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Test Formulation

The null hypothesis can be stated formally as,

$H_0$ : The observations from two samples come  
from populations with the same dispersion,

and the alternative as,

$H_1$ : The observations from two samples come from  
populations not having the same dispersion.

The test itself would be:

if  $|Z| \leq$  some critical value, accept  $H_0$ ;

if  $|Z| >$  some critical value, reject  $H_0$ .

## Faculty Working Papers

A RE-EXAMINATION OF THE EFFECTIVENESS OF  
DIVIDEND POLICY: A POOLED TIME-SERIES AND  
CROSS-SECTIONAL DATA APPROACH

Cheng F. Lee, Professor, Department of Finance  
Hui-shyong Chang, University of Tennessee

#556

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

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Summary:

Using the most generalized specifications and estimation models, the possible impacts of dividend policy for the industrial firms are re-examined in accordance with the capital asset pricing theory developed by Sharpe and Mossin. It is found that the dividend policy generally affects the average rates of return for high pay-out instead of low pay-out stocks.

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A Re-examination of the Effectiveness of  
Dividend Policy: A Pooled Time-Series and  
Cross-sectional Data Approach

I. Introduction

Recently Black and Scholes (1974) [BS] and Bar-Yosef and Kolodny (1976) [BK] have employed the capital asset pricing model (CAPM) developed by Lintner (1965), Sharpe (1964) and Mossin (1966) to test the effect of dividend policy on common stock returns. Based upon results obtained from time-series data, BS have not found any evidence to support that there exist some impacts of changing dividend policy on a corporation's stock price. However, by using the cross-sectional relationship between average pay-out ratio and average rates of return, BK have concluded that investors do in fact have a net preference for dividend. By using the error component model developed by Wallace and Hussain (1969) and others, Chang and Lee (1977) have demonstrated the importance of explicitly considering both the time effect and the firm effect<sup>1</sup> in empirical financial analysis. In addition, Chang and Lee have also demonstrated the importance of selecting a correct functional form in financial studies by introducing the Box and Cox's (1964) transformation technique into the error component model. The new techniques of financial analysis suggested by Chang and Lee can be used to investigate the validity of the cross-sectional model used by BK on a statistical ground. Furthermore, the effectiveness of dividend policy associated with either time or firm effect can also be explicitly taken into account.

The main purposes of this paper are, therefore, to consider the importance of time and firm effects in testing the effectiveness of dividend

policy and to examine the appropriateness of the linear relationship used by BK in testing the dividend policy. Annual data of both utility and industrial industries from 1968 to 1975 are used in the empirical study. In the second section, models used by both BS and BK are introduced and examined. New models are then developed. In the third section empirical results are presented and discussed. Finally, results of this study are summarized.

## II. The Models

Three equations used by BK relevant to the test of the effect of dividend policy on stock returns can be written as

$$R_i = a + b\beta_i + \epsilon_i \quad (1)$$

$$R_i = a + b\beta_i + cP_i + \epsilon_i \quad (2)$$

$$R_i = a + b\beta_i + cX_{1i} + dX_{2i} + \epsilon_i \quad (3)$$

- where  $R_i$  = average monthly geometric rate of return on security  $i$   
 $\beta_i$  = beta coefficient for security  $i$  in terms of monthly data  
 $P_i$  = average payout ratio for security  $i$   
 $X_{1i}$  = dummy variable 1 = 1 if low payout  
0 if other  
 $X_{2i}$  = dummy variable 2 = 1 if high payout  
0 if other

Equation (1) is the security market line (SML), which is used generally to test the risk-return relationship. Equations (2) and (3) are derived by adding dividend policy to (1) for the purpose of testing the importance of dividend policy in capital asset pricing.

Two possible specification problems exist in the BK's models. First, the models as indicated in equations (1), (2) and (3) do not allow the existence of non-linear relationships between the dependent and the explanatory variables. Second, the time effect and the firm effect are not taken into account explicitly. To reduce or avoid the weaknesses associated with BK's models, the above models are rewritten as

$$R_{it}^{(\lambda)} = a + b\beta_{it}^{(\lambda)} + \epsilon_{it} \quad (4)$$

$$R_{it}^{(\lambda)} = a + b\beta_{it}^{(\lambda)} + cP_{it}^{(\lambda)} + \epsilon_{it} \quad (5)$$

$$R_{it}^{(\lambda)} = a + b\beta_{it}^{(\lambda)} + cX_{1,it} + dX_{2,it} + \epsilon_{it} \quad (6)$$

$$i = 1, 2, \dots, N$$
$$t = 1, 2, \dots, T$$

where any variable, say Y, with a superscript  $(\lambda)$  is defined as

$$Y^{(\lambda)} = \frac{Y^\lambda - 1}{\lambda} \quad (7)$$

The subscript  $i$  indicates the observation on the  $i$ th security and the subscript  $t$  indicates the time period concerned. Other variables are the same as defined above.

$\lambda$  in equations (4)-(6) is a transformation parameter suggested by Box and Cox (1964) and Zarembka (1968). It is obvious that when  $\lambda = 1$ , equations (4)-(6) are in linear forms and are equivalent to (1)-(3). When  $\lambda = 0$ , it can be shown that the variables are transformed into logarithms [See, for example, Kmenta (1971), p. 466-468]. Different values of  $\lambda$  represents different specifications of the functional relationships

for the dependent and explanatory variables. Therefore, equations (4)-(6) are generalized functional forms for the study of dividend policy and common stock returns, in which the linear and log forms are special cases. This implies that the functional relationship used by previous researchers in testing the risk-return trade-off relationship and the effectiveness of dividend policy may well be subject to functional form bias.

The subscripts  $t$  and  $i$  in the equations indicate that the observations may vary over time and across different securities. The model is, therefore, also capable of being used to analyze data with both time and cross-sectional dimensions. To explain methods of estimating the equations, a model for analyzing both firm and time effect of a security returns can be written as

$$R_{it}^{(\lambda)} = \sum_{k=1}^K \beta_k Y_{kit}^{(\lambda)} + u_{it}, \quad \begin{array}{l} i = 1, 2, \dots, N \\ t = 1, 2, \dots, T \end{array} \quad (8)$$

where  $R_{it}$  represents the average rates of returns in  $i$ th security in period  $t$ ;  $Y^{(\lambda)}$ 's are the transformed explanatory variables used in equations (4), (5), or (6). In actuality the factors affecting the  $R_{it}$  are often numerous and complex and may not be readily observable or measurable. Consequently, only a subset of these factors is included in the equations. In addition, when cross-section and time-series data are combined in the estimation of a regression equation, certain unobservable "other effects" may be present in the data.<sup>2</sup> Without considering those other factors, the ordinary least squares (OLS) estimates of the  $\beta$ 's in (8), as indicated by Nerlove (1971) and Wallace and Hussain (1969), may be biased and inefficient. To consider other causal variables, equation (8) is written as:<sup>3</sup>

$$R_{it}^{(\lambda)} = \sum_{k=1}^K \beta_k Y_{kit}^{(\lambda)} + w_i + v_t + u_{it}, \quad \begin{array}{l} i = 1, 2, \dots, N \\ t = 1, 2, \dots, T \end{array} \quad (9)$$

where  $w_i$  represents more or less time invariant, unobserved firm effects;  $v_t$  represents more or less cross-section invariant, unobserved time effects on the average geometric rate of returns on security  $i$ ; and  $u_{it}$  represents the remaining effects which are assumed to vary in both cross-section and time dimensions. Other notations remain the same as in equation (8).

One way to estimate the parameters in equation (9) is through the treatment of  $w_i$  and  $v_t$  as constants. Under the assumption that  $u_{it}$  are independent with zero means and constant variances, least squares regression of  $R^{(\lambda)}$  on  $Y^{(\lambda)}$ 's and firm and time dummies can be used. This approach is known as the least squares with dummy variable technique (LSDV). As indicated by Maddala (1971), the use of this dummy variable technique eliminates a major portion of the variation among the dependent and explanatory variables if the between-firm and between-time period variation is large. In addition, in some cases, the loss of a substantial number of degrees of freedom occurs. Hence LSDV is not an efficient method for estimating equation (9).

Another approach to dealing with equation (9) is to treat  $w_i$  and  $v_t$  as random.<sup>4</sup> In this case, instead of  $N$   $w$ 's and  $T$   $v$ 's, we estimate only the means and the variances of the distributions of  $w$ 's and  $v$ 's. This is known as the error component model, in which the regression error is assumed to be composed of three components--one associated with time, another with cross-section, and the third variable both with the time and cross-section dimensions. Hence in the error component model, equation (9) becomes:

$$R_{it}^{(\lambda)} = \sum_{k=1}^K \beta_k Y_{kit}^{(\lambda)} + \epsilon_{it} \quad (10)$$

$$\epsilon_{it} = w_i + v_t + u_{it} \quad (11)$$

$$(i = 1, 2, \dots, N; t = 1, 2, \dots, T)$$

The assumptions on the components of the error term are that they are independent random variables with constant variances. Without loss of generality, it is also assumed that they have zero means. To estimate the parameters in (10), Aitken's generalized least squares (GLS) can be used. In matrix notation, equation (10) can be written as:

$$z = Y\beta + \epsilon \quad (12)$$

where  $z$  is an  $NT \times 1$  vector, the elements of which are the observations on the rate of return of firm  $i$  in period  $t$ ;  $Y$  is an  $NT \times K$  matrix with the observations on the  $K$  explanatory variables;  $\epsilon$  is an  $NT \times 1$  vector containing the error terms. Under the assumptions on the error components, the variance-covariance matrix of the disturbance terms  $\epsilon_{it}$  is the following  $NT \times NT$  matrix:

$$E(\epsilon\epsilon') = \Omega = \begin{bmatrix} \sigma_{wT}^2 & \sigma_{vT}^2 & \dots & \dots & \dots & \sigma_{vT}^2 \\ \sigma_{vT}^2 & \sigma_{wT}^2 & \dots & \dots & \dots & \sigma_{vT}^2 \\ \cdot & \cdot & \dots & \dots & \dots & \cdot \\ \cdot & \cdot & \dots & \dots & \dots & \cdot \\ \cdot & \cdot & \dots & \dots & \dots & \cdot \\ \cdot & \cdot & \dots & \dots & \dots & \cdot \\ \cdot & \cdot & \dots & \dots & \dots & \cdot \\ \sigma_{vT}^2 & \sigma_{vT}^2 & \dots & \dots & \dots & \sigma_{wT}^2 \end{bmatrix} \quad (13)$$

where  $I_T$  is a (T x T) identity matrix and  $A_T$  is a (T x T) matrix defined as:

$$A_T = \begin{bmatrix} \frac{\sigma^2}{\sigma_w^2} & 1 & \dots & \dots & \dots & \dots & \dots & 1 \\ \frac{\sigma^2}{\sigma_w^2} & 1 & \dots & \dots & \dots & \dots & \dots & 1 \\ 1 & \frac{\sigma^2}{\sigma_w^2} & \dots & \dots & \dots & \dots & \dots & 1 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 1 & 1 & \dots & \dots & \dots & \dots & \dots & \frac{\sigma^2}{\sigma_w^2} \end{bmatrix}$$

in which  $\sigma^2 = \sigma_w^2 + \sigma_v^2 + \sigma_u^2$ . Given equation (13), it is well known that the generalized least squares estimate of  $\beta$ , if  $\sigma_w^2$ ,  $\sigma_v^2$ , and  $\sigma_u^2$  are known, is

$$\hat{\beta} = (y' \Omega^{-1} y)^{-1} (y' \Omega^{-1} z) \tag{14}$$

with variance-covariance matrix

$$\text{Var}(\hat{\beta}) = (y' \Omega^{-1} y)^{-1} \tag{15}$$

GLS estimates are more efficient than LSDV or OLS estimates because they enable us to extract some information about the regression parameters from the between-firm and between-time-period variation. In finite samples, Nerlove (1971) has also found that it produces little bias.

In actuality  $\sigma_w^2$ ,  $\sigma_v^2$  and  $\sigma_u^2$  are usually unknown, but they can be estimated by the analysis of covariance techniques as follows [see, for example, Amemiya (1971)]:

$$\hat{\sigma}_u^2 = \frac{1}{(N-1)(T-1)} \sum_{i=1}^N \sum_{t=1}^T \left[ e_{it} - \frac{1}{T} \sum_{t=1}^T e_{it} - \frac{1}{N} \sum_{i=1}^N e_{it} \right]^2 \quad (16)$$

$$\hat{\sigma}_w^2 = \frac{1}{T} \left[ \frac{1}{(N-1)T} \sum_{i=1}^N \left( \sum_{t=1}^T e_{it} \right)^2 - \hat{\sigma}_u^2 \right] \quad (17)$$

$$\hat{\sigma}_v^2 = \frac{1}{N} \left[ \frac{1}{N(T-1)} \sum_{t=1}^T \left( \sum_{i=1}^N e_{it} \right)^2 - \hat{\sigma}_u^2 \right] \quad (18)$$

where  $e_{it}$  represents residuals obtained by applying the least squares method to the pooled data, assuming that  $w_i$  and  $v_t$  are constants to be estimated rather than random variables.

If  $\sigma_w^2$  and  $\sigma_v^2$  are estimated to equal zero, then  $\Omega$  in (13) is a  $NT \times NT$  identity matrix and hence equations (14) and (15) are the same as the OLS estimators. On the other hand, if the estimate of  $\sigma_w^2/\sigma^2$  approaches one and  $\sigma_v^2$  approaches zero, they are equivalent to LSDV with time dummies; if the estimate of  $\sigma_w^2/\sigma^2$  approaches one and  $\sigma_v^2$  approach zero, they are equivalent to LSDV with firm dummies. Hence in applying GLS rather than OLS or LSDV, the existence of other time or firm effects can be determined by the sample rather than assumed. The relative weights given to between and within firm and time period variations for the estimation of the parameters are determined by the data. In OLS it is assumed that the between and within variations are just added up; in LSDV the between variation is ignored completely [see Maddala (1971), pp. 341-344].



To demonstrate how the maximum logarithmic likelihood method can be used to estimate the parameters, equation (5) is written in terms of (10) and (11) as:

$$R_{it}^{(\lambda)} = a + b\beta_{it}^{(\lambda)} + cP_{it}^{(\lambda)} + w_i + v_t + u_{it} \quad (19)$$

Using the maximum likelihood method, Box and Cox (1964) derived a maximum logarithmic likelihood for determining the transformation parameter,  $\lambda$ :

$$L_{\max}(\lambda) = \text{constant} - \frac{n}{2} \log \hat{\sigma}^2(\lambda) + (\lambda-1) \sum_{i=1}^N \log R_{it} \quad (20)$$

where  $n$  is the sample size and  $\hat{\sigma}^2(\lambda)$  is the estimated error variance for a given  $\lambda$ . For calculating  $\hat{\sigma}^2(\lambda)$ ,  $R_{it}$  and  $\beta_{it}$ , and  $P_{it}$  are transformed according to equation (7). The maximum likelihood estimate of  $\lambda$ ,  $\hat{\lambda}$ , is obtained by plotting equation (20) against different value of  $\lambda$  and is the value of  $\lambda$  which maximizes equation (20) over the entire parameter space. Using the likelihood ratio method, an approximately 95 percent confidence region can be obtained from

$$L_{\max}(\hat{\lambda}) - L_{\max}(\lambda) < \frac{1}{2} \chi_1^2(0.05) = 1.92 \quad (21)$$

The new models associated with equations (4) and (6) can be defined and estimated in a similar manner for the pooled time-series and cross-section data.

### III. Empirical Results and Their Implications

All corporations which have complete data from 1968 to 1975 in the quarterly industrial file of the Compustat tapes are the sample of this

study. This dictates a sample size of 916 firms and 32 quarters.<sup>5</sup> Following BK, the security market line as defined in equation (22) below is used to estimate the beta coefficients for all of the 916 firms by using monthly data:

$$R_{it} = \alpha + \beta_i R_{mt} + \epsilon_{it} \quad (22)$$

where  $R_{mt}$  is monthly market rate of returns and  $R_{it}$ ,  $\beta_i$  and  $\epsilon_{it}$  are the same as defined before.

$\beta_i$  is calculated for each of the 8 years in the sample period. The annual pay-out ratios of 916 securities were also calculated for each of the eight years. In order to test the importance of dividend policy on the rate of returns of securities by using dummy variables for equation (6), the firms are classified into three groups: high pay-out group (with pay-out ratio greater than 0.6), medium pay-out group (with pay-out ratio between 0.6 and 0.4) and low pay-out group (with pay-out ratio less than 0.4).

Equation (19) was estimated by the OLS, LSDV and GLS methods so that the influence of including or excluding firm and time effects on the estimated results could be revealed. To investigate the impact of alternative functional forms on the estimated results, 17 regressions, each for a different value of  $\lambda$ , were run for each estimation method. The estimated results are given in Table I. From the table, it is seen that the optimum transformation parameters for OLS, LSDV and GLS estimates are -0.4, -0.2 and -0.2, respectively. By using the  $\chi^2$  test as indicated in equation (21), it can be seen that all these estimates of the parameters are significantly different from one or zero. The estimated results from LSDV are almost

identical to those from GLS. The results from OLS, however, are substantially different from those estimated from error-component models. BK used OLS to do the empirical studies and did not explicitly consider the possible impact of incorrect functional form in the estimated results. As shown in Table I, if the logarithmic form ( $\lambda = 0$ ) is used, then the average rates of return are negatively and significantly related to both estimated systematic risk and estimated pay-out ratio at the 0.01 level; if the linear form ( $\lambda = 1$ ) is used, then average rates of return are not significantly related to both systematic risk and pay-out ratio at  $\alpha = 0.05$ . According to the correction functional form ( $\lambda = -0.4$  and  $0.2$ ), the OLS results indicated that the average rates of return are negatively and significantly related to systematic risk and not significantly related to the pay-out ratio; the errors-component models indicate that average rates of return are negatively and significantly related to both systematic risk and pay-out ratio. These results imply that functional forms, time effect and firm effect are important factors in investigating the impact of dividend policy on individual security's rate of return. In sum, these empirical results imply that there exist some inverse relationship between dividend pay-out and return. Note that the results associated with equation (5) as reported in Table I cannot be used to identify the possible different impacts for high pay-out and low pay-out stocks.

To identify the possible different impacts of dividend policy for both high pay-out and low pay-out stocks, equation (6) was also estimated by OLS, LSDV and GLS methods with 17 alternative functional forms. Results are given in Table II. This table indicates that the optimum



transformation parameter for OLS, LSDV and GLS are also -.4, -.2 and -.2 respectively. With the optimum functional form, the OLS results indicate that the average rates of return are negatively and significantly related to the systematic risk and  $X_1$ ; the error-component model results indicated that the average rates of return are negatively and significantly related to systematic risk and  $X_2$ . The OLS results indicate that the dividend policy matters for low pay-out stock and it does not matter for high pay-out stock. But the results obtained from error-component models imply that the dividend policy does matter for high pay-out stock instead of low pay-out stock.<sup>6</sup> It is well-known that low pay-out stocks are usually growth stocks and therefore, the change of dividend policy has less chance to influence their rates of return. Hence the results obtained from the errors-component models are more reasonable than those obtained from the OLS method. Incidentally, the results of equation (6) estimated by either the LSDV or the GLS method are similar to the results of equation (5) estimated by either the LSDV or the GLS method.

Now, the impact of functional form on the empirical results of testing the impact of dividend policy is discussed. If the functional form parameter is arbitrarily assumed to be one as used by Bar-Yosef and Kolodny (1976), then it is found that the average rates of return are negatively significantly related to the low pay-out dummy variable ( $X_1$ ) and positively significantly related to high pay-out dummy variable ( $X_2$ ). In other words, the results associated with the linear form imply that the dividend policy is matter for both high pay-out and low pay-out stocks. As the results of linear form is a special case of the results

associated with generalized functional form, therefore, the results obtained by BK are biased.

Finally, the specification of (4) is estimated by the OLS, the LSDV and the GLS and the results are listed in Table III. Table III shows that the optimum transformation parameters for the OLS, the LSDV and the GLS estimates are also  $-.4$ ,  $-.2$  and  $-.2$  respectively. All these estimated parameters are significantly different from zero and one. These results imply that in the empirical studies of SML by Lintner (1965), Douglas (1969) and others on the risk-return decomposition, a correct functional form was not used. Therefore, the model and method proposed in this paper can be used to re-examine their results.

#### IV. Summary

Error-component models are proposed to re-examine the validity of the cross-sectional models developed by Bar-Yosef and Kolodny. Nine hundred and sixty-one industrial firms during 1968-1975 are used for the empirical studies. It is found that functional forms, time effect and cross-sectional effect are three important factors for detecting the effectiveness of dividend policy in the industrial firms. It is also found that the linear SML specification used by previous researchers to test the risk-return relationship is not correct. The results associated with the most appropriate specification and estimate method as indicated in Table II imply that the dividend policy will affect the rates of return for high pay-out stocks instead of low pay-out stocks.

FOOTNOTES

<sup>1</sup>The firm effect refers to the effect of factors affecting the behavior of an individual firm; it is assumed to be constant over time. The time effect refers to the economic condition of a particular time point; it varies over time.

<sup>2</sup>For a discussion of the existence of unobservable effects, see either Friend and Puckett (1964), Bower and Bower (1969) and Chang (1974).

<sup>3</sup>Bemus, Kmenta and Shapiro (1976) have also used similar methods to investigate household budget allocation to food.

<sup>4</sup>For a discussion of this sort, see, for example, Balestra and Nerlove (1968).

<sup>5</sup>BK considered only 479 firms and the time period they used is 1963-1971. Our sample size is therefore larger than that of BK and our sample period is more updated than theirs.

<sup>6</sup>Black and Scholes [1974, 6] have argued that there exists two ways to state any hypothesis about the impact of dividend policy, i.e., the effect of dividend policy can be stated in terms of either the change of price of shares or the expected rates of return, it is clear that we investigate the relationship between the average pay-out ratio and average rates of return instead of price.

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TABLE I

Estimated Results for  $R_{1c} = bR_{1c} + cP_{1c} + a$ 

$\lambda$	Coefficient for $\beta$ (b)			Coefficient for $\frac{DIV}{RN}$ (c)			Constant (a)			$R^2$			$L_{max}(\lambda)$					
	OLS	LSDV	GLS	OLS	LSDV	GLS	OLS	LSDV	GLS	OLS	LSDV	GLS	OLS	LSDV	GLS			
1.6	0.0224 (1.597)	0.224 (1.929)	0.0224 (1.930)	0 (0.417)	0 (0.650)	0 (0.650)	0.0880 (15.409)	0.0880 (18.606)	0.0880 (0.916)	0.000	0.000	0.000	.315	.315	.315	593.4	766.2	766.2
1.4	0.0072 (0.557)	0.0072 (0.681)	0.0072 (0.681)	0 (0.449)	0 (0.709)	0 (0.709)	0.0706 (12.888)	0.0705 (15.745)	0.0705 (0.761)	0.000	0.000	0.000	.331	.330	.330	692.7	876.2	876.2
1.2	-0.0052 (-0.442)	-0.0052 (-0.545)	-0.0052 (-0.545)	0 (0.475)	0 (0.760)	0 (0.760)	0.0536 (10.085)	0.0535 (12.442)	0.0535 (0.595)	0.000	0.000	0.000	.344	.343	.343	781.6	974.3	974.3
1.0	-0.0145 (-1.355)	-0.0145 (-1.684)	-0.0145 (-1.684)	0 (0.483)	0 (0.781)	0 (0.781)	0.0370 (7.105)	0.0370 (8.831)	0.0370 (0.420)	0.000	0.000	0.000	.354	.353	.353	860.4	1059.6	1059.6
0.8	-0.0205 (-2.135)	-0.0205 (-2.667)	-0.0205 (-2.667)	0.0001 (0.428)	0.0001 (0.694)	0.0001 (0.694)	0.0208 (4.055)	0.0208 (5.067)	0.0208 (0.241)	.001	.001	.001	.360	.360	.360	928.9	1133.0	1133.3
0.6	-0.0233 (-2.734)	-0.0233 (-3.423)	-0.0233 (-3.423)	0.0001 (0.211)	0.0001 (0.211)	0.0001 (0.211)	0.0053 (1.026)	0.0053 (1.268)	0.0053 (0.062)	.001	.001	.001	.363	.363	.363	987.2	1193.3	1193.3
0.4	-0.0228 (-3.108)	-0.0229 (-3.894)	-0.0229 (-3.895)	-0.0018 (-0.188)	-0.0031 (-1.521)	-0.0031 (-1.520)	-0.0110 (-2.049)	-0.0118 (-2.749)	-0.0118 (-0.139)	.001	.001	.001	.363	.362	.362	1035.7	1241.1	1241.1
0.2	-0.0196 (-3.208)	-0.0196 (-4.005)	-0.0196 (-4.005)	-0.0142 (-2.264)	-0.0239 (-5.093)	-0.0239 (-5.090)	-0.0345 (-5.029)	-0.0430 (-7.783)	-0.0429 (-0.504)	.002	.002	.002	.360	.360	.360	1074.0	1277.1	1277.1
0.0	-0.0144 (-2.967)	-0.0140 (-3.584)	-0.0140 (-3.585)	-0.0191 (-2.403)	-0.0429 (-6.575)	-0.0429 (-6.575)	-0.0429 (-6.473)	-0.0728 (-10.822)	-0.0728 (-0.845)	.002	.002	.002	.353	.353	.353	1101.3	1299.6	1299.6
-0.2	-0.0091 (-2.526)	-0.0085 (-2.887)	-0.0085 (-2.887)	-0.0098 (-1.344)	-0.0336 (-5.550)	-0.0336 (-5.544)	-0.0604 (-7.167)	-0.0820 (-11.820)	-0.0820 (-0.940)	.001	.001	.001	.340	.339	.339	1117.6	1307.1	1307.1
-0.4	-0.0049 (-1.987)	-0.0043 (-2.126)	-0.0043 (-2.127)	-0.0010 (-0.165)	-0.0212 (-4.051)	-0.0212 (-4.043)	-0.0663 (-8.010)	-0.0870 (-12.611)	-0.0870 (-0.981)	.001	.001	.001	.323	.322	.322	1122.9	1300.8	1300.8
-0.6	-0.0022 (-1.429)	-0.0018 (-1.426)	-0.0018 (-1.427)	0.0044 (0.859)	-0.0115 (-2.627)	-0.0115 (-2.619)	-0.0749 (-9.236)	-0.0937 (-13.678)	-0.0937 (-1.031)	0.000	0.000	0.000	.303	.302	.302	1116.2	1261.0	1261.0
-0.8	-0.0008 (-0.938)	-0.0006 (-0.875)	-0.0006 (-0.876)	0.0069 (1.654)	-0.0050 (-1.408)	-0.0050 (-1.400)	-0.0874 (-10.915)	-0.1037 (-15.132)	-0.1037 (-1.107)	0.000	0.000	0.000	.281	.280	.280	1097.1	1247.6	1247.6
-1.0	-0.0002 (-0.567)	-0.0002 (-0.500)	-0.0002 (-0.501)	0.0071 (2.184)	-0.0013 (-0.452)	-0.0013 (-0.444)	-0.1040 (-13.005)	-0.1176 (-16.929)	-0.1176 (-1.209)	.001	.001	.001	.257	.256	.256	1064.8	1200.2	1200.2
-1.2	-0.0001 (-0.322)	0 (-0.276)	0 (-0.276)	0.0060 (2.428)	0.0005 (0.205)	0.0005 (0.213)	-0.1249 (-15.322)	-0.1356 (-18.885)	-0.1356 (-1.333)	.001	.001	.001	.231	.230	.230	1018.5	1138.1	1138.1
-1.4	0 (-0.182)	0 (-0.158)	0 (-0.158)	0.0044 (2.404)	0.0009 (0.565)	0.0010 (0.574)	-0.1496 (-17.552)	-0.1577 (-20.678)	-0.1577 (-1.470)	.001	.001	.001	.204	.204	.204	947.1	1061.1	1061.1
-1.6	0 (-0.117)	0 (-0.108)	0 (-0.109)	0.0029 (2.176)	0.0008 (0.680)	0.0008 (0.688)	-0.1780 (-19.312)	-0.1838 (-21.957)	-0.1838 (-1.611)	.001	.001	.001	.178	.177	.177	879.9	968.7	968.7

Notes: Coefficients in parentheses are t-ratios.

 $L_{max}(\lambda)$  were calculated according to equation (20).

TABLE 11

Estimated Reaction for  $K_{11} = a + bX_1 + cX_2 + dX_3$

OLS	Coefficient for $\beta$ (b)		Coefficient for $X_1$ (c)		Coefficient for $X_2$ (a)		Constant (a)		$R^2$	OLS	LSDV	OLS	LSDV	OLS	LSDV	OLS	LSDV	OLS	LSDV
	OLS	LSDV	OLS	LSDV	OLS	LSDV	OLS	LSDV											
6	0.0060 (0.284)	-0.0030 (-0.175)	-0.0020 (-0.174)	0.5486 (4.401)	0.0795 (7.630)	0.0794 (7.627)	-0.0148 (-3.277)	-0.0507 (-4.486)	-0.0507 (-4.485)	0.0754 (7.945)	0.0543 (8.439)	0.0663 (0.682)	.008	.328	.328	596.8	71.8	1200.2	1200.2
4	-0.0073 (-0.559)	-0.0129 (-1.216)	-0.0122 (-1.215)	0.0442 (3.770)	0.0694 (7.165)	0.0693 (7.162)	-0.0424 (-3.291)	-0.0542 (-4.574)	-0.0542 (-4.574)	0.0619 (0.697)	0.0524 (7.110)	0.0524 (0.559)	.007	.343	.342	695.7	85.6	1200.2	1200.2
2	-0.0160 (-1.344)	-0.0209 (-2.188)	-0.0209 (-2.187)	0.0342 (3.068)	0.0600 (6.575)	0.0600 (6.575)	-0.0401 (-3.252)	-0.0457 (-4.596)	-0.0457 (-4.596)	0.0486 (5.628)	0.0388 (5.500)	0.0388 (0.426)	.005	.354	.354	784.1	95.5	1200.2	1200.2
0	-0.0220 (-2.040)	-0.0262 (-3.036)	-0.0262 (-3.036)	0.0247 (2.302)	0.0512 (5.865)	0.0511 (5.861)	-0.0377 (-3.188)	-0.0432 (-4.545)	-0.0432 (-4.545)	0.0356 (4.256)	0.0255 (3.793)	0.0255 (0.287)	.004	.363	.362	862.2	106.2	1200.2	1200.2
3	-0.0252 (-2.611)	-0.0286 (-3.706)	-0.0286 (-3.706)	0.0155 (1.482)	0.0427 (5.069)	0.0426 (5.064)	-0.0354 (-3.066)	-0.0407 (-4.417)	-0.0407 (-4.417)	0.0329 (2.606)	0.0126 (1.933)	0.0126 (0.145)	.004	.368	.368	930.2	103.6	1200.2	1200.2
6	-0.0258 (-1.024)	-0.0282 (-4.146)	-0.0282 (-4.146)	0.0054 (0.624)	0.0344 (4.144)	0.0344 (4.144)	-0.0329 (-2.897)	-0.0382 (-4.212)	-0.0382 (-4.212)	0.0107 (1.132)	0.0002 (0.0059)	0.0002 (0.0029)	.003	.369	.369	988.2	107.4	1200.2	1200.2
1	-0.0239 (-3.250)	-0.0253 (-4.316)	-0.0253 (-4.316)	0.0049 (0.552)	0.0164 (3.189)	0.0164 (3.189)	-0.0393 (-2.684)	-0.0426 (-3.937)	-0.0426 (-3.936)	-0.0010 (-0.127)	-0.0117 (-1.019)	-0.0117 (-0.136)	.003	.367	.366	1036.4	120.3	1200.2	1200.2
2	-0.0200 (-3.262)	-0.0205 (-4.188)	-0.0205 (-4.189)	0.0116 (1.123)	0.0186 (2.216)	0.0185 (2.210)	-0.0277 (-2.435)	-0.0329 (-3.604)	-0.0329 (-3.604)	-0.0122 (-1.533)	-0.0231 (-3.571)	-0.0231 (-0.270)	.002	.361	.360	1074.0	127.6	1200.2	1200.2
0	-0.0149 (-3.059)	-0.0148 (-3.776)	-0.0148 (-3.776)	0.0206 (1.958)	0.0109 (1.266)	0.0109 (1.266)	-0.0251 (-2.316)	-0.0303 (-3.236)	-0.0303 (-3.236)	-0.0211 (-2.883)	-0.0342 (-5.183)	-0.0342 (-0.396)	.002	.351	.351	1101.3	126.1	1200.2	1200.2
2	-0.0096 (-2.656)	-0.0092 (-3.127)	-0.0092 (-3.128)	0.0295 (2.725)	0.0035 (0.384)	0.0035 (0.388)	-0.0275 (-1.854)	-0.0279 (-2.060)	-0.0279 (-2.059)	-0.0010 (-0.127)	-0.0117 (-1.019)	-0.0117 (-0.136)	.002	.338	.338	1117.9	130.3	1200.2	1200.2
4	-0.0052 (-2.118)	-0.0048 (-2.345)	-0.0048 (-2.349)	0.0366 (3.419)	-0.0037 (-0.388)	-0.0037 (-0.388)	-0.0092 (-1.619)	-0.0256 (-2.500)	-0.0256 (-2.500)	-0.0447 (-5.200)	-0.0567 (-7.978)	-0.0567 (-0.641)	.002	.322	.321	1123.4	129.9	1200.2	1200.2
6	-0.0023 (-1.539)	-0.0020 (-1.584)	-0.0020 (-1.585)	0.0460 (4.024)	-0.0109 (-1.080)	-0.0109 (-1.080)	-0.0181 (-1.377)	-0.0240 (-2.170)	-0.0240 (-2.170)	-0.0564 (-9.183)	-0.0693 (-0.764)	-0.0693 (-0.764)	.003	.303	.302	1117.1	128.7	1200.2	1200.2
3	-0.0009 (-1.032)	-0.0007 (-0.968)	-0.0007 (-0.969)	0.0381 (4.549)	-0.0186 (-1.689)	-0.0187 (-1.693)	-0.0164 (-1.160)	-0.0225 (-1.871)	-0.0225 (-1.870)	-0.0695 (-7.277)	-0.0833 (-10.232)	-0.0833 (-0.911)	.003	.281	.281	1096.2	127.0	1200.2	1200.2
0	-0.0003 (-0.660)	-0.0002 (-0.555)	-0.0002 (-0.555)	0.0694 (4.994)	-0.0598 (-2.217)	-0.0598 (-2.227)	-0.0145 (-0.965)	-0.0212 (-1.599)	-0.0212 (-1.598)	-0.0841 (-8.143)	-0.0992 (-11.063)	-0.0992 (-1.020)	.003	.256	.257	1066.2	1200.2	1200.2	1200.2
2	-0.0001 (-0.445)	-0.0001 (-0.318)	-0.0001 (-0.319)	0.0820 (5.353)	-0.0363 (-2.638)	-0.0363 (-2.670)	-0.0134 (-0.793)	-0.0202 (-1.357)	-0.0202 (-1.355)	-0.1003 (-8.623)	-0.1166 (-11.624)	-0.1166 (-1.147)	.006	.232	.232	1020.4	1138.5	1200.2	1200.2
4	0 (-0.292)	0 (-0.201)	0 (-0.202)	0.0965 (5.044)	-0.0669 (-3.006)	-0.0669 (-3.013)	-0.0471 (-0.649)	-0.0196 (-1.151)	-0.0196 (-1.149)	-0.1182 (-8.280)	-0.1359 (-11.894)	-0.1359 (-1.269)	.005	.205	.205	959.0	1061.5	1061.5	1061.5
6	0 (-0.227)	0 (-0.154)	0 (-0.155)	-0.1133 (-5.772)	-0.0690 (-3.257)	-0.0692 (-3.272)	-0.0592 (-0.588)	-0.0195 (-0.985)	-0.0194 (-0.983)	-0.1379 (-9.498)	-0.1574 (-11.879)	-0.1574 (-1.163)	.005	.179	.178	882.0	969.3	969.3	969.3

TABLE III  
Estimated Results for  $R_{1c} = a + bI$

$\lambda$	Coefficient for $b$ (b)			Constant (a)			$R^2$	$L_{max}$ (%)				
	OLS	LSDV	GLS	OLS	LSDV	GLS		OLS	LSDV	GLS		
1.6	0.0223 (1.595)	0.0223 (1.926)	0.0223 (1.926)	0.0880 (25.421)	0.0880 (18.623)	0.0880 (0.912)	0	.315	.314	593.4	766.2	766.2
1.4	0.0071 (0.556)	0.0071 (0.677)	0.0071 (0.677)	0.0706 (11.899)	0.0706 (15.762)	0.0706 (0.762)	0	.331	.330	692.7	876.2	876.2
1.2	-0.0052 (-0.445)	-0.0052 (-0.548)	-0.0052 (-0.549)	0.0536 (10.096)	0.0536 (12.457)	0.0536 (0.596)	0	.344	.343	781.6	974.3	974.3
1.0	-0.0145 (-1.357)	-0.0145 (-1.688)	-0.0145 (-1.688)	0.0370 (7.113)	0.0370 (8.843)	0.0370 (0.421)	0	.354	.353	860.4	1059.6	1059.6
0.8	-0.0206 (-2.137)	-0.0206 (-2.670)	-0.0206 (-2.670)	0.0208 (4.055)	0.0208 (5.066)	0.0208 (0.241)	.001	.360	.360	928.9	1133.0	1133.0
0.6	-0.0233 (-2.735)	-0.0233 (-3.424)	-0.0233 (-3.424)	0.0052 (1.018)	0.0052 (1.875)	0.0052 (0.061)	.001	.363	.363	987.6	1193.3	1193.3
0.4	-0.0228 (-3.103)	-0.0228 (-3.883)	-0.0228 (-3.883)	-0.0098 (-1.920)	-0.0098 (-2.403)	-0.0098 (-0.116)	.001	.363	.362	1035.7	1241.1	1241.1
0.2	-0.0196 (-3.207)	-0.0196 (-3.998)	-0.0196 (-3.998)	-0.0242 (-4.714)	-0.0242 (-5.877)	-0.0242 (-0.285)	.001	.358	.357	1074.0	1275.6	1275.6
0.0	-0.0147 (-3.031)	-0.0147 (-3.754)	-0.0147 (-3.755)	-0.0380 (-7.340)	-0.0380 (-9.115)	-0.0380 (-0.445)	.001	.349	.348	1101.0	1297.2	1297.2
-0.2	-0.0094 (-2.603)	-0.0094 (-3.194)	-0.0094 (-3.195)	-0.0515 (-9.099)	-0.0515 (-12.148)	-0.0515 (-0.595)	.001	.337	.337	1117.6	1304.9	1304.9
-0.4	-0.0049 (-2.004)	-0.0049 (-2.431)	-0.0049 (-2.431)	-0.0653 (-12.394)	-0.0653 (-15.034)	-0.0653 (-0.741)	.001	.321	.321	1122.9	1295.6	1295.6
-0.6	-0.0021 (-1.367)	-0.0021 (-1.636)	-0.0021 (-1.636)	-0.0802 (-14.851)	-0.0802 (-17.770)	-0.0802 (-0.887)	0	.302	.302	1116.2	1280.7	1280.7
-0.8	-0.0007 (-0.827)	-0.0007 (-0.975)	-0.0007 (-0.975)	-0.0968 (-17.157)	-0.0968 (-20.220)	-0.0968 (-1.037)	0	.281	.280	1096.9	1247.6	1247.6
-1.0	-0.0002 (-0.453)	-0.0002 (-0.5250)	-0.0002 (-0.5250)	-0.1155 (-19.137)	-0.1155 (-22.186)	-0.1155 (-1.190)	0	.257	.256	1064.6	1200.2	1200.2
-1.2	0 (-0.236)	0 (-0.269)	0 (-0.269)	-0.1365 (-20.688)	-0.1365 (-23.549)	-0.1365 (-1.342)	0	.231	.230	1018.2	1136.1	1136.1
-1.4	0 (-0.130)	0 (-0.146)	0 (-0.145)	-0.1599 (-21.666)	-0.1599 (-24.279)	-0.1599 (-1.490)	0	.204	.204	956.8	1061.1	1061.1
-1.6	0 (-0.091)	0 (-0.100)	0 (-0.100)	-0.1862 (-22.152)	-0.1862 (-24.413)	-0.1862 (-1.632)	0	.177	.177	879.7	968.7	968.7

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