=R19-EX19*CF1'$
matr;E20=Init(T,1,0);CF1=[B1(23),B1(2),B1(3)];E20=R20-EX20*CF1'$
matr;BIGE1=[E1,E2,E3,E4,E5,E6,E7,E8,E9,E10]$
matr;BIGE2=[E11,E12,E13,E14,E15,E16,E17,E18,E19,E20]$
matr;BIGE=[BIGE1,BIGE2]$
matr;SIGMA1=BIGE'BIGE*<T>$
samp;1-NCF$
matr;BEGIN2=B1$
samp;FROM-TO$
NLSUR;Lhs=x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17,x18,x19,x2
0
    ;start=BEGIN2
    ;Labels=gamma1,gamma2,gamma3,20_beta
    ;Fn1=beta1*(gamma1+x21)+gamma2*(beta1^2)+gamma3*(x32-beta1*x52)
    ;Fn2=beta2*(gamma1+x21)+gamma2*(beta2^2)+gamma3*(x33-beta2*x52)
    ;Fn3=beta3*(gamma1+x21)+gamma2*(beta3^2)+gamma3*(x34-beta3*x52)
    ;Fn4=beta4*(gamma1+x21)+gamma2*(beta4^2)+gamma3*(x35-beta4*x52)
    ;Fn5=beta5*(gamma1+x21)+gamma2*(beta5^2)+gamma3*(x36-beta5*x52)
    ;Fn6=beta6*(gamma1+x21)+gamma2*(beta6^2)+gamma3*(x37-beta6*x52)
    ;Fn7=beta7*(gamma1+x21)+gamma2*(beta7^2)+gamma3*(x38-beta7*x52)
    ;Fn8=beta8*(gamma1+x21)+gamma2*(beta8^2)+gamma3*(x39-beta8*x52)
    ;Fn9=beta9*(gamma1+x21)+gamma2*(beta9^2)+gamma3*(x40-beta9*x52)
    ;Fn10=beta10*(gamma1+x21)+gamma2*(beta10^2)+gamma3*(x41-beta10*x52)
    ;Fn11=beta11*(gamma1+x21)+gamma2*(beta11^2)+gamma3*(x42-beta11*x52)
    ;Fn12=beta12*(gamma1+x21)+gamma2*(beta12^2)+gamma3*(x43-beta12*x52)
    ;Fn13=beta13*(gamma1+x21)+gamma2*(beta13^2)+gamma3*(x44-beta13*x52)
    ;Fn14=beta14*(gamma1+x21)+gamma2*(beta14^2)+gamma3*(x45-beta14*x52)
    ;Fn15=beta15*(gamma1+x21)+gamma2*(beta15^2)+gamma3*(x46-beta15*x52)
    ;Fn16=beta16*(gamma1+x21)+gamma2*(beta16^2)+gamma3*(x47-beta16*x52)
    ;Fn17=beta17*(gamma1+x21)+gamma2*(beta17^2)+gamma3*(x48-beta17*x52)
    ;Fn18=beta18*(gamma1+x21)+gamma2*(beta18^2)+gamma3*(x49-beta18*x52)
    ;Fn19=beta19*(gamma1+x21)+gamma2*(beta19^2)+gamma3*(x50-beta19*x52)
    ;Fn20=beta20*(gamma1+x21)+gamma2*(beta20^2)+gamma3*(x51-beta20*x52)
    ;SIGMA=SIGMA1$
crea;Paolo=B$
matr;VARI=[VARB(1,1)/VARB(2,2)/VARB(3,3)/VARB(4,4)/VARB(5,5)/VARB(6,6)/VARB
(7,7)/VARB(8,8)/VARB(9,9)/VARB(10,10)]$
matr;VARII=[VARB(11,11)/VARB(12,12)/VARB(13,13)/VARB(14,14)/VARB(15,15)/VARB
(16,16)/VARB(17,17)/VARB(18,18)/VARB(19,19)/VARB(20,20)]$
matr;VARIII=[VARB(21,21)/VARB(22,22)/VARB(23,23)]$
matr;VARIV=[VARI/VARII/VARIII]$
crea;Pasqua=VARIV$
writ;Paolo,Pasqua;File=a:\outputD256-60.wks;format=wks$


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