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Development of Climate Indices for Application in Empirical Crop Production Studies

A major source of crop yield variability in agricultural production is varying climatic conditions. Interrelated climatic variables such as rainfall, temperature, solar radiation, humidity, and wind affect plant growth. Inclusion of these variables into analysis of agricultural production systems is not straight forward, because the variables are highly interrelated and affect crop growth differently at different stages of plant development. Numerous procedures have been developed to account for climatic/weather variability in agricultural research, but no single method is widely accepted. The procedures commonly used are: 1) ignoring climate conditions (e.g. Antle; Blackmer), 2) incorporating a measure of yield variability (e.g. Smith et al.; El-Nazer and McCarl), 3) incorporating one or more climate variables usually rainfall and temperature (e.g. Runge; Olson and Olson; Dixon et al.), 4) or incorporation of a climate/weather index (e.g. Solomon; LaFrance and Burt; Shumway and Powell). The procedure chosen is a function of both the problem and available data.

Shaw and Durost developed a methodology to construct a climate index which consists of detrending a crop yield series. The index is computed by dividing the actual yield by the predicted yield trend. Stallings (1960) used a similar methodological approach in developing weather indices. Doll developed a statistical model to estimate a rainfall index for corn, but indicated that the model could be generalized to include other climatic variables. Doll's rainfall index is the ratio of the yield predicted for the actual weather occurring during a year to the yield predicted had average weather occurred during the year. Doll states the advantages of his index over that of Shaw and Durost or Stallings are: 1) the index is freed of the vagaries of trend estimation, 2) the methodology allows for interactions between time periods within a year, 3) the index can be estimated with readily available meteorological data, and 4) because meteorological variables are included in the model, weather phenomena such as runs and extremes are "explained" by the meteorological model.

Indices have also been used to explain the affect of intraseasonal climatic conditions on yield (Dale and Shaw; Morris; Hollinger and Hoeft). Morris modifies the index used by Dale and Shaw to develop a simulation model to calculate both an excess moisture index and a moisture stress index. These indices were included in a series of regression equations for corn yields in Iowa. Morris concludes that:

> "these equations showed that the indexes of moisture stress and excess moisture, separately and in combination significantly explained corn yield variations resulting from weather differences" (p.182).

Hollinger and Hoeft describe the effectiveness of rainfall as expressed by the ratio of precipitation to evaporation, and conclude that this factor's interaction with nitrogen is important in determining the efficiency of nitrogen use by corn.

Stallings (1961) states "... that the characteristics of an ideal measure of the influence of weather depend largely upon the proposed use of the measure" (p. 1156). Given the diverse applications possible for climate indices and that the index must be both crop and geographical area specific, no single index will satisfy all empirical researchers. The short preceeding review of various methodological approaches for incorporation of climatic variables in production studies exemplifies the need for different indices. In recent years agronomic-meteorological research has concentrated more on the affect of weather on crop development, (e.g. Saini and Nanda;

and Baker et al.) than on the development of climatic indices. The methodology developed in this paper capitalizes on this research in calculating climate indices.

This study develops a climate index which is targeted for use in microproduction analysis dependent upon the estimation of a production function. To accurately estimate the influence of management practices on crop yields, the affect of climatic conditions and climate-management inputs interactions must be taken into account. Consider, for example, a crop in which the yield is dependent on only two climatic factors (e.g. rainfall and temperature) at one period during the growing season, and management practices are not a factor in the analysis. A simple factorial design has yield as a function of five independent variables (rainfall, rainfall squared, temperature, temperature squared, and a rainfall-temperature interaction). If yield were dependent on three climatic variables the number of independent variables doubles relative to the two climate variable case. With five climatic variables the number of independent variables is thirty-four. However, in all cases only one or two independent variables are necessary (linear or linear and squared terms) with a climate index because an index should account for interactions between the different climatic variables.

Additional problems with degrees of freedom and multicollinearity may surface with the inclusion of climatic variables. Collinearity problems exist because climatic variables are not independent, e.g. high rainfall may be correlated with lower temperatures because of cloud cover. With most crops climatic conditions occuring in more than one period are important in determining final crop yield, this creates additional problems trying to estimate yield as a function of climatic conditions. Adding climatic variable interactions with management practices only increases collinearity and specifications problems.

Many statistical studies only include aggregate rainfall and temperature for a given time period, leading to the classic aggregation problem (Shaw). For example, if July rainfall is 5 inches, years with rainfall distributed evenly at 1 1/2" per week differ from years in which 5" of rain falls the first two days of the month. These problems, specification, multicollinearity and aggregation, are the primary reasons for the development of a climate index for use in production studies. Although climate indices do not totally overcome these problems, they help alleviate them.

The present study develops a climate index proxy for use in empirical production decision studies. This proxy is based on the accumulation of dry matter determined by a crop-growth simulation model. The crop-growth simulation model integrates many of the necessary climatic variables and is applicable to a wide range of geographical areas and crops. The climate index developed is used in estimating a production function, which has been used successfully in microproduction decision analysis (Mjelde). Besides providing a climate index, this study hopes to stimulate research interest on increased realistic incorporation of climatic variables in production decision analysis.

CLIMATE INDEX DEVELOPMENT

The proposed climate index is determined by the relative change in dry matter accumulation as calculated by a crop-growth simulation model. This approach is similar to classifying climatic regions by their vegetation, in that the plant, or in this case, the simulation model serves as a meteorological instrument which integrates the various climatic variables.

Obviously, the index is only as good as the crop-growth model used. In this study, it is assumed that a reliable crop-growth simulation model requiring daily weather data is available. (For a discussion of verification and validation issues in use of simulation models see Oren, Mihram, or Anderson). Shaw and Durost in developing a yearly climate index state five characteristics of an "ideal" indicator of the influence of climate;

1) an indicator should measure the influence of meteorological and other factors closely associated with meteorological factors on crop yield,
2) an indicator should allow adjustments of actual yields for annual deviations in weather,
3) the indicator is relevant to the level of technology that exists at each point in time, i.e. crop varieties in use in the 1980's may be affected by weather differently than varieties in use in the 1940's,
4) the indicator should be specific to a given crop, i.e. weather affects different crops differently, and
5) the indicator should be specific to a given geographical location.

The proposed climate index possesses these five ideal characteristics. In addition, meteorological variables are included in the development of the index, a characteristic Doll determines as important. Inclusion of daily meteorological variables helps eliminate the aggregation problem discussed earlier. Because climatic variables affect crop growth differently at alternative stages of crop growth, the climate index should be divisible into varying time lengths.

Two disadvantages of the proposed index are: (1) the index requires meteorological data not readily available in all locations, and (2) no index can be calculated during periods of the year when crops are not grown. Even with these drawbacks, the proposed methodology should be of interest to empirical researchers. The methodology provides a climatic index which can be incorporated into a variety of production studies to account for the affect of weather/climatic conditions on yield.

Experimental Design

A physiologically - based model of corn plant growth is adapted to generate the data necessary to develop the index (Reetz; Hollinger, 1985). Daily weather data required by the model are solar radiation, maximum and minimum temperature, precipitation, and evaporation. Management practices that can be evaluated include planting date, plant density, and corn hybrid. To develop the climate index forty-five different management combinations per year are evaluated by the corn-growth simulation model. The 45 combinations consist of all possible permutations of five planting dates (April 20, May 5, May 15, May 25 and June 10), three plant densities (20,000, 24,000 and 32,000 plants per acre), and three hybrids (short, medium, and full requiring 1276, 1454, and 1494 growing degree days respectively). Weather data for Urbana, Illinois for the years 1970-83 are used to drive the crop model. Drummer soil, a representative soil type in east-central Illinois is the soil type for the example shown in this paper.

In developing the synthetic yield-management practices data set for estimation of the production function, Reetz's corn growth model was augmented with a nitrogen function developed by Hollinger and Hoeft. In addition to the 45 management practice combinations described earlier, eight applied nitrogen levels are considered (0, 44.5, 89, 133.5, 150, 178, 222.5, 267 lbs per acre). It should be stressed that two data sets are developed; one with 45 management practice combinations per year for use in developing the climate index, and the other with 360 combinations (45 times eight different applied nitrogen levels) per year for estimation of the production function. Hollinger (1987) provides a description of the corn-growth simulation model utilized in this study and its ability to represent actual corn production.

Index Calculation

A climate index for corn production is calculated for the 1970-83 growing seasons for east-central Illinois. Within the growing season five indices, early spring (April 1-May 15), late spring (May 16-June 10), early summer (June 10-July 10), mid-summer (July 15-July 31), and late summer (Aug 1-Sept 30), are calculated. The five index periods roughly correspond to the critical growth periods for corn production in the midwest (Sonka et al. (1986); Hollinger (1985)). In order to calculate the index, total dry matter accumulated at the end of each time period is obtained from the model. A growth rate, GR_t, for each period and management practice set is then calculated as

$$GR_t = \frac{G_{j,t} - G_{j,t-1}}{(G_{j,t} + G_{j,t-1})/2} \qquad (1)$$

where $G_{j,t}$ is total dry matter at the end of time t, for the j^{th} management combination simulated by the model for each year. The individual growth rates are highly correlated with the management variables (i.e. plant density, hybrid, and date of planting). To remove the effects of plant density, hybrid, and date of planting, the mean of the combined management practices is used to represent the climate index. This index is given by

$$CI_t = \sum_{j=1}^{N} \frac{1}{N} \frac{G_{j,t} - G_{j,t-1}}{(G_{j,t} + G_{j,t-1})/2} \qquad (2)$$

where N is the number of simulation model runs.

A growth rate is calculated for each of the five growing season periods, early spring through late summer, for each of the 45 simulation model runs within a given year . The resulting climate indices (average growth rate) are not highly correlated with any management variable over the 14 growing seasons. Two important aspects of the climate index are: (1) the index is not total dry matter accumulated, but a relative change in dry matter that occurs in each of the time periods, and (2) the index includes dry matter accumulation in both the corn stalk (vegetative) and the corn ear (grain).

In calculating the early spring climate index only the 27 management practice simulation runs associated with the planting dates April 20, May 5, and May 15 are used. This is because the two planting dates, May 25, and June 10, occur after the early spring stage ends. The remaining stages utilize all 45 simulation model runs in calculating the climate index (except the restricted late summer index discussed below).

Two variations of the late summer climate index are calculated. The unrestricted climate index uses all 45 corn growth simulation model runs to calculate the index for a particular period within each year. The second variation involves the placement of restrictions on the calculations of the index for the late summer periods. This variation is referred to as the late summer restricted index.

To be included in the late summer restricted climate index calculation, the date of maturity for the simulation run had to occur after September 1. Because of the length of the late summer stage (August 1 to September 30), it is felt that a growth rate which occurs over most of the time period may be a better indication of the climatic conditions that occur in late summer than a growth rate which covers less than one-half of the time period. The restriction on the late summer index affects both the correlation coefficients associated with the various climatic factors and the estimated production function coefficients. Results obtained from using both the restricted and unrestricted late summer climate index are presented. The restrictions placed on the late summer index does not affect the climate indices for the other growth stages.

The climate indices by time period (Table 1) show that the relative rank (largest to smallest value) in any given year varies by time period. That is, 1977 has the largest early spring index but its late spring index is third from the largest, whereas, 1978 has the largest late spring index but the early spring index is second from the smallest. Varying rankings on such short time periods is an expected result for a climate index, because the climatic conditions occurring within any given year vary. No single year has the optimal climatic conditions for corn growth throughout the entire year. A difference between the late summer restricted and unrestricted indices is shown in Table 1. Not only do the index values for a particular year vary, but the relative rank also varies.

Simple correlation coefficients between the climate index and various climatic variables are presented in Table 2. In most cases the relative magnitudes and signs of the correlation coefficients are as expected. The negative correlation between the climate index and precipitation during the spring periods occurs because there is usually more than adequate soil moisture and rainfall in the spring in east-central Illinois. Additional rainfall contributes little to the available soil moisture for the corn plant and is usually associated with cooler overcast days that result in slower growth rates. Therefore, years with higher than normal rainfall are associated with slower growth rates than years with below normal rainfall.

The restricted and unrestricted late summer climate indices have different correlation coefficients associated with the various climatic variables. The difference is greatest for the coefficients associated with total precipitation and mean solar radiation. Prior expectations are that the correlation coefficient between a climate index and precipitation for late summer would be positive. The restricted late summer index is more in line with these expectations. Aggregation problems previously discussed may affect the correlations as the climatic variables are aggregated over the time period. Further differences in these two indices are examined in the next section with respect to their impact on statistical estimation of a crop production function.

EXAMPLE OF USE

The proposed index is used to estimate a production function in which corn yield is estimated as a function of management practices and the climate indices. Using the previously described data set, various specifications of the following general production function are estimated;

$$\begin{aligned} \ln Y = \ln A + \sum_{i=1}^{5} [\alpha_{1i}(\ln \mathrm{Den}_i) + \sum_{j=1}^{3} (\delta_{ij}\ \mathrm{Var}_j\mathrm{Dum}_i)] &+ \\ \gamma_1 (\ln N) + \gamma_2 (\ln N)^2 + \gamma_3 (\ln N)(\ln CI_3) &+ \\ \gamma_4 [(\ln N)(\ln CI_3)]^2 + \sum_{k=1}^{5} \beta_k \ln CI_k & \qquad (3) \end{aligned}$$

where ln is natural logrithms, A is an intercept, i is the subscript for planting date, Den_i is planting density at planting date i, j is the subscript for hybrid planted, $\mathrm{Var}_j\mathrm{Dum}_i$ is a binary variable for hybrid planted at each planting date, N is applied nitrogen, CI is the climate index, k is the subscript for the five growing season periods, and α, δ, γ, and β are parameters to be estimated. The assumptions made in estimating the production function are: 1) nitrogen is applied in the spring, and 2) based on work by Hollinger and Hoeft only the climatic conditions occurring during the early summer period (denoted as CI_3) have a significant interaction with nitrogen. Therefore, the production function is estimated with only a nitrogen-climate interaction for the early summer period.

Given the specification in equation (3) there are five independent variables associated with plant density, one for each planting date. Planting could only occur at one of the five dates. The plant density associated with this date is set at the specified plant density level, whereas, the plant density variables associated with the other four planting dates are set equal to one. By setting the variable equal to one instead of zero the logarithm can be taken. Likewise, applied nitrogen is set equal to one if the applied nitrogen level is zero. The formulation of fifteen hybrid planting date dummies and five different density coefficients allows for greater interactions between planting date and hybrid or planting date and density. When estimating the production function variable Var_3Dum_5 is omitted to avoid a singular regressor matrix.

With the preceeding considerations various specifications of the production function are estimated. Table 3 presents the coefficients associated with plant density and hybrid management variables. These coefficients do not vary among the model specifications; therefore, these coefficients are presented only once although all model specifications include these variables. The t-ratios, in Table 3, are for model two in Table 4, and vary slightly between model specifications.

The coefficients for plant density and hybrid selection cannot be analyzed separately because associated with every planting date is a plant density coefficient and three hybrid coefficients. To examine the effect of varying the planting date on yield given a specific hybrid, involves four coefficients, specifically, the two different plant density coefficients and the two hybrid coefficients associated with the two planting dates. For example, to determine the difference in yield between planting a short season hybrid on April 20 versus June 5, the four coefficients needed are: 1)Den_1, the April 20th density coefficient, 2) Var_1Dum_2, the short season hybrid coefficient associated with April 20th planting, 3) Den_5, June 5 density coefficient, and 4) Var_1Dum_5, the short season hybrid coefficient associated with June 5th. Examining the coefficients in this fashion shows that later planting dates have a lower yield than earlier planting dates, holding everything else constant.

Five different model specifications are presented in Tables 4 and 5. The various model specifications differ with respect to the nitrogen and climate variables and the nature of their interaction. Model one contains all the variables in Table 3 plus applied nitrogen variables. The adjusted coefficient of determination, $\bar{R}^2$, for model one is .75, indicating that management practices explain the majority of the variation in yields. Models two through five contain all the management variables along with the climate indices as independent variables. The adjusted R-squared for models two through five range from .83 to .85. This increase in the adjusted R-squared over model one indicates that the inclusion of the climate index as an independent variable increases the explanatory power of the estimated production function.

Prior expectations are that the estimated coefficients associated with the climate indices should be positive. The coefficient associated with the late summer index is negative and insignificant in models three, four, and five when estimated using the restricted late summer index (Table 5). In the remaining model specifications the coefficients associated with the unrestricted late summer index are positive and significantly different from zero (Table 4). In a manner analogous to the coefficients associated with density and hybrid, the coefficients associated with the climate indices and applied nitrogen cannot be evaluated separately.

A major difficulty associated with the climate index is the calculation of the index once the crop becomes mature. Two variations of the late summer index are calculated in this example. One variation is to ignore the maturity date and use the index calculated for all 45 simulations. For the production function estimated here, this index is more robust in terms of its significance and impact on yield than the restricted index. But on the other hand, the restricted index has more intuitive correlations with the various climatic variables.

CONCLUSIONS

Until the early seventies there was considerable interest in developing climate indices that would explain the impact of climate on crop yields. This interest in agricultural meteorology research has been replaced with an emphasis on research directed towards explaining the impact of climate variables directly on plant development. The climate index methodology capitalizes on this current research. Furthermore, the proposed index possesses many of the important climate index characteristics that previous studies have deemed desirable.

The methodology used in developing the climate indices is applicable to a wide variety of crops and geographical areas. Utilizing crop-growth models allows the index to capture moisture stress (inline with previous indices) along with capturing the affect of other climatic variables on crop development. This method provides a more accurate representation of the affect of prevailing climatic conditions on yield. Crop-growth simulation models have been developed for most of the major crops (e.g. corn, wheat, soybeans, cotton). Development of these models allows climate indices to be calculated which are specific to a crop and geographical area. Coupling the specific nature of the index with the ability to create indices for varying time lengths within the growing season, makes the methodology applicable in a wide variety of agricultural problems.

Finally, an example of the proposed climate index is calculated for corn production in east-central Illinois. In most cases the correlation coefficients between the proposed indices and climatic variables corresponds to prior expectations. Including the climate indices in the estimation of a corn production function indicates that the indices help explain yield variability. This index has been successfully interfaced with a corn production decision model to evaluate the value of climate forecast information to production agriculture (Sonka et al.; Mjelde).

Table 1. Calculated Climate Index Values by Stage for the Fourteen Years Used as the Data Base

Year	Early Spring[1]	Late Spring[2]	Early Summer	Mid-Summer	Unrestricted Late Summer	Restricted Late Summer	Obser.[3]
1970	1.6341	1.4340	1.7414	.47314	.61487	.71143	33
1971	1.5124	1.4445	1.8326	.36404	.65484	.67415	42
1972	1.5775	1.5703	1.7548	.56691	.66716	.68838	42
1973	1.4368	1.4145	1.8462	.46992	.61981	.66589	36
1974	1.6275	.9604	1.8393	.50833	.73984	.73984	45
1975	1.6140	1.4578	1.7702	.51715	.59186	.71985	27
1976	1.4160	1.3638	1.8505	.55711	.68841	.68841	45
1977	1.7601	1.5656	1.6595	.45561	.53750	.68035	27
1978	1.3915	1.5797	1.8280	.44063	.68379	.70231	42
1979	1.5359	1.4878	1.8007	.52685	.69861	.72195	42
1980	1.5502	1.5341	1.7991	.43472	.59393	.69982	27
1981	1.4055	1.5243	1.8405	.39594	.68528	.70503	42
1982	1.6391	1.3484	1.7626	.56884	.65271	.67732	42
1983	1.2309	1.1347	1.9011	.48342	.56342	.65307	24
Mean	1.5237	1.4157	1.8019	.48304	.64229	.69484	
SD[4]	.1360	.1756	.0604	.0623	.0573	.0239	

[1] Number of corn growth simulation runs used to calculate the early spring climate index was 27/year.

[2] Number of simulation runs used to calculate late spring through midsummer and unrestricted late summer climate index was 45/year.

[3] Obser. is the number of simulation runs used to calculate the restricted late summer climate index.

[4] Standard deviation.

Table 2. Simple Correlation Coefficients Between the Climate Index and Various Climatic Factors

Climatic Variable	Early Spring	Late Spring	Early Summer	Mid-Summer	Unrestricted Late Summer	Restricted Late Summer
Mean Max. Temp.	.60704	.76154	.26619	.37372	-.53130	-.54651
Mean Min. Temp.	.48944	.28142	.30229	.49352	-.55077	-.48658
Total Precipitation	-.40081	-.51891	.45011	-.02107	-.23260	.15019
Mean Solar Radiation	-.42543	.55849	.39454	.33853	.38614	-.09626
Total Pan Evaporation	.20812	.47018	.07906	-.08017	-.14865	-.44025
Mean Temp.	.60456	.63627	.30066	.44283	-.56854	-.54758

Table 3. Regression Coefficients Associated with Planting Density and Hybrid Variable (5040 Observations)

Management Variable	Estimated Coefficient	Management Variable	Estimated Coefficient
Den_1	.33738 (15.14)[1]*	Var_3Dum_2	.54084 (5.31)*
Den_2	.40549 (18.20)*	Var_1Dum_3	.031840 (.31)
Den_3	.45695 (20.51)*	Var_2Dum_3	.19871 (1.95)*
Den_4	.47739 (21.43)*	Var_3Dum_3	.25765 (2.53)*
Den_5	.49466 (22.20)*	Var_1Dum_4	-.13659 (-1.34)
Var_1Dum_1	.68402 (6.72)*	Var_2Dum_4	.040136 (.39)
Var_2Dum_1	.83847 (8.24)*	Var_3Dum_4	.10052 (.99)
Var_3Dum_1	.88580 (8.70)*	Var_1Dum_5	-.26325 (-24.93)*
Var_1Dum_2	.32179 (3.16)*	Var_2Dum_5	-.060763 (-5.75)*
Var_2Dum_2	.48529 (4.77)*	Var_3Dum_5	--

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[1] Asymptotic t-ratios in parentheses for model 2 in Table 4.

* Indicates significantly different from zero, α=.10.

Table 4. Estimated Coefficients Associated with Nitrogen and Climate Index, with Late Summer Climate Index Unrestricted (5040 Observations)

	Model Specification				
Variable	One	Two	Three	Four	Five
Intercept	2.4050 (26.15)*	1.4482 (7.19)*	1.7312 (8.89)*	1.7331 (8.90)*	.55479 (3.08)*
CI_1		1.0029 (15.76)*	.93862 (14.99)*	.93862 (14.99)*	.93862 (14.72)*
CI_2		.83707 (37.14)*	.81197 (36.76)*	.81197 (36.76)*	.81197 (36.11)*
CI_3		1.3780 (5.13)*	.93995 (3.67)*	.93995 (3.67)*	2.9598 (13.94)*
CI_4		.49662 (28.26)*	.48700 (27.79)*	.48700 (27.78)*	.48700 (27.29)*
CI_5		.43194 (13.57)*	.42531 (13.34)*	.42531 (13.34)*	.42531 (13.10)*
N	.13491 (93.66)*	.29494 (3.49)*	-.13629 (-6.51)*	-.14174 (-6.95)*	.13491 (116.96)*
N^2		-.042063 (-5.36)*	-.0010115 (-1.16)		
$NxCI_3$		-.26276 (-1.83)*	.47024 (15.58)*	.47024 (13.58)*	
$(NxCI_3)^2$		.11825 (5.27)*			
$\bar{R}^2$	.7500	.8462	.8453	.8453	.8397

[1] Asymptotic t-ratio in parentheses.

* Indicates significantly different from zero, α=.10.

Table 5. Estimated Coefficients Associated with Nitrogen and Climate Index with Late Summer Climate Index Restricted (5040 Observations).

	Model Specifications			
Variable	Two	Three	Four	Five
intercept	-.059689 (-.32)[1]	.18957 (1.05)	.19138 (1.06)	-.99691 (6.21)*
CI_1	1.5238 (24.94)*	1.4692 (24.45)*	1.4692 (24.45)*	1.4692 (24.03)*
CI_2	.95592 (44.84)*	.93265 (44.92)*	.93265 (44.91)*	.93265 (44.14)*
CI_3	3.2862 (13.56)*	2.8883 (12.71)*	2.8883 (12.71)*	4.9081 (28.47)*
CI_4	.57941 (34.38)*	.57014 (34.00)*	.57014 (34.00)*	.57014 (33.41)*
CI_5	.011569 (.16)	-.012113 (-.16)	-.012113 (-.16)	-.012113 (-.16)
N	.25191 (2.92)*	-.13629 (-6.40)*	-.14174 (-.69)	.13491 (115.01)*
N^2	-.037966 (-4.75)*	-.0010115 (-1.14)		
$NxCI_3$	-.18961 (-1.30)	.47024 (13.34)*	.47024 (13.34)*	
$(NxCI_3)^2$	.10644 (4.65)*			
$\bar{R}^2$	.8405	.8398	.8398	.8342

[1] Asymptotic t-ratio in parentheses.

* Indicates significantly different from zero, α=.10.

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