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Tree nursery production conditions in Henan Province, People's Republic of China

Gao Feng

The University of Montana

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Gao Feng

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This study examined production efficiency in state-owned tree nurseries of the Henan province in China. By empirically examining the role of tree nursery size, labor use, and specialization in nursery production, public-sector policy makers can decide to improve management efficiency. A Cobb-Douglas function was employed in this study as the primary approach to describing the relationship between factor inputs and product output. The most important finding of the study is the market reform policy produced a 145% increase in seedling output.

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Introduction

In 1978, the government of the People's Republic of China (China) introduced new economic policies that emphasized market reform and the use of market institutions. The government simplified economic administration, shifted power to local authorities and granted managers of industrial enterprises broader decision-making authority to encourage rapid economic growth. In 1983 and 1984 a new, and even greater wave of reforms were instituted. Under these reforms, managers can retain large shares of profits earned by the enterprises. These later reforms also included a campaign to eliminate losses at state-operated enterprises (Field, 1992). However, thousands of money-loosing state enterprises remain. These state firms continue to provide over half China's GDP. Nevertheless, the inefficiency of the older state enterprises accounts for more than a 25% annual inflation rate in China (China Survey, 1995).

Improving management efficiency is a highly desirable activity in a country such as China. Basic to managerial efficiency is the idea of production efficiency. Therefore, production theory, a cornerstone of microeconomic theory, with the purpose of explaining and prescribing efficient production decisions, is a necessary step to understanding and improving management efficiency. This study examined production efficiency in state-owned tree nurseries. By empirically examining the role of tree nursery size, labor use, and specialization in nursery production, public-sector policy makers can make more informed decisions to improve management efficiency.

Two alternative production function models, the Cobb-Douglas and the transcendental logarithmic (translog function), were used to estimate production functions for fifty-two state tree nurseries in Henan province. The translog production function suffered from high multicollinearity and yielded only a few statistically significant regression coefficients. Therefore, we employed only a Cobb-Douglas function in this study as the primary approach to describing the relationship between factor inputs and product output. The related results of the translog model are found in the Appendix. The Results suggest the problems that arose in attempting to use this alternative approach to modeling production relationships.

The plan of the paper is as follows. After the introduction. the first section contains an overview of production theory and empirical approaches for estimating the Cobb-Douglas production functions. We give the variables in section two. Econometric results, general production characteristics, and the result of relaxing some assumptions of the model are analyzed in sections three, four and five. Finally, section six contains a brief summary and concluding remarks.

The most important findings of the study are: (a) Small nurseries are more productive than large ones; (b) New nurseries, formed after the economic reforms, are more productive than old ones; (c) Non specialized nurseries are more productive than specialized ones; (d) Part time labor is less productive than full-time labor; (e) The market reform policy produced a 145% increase in seedling output.

Production Function Specification

Characteristics of the data determined many fundamental modeling decisions in this study. The primary data set consists of cross-sectional micro data from the Henan Province Forest Bureau (January 1994). In the data set, the core variables are nursery level observations of seedlings produced, land size, number of laborers, and the number of wells and trucks employed. (See table A5 and table A6 in the Appendix). The core-variable data measures factor inputs and product output.

Production involves a process of creating some homogeneous output or product by combining and coordinating homogeneous inputs. A production function is a mathematical relationship that specifies a purely physical relationship between inputs and output (Beattie & Taylor 1993). It is not an economic optimization problem requiring maximization assumption regarding producer behavior or the separation of inputs into fixed and variable inputs.

The nature of the data motivates two modeling decisions. First, individual nursery-level observations regarding crop input and seedling output quantities, rather than financial data, mandate a primal rather than a dual approach (Moore 1992).

Second, without loss of generality, output and inputs are estimated by per-unit of total land (mu, where 1 hectare = 15 mu). Because most of the tree nurseries are part of large forest firms, they have multi-product outputs such as orchard and forest products. In multi-product nurseries, labor, wells, and trucks are employed both in tree nurseries and in other product production activities. In this study, total firm land size divides all variables to obtain better estimates of the relationship between inputs and outputs and more significance regression coefficients. The per-unit of land production function contains identical information in principle to a function where land is an independent variable. By using the per-unit data, we reduce the chance of introducing heteroskedastic error terms (Moore 1992).

The Cobb-Douglas production function has generally been used in agricultural production function studies from cross-sectional data. In his paper, for example, Zvi Griliches of the University of Chicago chose the function to specify and estimate of agricultural production functions (Griliches 1963). Paul N. Wilson also estimated a Cobb-Douglas production to decide economies of scale on commercial cash-grain hog farms (Wilson 1984). Yujiro Hayami of Tokyo Metropolitan University, explored the causes of enormous increases in agricultural productivity. He found differences existing among the developed and less developed countries with the Cobb-Douglas production function (Hayami 1969).

However, the Cobb-Douglas function assumes additivity and homotheticity. The assumptions associated with the function yield highly restrictive results, because they imply that the factor shares are constant and that the elasticity of substitution is limited to unity (Chung 1994).

The per-unit production function for the Cobb-Douglas (Chung, 1994) specification is:

$$Y=A_0X_1^{A1}X_2^{A2}X_3^{A3}X_4^{A4}X_5^{A4} \qquad (1)$$

Where

Y (seedlings) = output (number of seedlings) per unit of total land (seedlings/mu);

X_1 (land) = Seedling land per unit of total land (seedling land/mu);

X_2 (F labor) = full time labors per unit of total land (full time labors/mu);

X_3 (P labor) = part time labors per unit of total land (Part time labors/mu)

X_4 (Well) = wells per unit of total land (wells/mu)

X_5 (truck) = trucks per unit of total land (trucks/mu)

A0, A1, A2, A3, A4, A5, A6 are parameters to be estimated.

The number 0.0000001 was added to each datum of X3, X4, and X5, to avoid any zero value in the variables.

Data and Variables

The primary data set is composed of fifty-two observations from a Henan Province Forest Bureau. Each observation is a state tree nursery. The survey instrument emphasized seedling quantity and contained no information on other purchased inputs and human capital. For each tree nursery, the survey reports output (number of seedlings), inputs such as number of full time, part time, and retired labor, wells, trucks and other property.

The dependent variable for each tree nursery is number of seedlings per unit of total land (mu). In contrast, the independent variables are seedling land per unit of total land (mu), full time labor per unit of total land (mu), part time labor per unit of total land (mu), wells per unit of total land (mu), and trucks per unit of total land (mu).

Four dummy variables are also used in the production functions. They describe firm characteristics and include: nursery specialization; nursery products; nursery size; and nursery ages.

Where:

D_1 (Specialized) = Dummy variable that is 1 if a firm only had nursery land, and 0 if a firm had other product land such as orchard and forest.

D_2 (Mixed Cropping) = Dummy variable that is 1 if a nursery only had young trees for landscaping. The young trees need more inputs, such as labor. Dummy variable is 0 if a nursery had both young trees and seedlings.

D_3 (New Nursery) = Dummy variable that is 1 if a nursery was less than or equal to 10 years old by 1994 and 0 if a nursery was more than 10 years old by 1994.

D_4 (Small Nursery) = Dummy variable that is 1 if the size of a nursery was less or equal 70 mu (about 4.67 hectare) and 0 if the size of a nursery was more than 70 mu.

An intercept shift term Age^2 (Age) is also employed in the functions.

AGE^2 = nurseries' age squared.

Econometric Results

Table 1 Cobb-Douglas Model Results

$R^2 = 0.7793$ Adj. $R^2 = 0.7241$ F Statistic=14.123 Critical F (9/40, 0.05)=2.12

T Critical (40/0.05) =2.021

Variable Name	Regression Coefficient	Standard Error	T-Ratio 40 DF
Constant	0.013695	0.4623	0.0296
Log Land	0.76926	0.1246	6.174
Log F-Labor	0.30124	0.1412	2.133
Log P-labor	-0.006305	0.01221	-0.5165
Log Wells	-0.032297	0.02644	-1.221
Log Trucks	0.15887	0.01234	1.287
Specialize (D_1)	-0.66879	0.3145	-2.120
Mix Crops (D_2)	-1.6857	0.4124	-4.088
Policy (D_3)	0.89652	0.3864	2.320
Small Nur. (D_4)	1.0041	0.3185	3.152
Age^2	-0.000446	0.000175	-2.550

The Cobb-Douglas production function was estimated by using ordinary least squares expressed in loglog form with Shazam econometrics, a computer program (White 1993). The form is used when the dependent variable and all the independent variables are in log form. In this estimation, we estimate the output elasticity's as independent variable parameters (Marsh, 1983). We summarize the model in Table 1.

The four dummy variables and the intercept term AGE^2 are estimated using ordinary least squares expressed in loglin form with Shazam. The loglin form is used when the dependant variable is in LOG form, but the independent variables are linear.

Assessing the Cobb-Douglas specification, the parameters are significant (at the 5 percent error level) except part time labors, wells and trucks. Negative signs are for the coefficients of part time labors and wells. For part time labor, wells and trucks, their small observation sizes likely cause the insignificant parameters. Some nurseries of the fifty-one observations do not have part time labor, wells or trucks (see Appendix II data). Therefore, the parameters are not significant.

To Learn wether the production function is well behaved, we look at the determinants of bordered Hessian matrixes:

the first variable, land	< 0
the second variable, full time labor	> 0
the third variable, part time labor	> 0
the fourth variable, well	> 0
the fifth variable, truck	< 0

Note that the third variable is positive and that therefore the production function is not strictly quasi-concave. The isoquant is bent with respect to part time labor, so the function is neither monotonic nor convex. Given these qualities, the Cobb-Douglas production function is not well behaved in this study.

The adjusted R square is 0.7241 in Table 1. Evaluating and selecting functional specification based on R squares' is inappropriate (Gujarati 1988). We report other tests such as T and F tests in a subsequent section of the thesis.

Land

Land is a significant determinant of seedling output, with the estimated coefficient significant at the 5 percent error level. The estimated land coefficient is 0.76926 which means that, holding all other variables constant, a 10 percent increase in seedling land implies a 7.69 percent increase in seedling output.

Labor

We included three types of labor in the data set; full time, part time, and retired. We include only full and part time labor in the model since the retired labor is no longer an active productive input. As Table 1 shows, the coefficient for the full time labor term is 0.30124 which is significant and positive. However, the coefficient for the part time labor is -0.00630 which is not significant and negative. Holding all other variables constant, a 10 percent increase in full time labor implies a 3 percent increase in seedling output. In contrast, holding all other variables constant a 10 percent increase in part time labor implies a 0.06 percent decrease in seedling output. For full time labor, the second partial derivative is negative (Table 3) which implies diminishing returns for the full time labor inputs. A well-known property of the Cobb-Douglas production function tells us that full time labor inputs are in stage II production and technically efficient.

Table 2 FIRST AND SECOND ORDER PARTIAL DERIVATIVES OF COBB-DOUGLAS MODEL

Marginal Products / Change in Marginal Products

Land	F_1	0.56742	F_{11}	-3.6337
F Labor	F_2	0.88457	F_{22}	-27.525
P Labor	F_3	-0.12308E+07	F_{33}	0.15298E+16
Wells	F_4	-0.70737E+06	F_{44}	0.78366E+16
Trucks	F_5	0.28447E+07	F_{55}	-0.10476E+17

Specialized Nursery Dummy Variable (D_1)

People expect that specialized nurseries increase yields. The results from this study show otherwise. A value of one for the dummy variable (D_1) suggests nurseries that specialize in tree seedling production produce fewer seedlings per mu than nonspecialized nurseries. The coefficient for the single product is negative and significant. This means that single product nurseries produced fewer seedlings per unit of land than multi-product nurseries.

In China, the market economy began in 1978 and this coincided in nurseries with the seedling industry. They organized most state nursery seedlings to produce seedlings for self consumption. They sold only surplus seedlings on the open market. Likewise, only a limited market for seedlings because most firms that needed seedlings were state owned. Quite possibly, the limited size of the market results in the lower level of efficiency for specialized single product nurseries.

Mixed Cropping Dummy Variable (D_2)

To provide a picture of the role of mixed cropping (seedlings and young trees for landscaping), we introduced a second dummy variable (mixed cropping). The coefficient for mixed cropping is negative and significant. As one would expect, a significant decline exists in seedling output for mixed cropping nurseries. Since mixed cropping nurseries produce seedlings and young trees, more young trees mean fewer total number of seedlings produced. Therefore, the relative efficiency of either form of the nursery is unclear. Mixed cropping (seedlings and young trees) can affect seedling output. However, we are not examining profit and do not know the relative prices of seedlings and young trees. We cannot conclude those mixed cropping nurseries are necessary more or less profitable then single crop nurseries.

The Policy Change Dummy Variable (D_3)

The third dummy (policy change) shows the nurseries that they established after the market economy initiatives are more productive than the others. The coefficient for the policy change variable is 0.89652 and significant (t=2.32). Actually, the policy produced a 145% increase in seedling output [(e**0.89652-1)*100=145%]. Several factors are apparently included in the policy shift which we will discuss more fully in the subsequent conclusions.

The Small Nursery Dummy Variable (D_4)

The fourth dummy variable (Small Nursery) shows which nurseries are less than 70 mu (1050 hectares) in land size. The coefficient for this variable is positive and significant. Nurseries larger than 70 mu can be expected to produce 173% less output per unit [(E**1.0041-1)*100=173%] than nurseries less than 70 mu in size. This suggests that nursery size can affect output significantly. Two reasons for the greater productivity of small versus large nurseries. First, the open market is quite new, small and regional and small nurseries can more easily find a market niche than can large ones. Second, the tree nursery industry is labor intensive in China. Some nurseries still use farm animals rather than mechanical equipment. (A5). Small nurseries make more intensive use of labor.

Nursery Age (A^2)

Newer nurseries produce higher output and are more productive. The negative and significant coefficient for the A^2 variable suggests that older nurseries are less productive than newer ones. This may be the result of the general depreciation of the overall capital stock of the nursery, or that newer nurseries are simply more innovative than older ones. This result essentially corresponds with the policy shift variable. Together, they suggest that nurseries experience a comparative difference in productivity depending on their age.

The A^2 variable suggests a decline in productivity associated with nursery age. Older nurseries have been organized around the philosophy of a planned economy with centralized decision-making and broader social responsibilities (caring for retired workers). Moreover, the traditional individual state owned nurseries are a small community and it was difficult if not impossible for the nursery to separate productive activities from social services (China Survey, 1995).

Since the previously mentioned policy reforms, the new nursery managers are concerned more completely with production issues. They more closely focus decisions on market demand and cost considerations. Greater responsibility for self-reliance is placed on the nursery employee. They have not introduced these kinds of changes to the community nurseries which were in existence before the introduction of market reforms.

General Production Characteristics

The econometric results also provide valuable information concerning the broad general characteristics of the production function such as overall returns to scale, output elasticities of land and labor, and factors (land and labor) substitutability.

Returns to Scale

Return to scale has very important implications regarding overall nursery policy. The estimates help policy makers and managers answer the question of how a proportionate change in all factors will influence overall production. The overall economy of scale (scale elasticity) is the sum of the output elasticities of the five inputs (Walters, 1963). Here it is equal to 1.047785 (See Table 1) and was calculated using sample means for the inputs. Using the Cobb-Douglas function loglog form calculated these elasticities. The results suggest that the positive output elasticity of the land variable be largest, followed by full time labor, and then by trucks (see Table 1). Output elasticity of part time labor is the smallest, and wells exceed part time labor.

Since constant returns to scale (a theoretical quality of Cobb-Douglas functions) is shown when the sum of the output elasticities is one, we conducted a test to learn whether the calculated scale elasticity was significantly different from one (See table 3 below). Refuting constant returns to scale was not possible. The calculated scale elasticity was not significantly different from one and one must conclude constant returns to scale in the nursery industry.

Table 3. SUM OF THE OUTPUT ELASTICITY'S TEST.

TEST $A_1 + A_2 + A_3 + A_4 + A_5 = 1$	
TEST VALUE = 0.47785E-01	STD. ERROR OF TEST VALUE = 0.14940.
T STATISTIC = 0.31984706 T CRITICAL = 2.021	W/H 40 D.F. P-VALUE=0.75075 AT 5% ERROR TERM
F STATISTIC = 0.10230214 F CRITICAL = 4.08	W/H 1 AND 40 D.F. P-VALUE=0.75075 AT 5% ERROR TERM

Constant return to scale implies constant average costs because a proportionate change in inputs produces a proportionate change in outputs. Holding factor prices constant, changing output levels will not affect average variable costs. The Henan nursery industry is operating in stage II of production and production is technically efficient.

At first, constant returns to scale seems to contradict the previous discussion of the effect of small nursery size (less than 70 mu) on output. Since the small size dummy variable shifts (increases) production, it will also produce a corresponding shift in the average cost function. In effect two industry average cost functions, one for large nurseries and one for small nurseries. Constant returns to scale resulting constant average costs for both classes of nursery sizes.

Output Elasticity of Land

The output elasticity of land in Table 1 is 0.76926. By comparing the output elasticity of land to that of other inputs, one must conclude that the output elasticity with respect to the land factor is greater than that of any other factor of production. Holding other variable constant, a 10-percent increase in land will produce a 7.7-percent increase in seedling products. This no doubt reflects the relative scarcity of productive land in China and the resulting intensive use of land.

Output Elasticity of Full-Time Labor

The estimate of output elasticity for full-time labor is 0.30124. It gives insight into the production consequences of full time labor employment. For these nurseries, for example, a 10-percent reduction in full time labor use would induce a 3-percent reduction in output. By using the mean level of full time labor (table a 7) and holding other variables constant, a 10-percent reduction in full time, translates into a decline of 854 seedlings (Change-Y=A2 * (Y/X2) * 10% * 10,000) per mu in production. Given the mean yield of 2,346 seedlings per mu, the output reduction is minor.

Technical Substitution of Land and Full Time Labor

While the elasticities suggest that land be more important to production than full time labor. Assessing their substitutability can analyze the relative contribution of the two inputs most effectively. The marginal rate of technical substitution (MRTS) between full time labor and land explains substitutability. The MRTS between full time labor and land measures the number of full time labors needed to substitute for a unit of total land (mu) to maintain a constant level of output. The Cobb-Douglas formulation makes estimates of the marginal rate of technical substitution computationally simple.

The Cobb-Douglas MRTS = (-a1/a2) (fl/ld)

Where:

fl = full time labor per unit of total land;

ld = seedling land per unit of total land;

a2 = exponent for full time labor;

a1 = exponent for land.

We evaluate time labor and land input levels at the seedlings' mean which is a total product per unit of total land (see the table a 7).

MRTS = (-0.76926/0.30124)*(0.08298/0.35019) = - 0.605 mu-labor

The MRTS level explains a critical point: full time labor and land do substitute. As microeconomics principles suggest, the optimal labor-land input combinations depend on relative prices of labor and land (among other factors).

In China, in comparison to say the United States, the ratio of labor to land costs is lower (Rozelle, 1993). As a result the nursery industry in China should be labor intensive.

Relaxing Ols Assumptions

In this part, we examine how the assumptions of ordinary least squares regression modeling may affect results. We also discuss the validity of the estimates of model parameters based upon a small cross-section sample. Multicollinearity, or lack of independence of regression variables, may affect the significance of estimated parameters. The result is that researchers may not reject the null hypothesis when they should.

Multicollinearity Test

To test if the Cobb-Douglas model has multicollinearity, we apply the Auxrsqr test as found in Shazam (White, 1993). The Auxrsqr test is the R-square statistics for the auxiliary regressions of each independent variable on all other independent variables. If these R-square statistics are larger than the estimated R-square, a model may have multicollinearity.

The test shows that all R-square statistics are smaller than the estimated R-square, therefor the multicollinearity is very low (table 4). Cobb-Douglas model has low multicollinearitiy. We found the same result in simple correlation and condition index forms (see the table a 8 and table a 9).

Table 4. Multicollinearity Test Auxrsqr-test Results.

....	R-SQUARE	=0.7793
R-SQUARE OF L Land	ON OTHER INDEPENDENT VARIABLES	=0.3912
R-SQUARE OF L F Labor	ON OTHER INDEPENDENT VARIABLES	=0.3493
R-SQUARE OF L P Labor	ON OTHER INDEPENDENT VARIABLES	=0.3007
R-SQUARE OF L Wells	ON OTHER INDEPENDENT VARIABLES	=0.1486
R-SQUARE OF L Trucks	ON OTHER INDEPENDENT VARIABLES	=0.2198
R-SQUARE OF Specialized	ON OTHER INDEPENDENT VARIABLES	=0.2756
R-SQUARE OF Tree	ON OTHER INDEPENDENT VARIABLES	=0.2056
R-SQUARE OF New Nursery	ON OTHER INDEPENDENT VARIABLES	=0.3069
R-SQUARE OF Small Nursery	ON OTHER INDEPENDENT VARIABLES	=0.3774
R-SQUARE OF Age2	ON OTHER INDEPENDENT VARIABLES	=0.2522
R-SQUARE OF CONSTANT	ON OTHER INDEPENDENT VARIABLES	=0.0000

Heteroscedasticity Test

If there is heteroscedasticity, the variances of dependent variables are different. We persist in using the usual testing procedures despite heteroscedasticity, whatever conclusions we draw or inferences we make may be very misleading. By using the per-unit data, we avoid the introduction of heteroscedasticity error terms with Cobb-Douglas function (Moore 1992). The study gets the same result by applying a series test for Heteroskedasticity tests with Shazam (White 1993).

The critical Chi-square is 18.307 with 10 degree freedom at 5-percent error level. The test results are 6.545 with B-P-G tests, 13.24 with Harvey test, and 9.787 with

Glejser tests. The results are less than the critical Chi-square value, so there is no heteroscedasticity error (see table 5).

Table 5. HETEROSKEDASTICITY TESTS

CRITICAL CHI-SQUARE = 18.3070 WITH 10 D.F. AT 5 percent error LEVEL

E**2	ON X (B-P-G) TEST	CHI-SQUARE = 6.545 WITH 10 D.F.
LOG(E**2)	ON X (HARVEY)	CHI-SQUARE = 13.24 WITH 10 D.F.
ABS(E)	ON X (GLEJSER)	CHI-SQUARE = 9.787 WITH 10 D.F.

Model Specification Test

Excluding a relevant variable or including an irrelevant variable in the model may produce perverse results caused specification errors. If we exclude a relevant variable, the usual hypothesis testing procedures become invalid. Including an irrelevant variable give us fewer precise parameters. We show specification error tests in table 6.

TABLE 6. RAMSEY RESET SPECIFICATION TESTS USING POWERS OF YHAT (White, 1993) AT 5 percent error LEVEL

RESET(2) = 0.41255	F CRITICAL = 4.08	- F WITH DF1=1 AND DF2=39
RESET(3) = 6.7780	F CRITICAL = 3.23	- F WITH DF1=2 AND DF2=38
RESET(4) = 4.8096	F CRITICAL = 2.84	- F WITH DF1=3 AND DF2=37

The Cobb-Douglas model has specification errors suggested by the test results, because some input variables, such as fertilizer and other equipment, are missing in the model.

Two conclusions can be drawn from these tests. One, with more information on other purchased inputs (such as labor, capital, and fertilizer) or more variation in price data, we could get better results with a translog function that is more flexible. Two, the model specification problem shows that some variables may be missing such as fertilizer and animal labor.

Summary and Conclusions

In his opening speech of National People's Congress Li Peng, the prime minister of China, called for sweeping changes in state-owned industry; the separation of productive activities from social services; mechanisms to allow loss-making companies to go bankrupt in March 1995 (China Survey, 1995). Nevertheless, in agriculture the public and private sales of land are forbidden, and farms cannot be partitioned into units to give economies of scale.

Constant returns to scale are found for the Henan tree nursery industry. Constant returns to scale implies that average unit cost is constant along with constant inputs. On the other hand, the newer and smaller tree nurseries are more productive. Land reform policy should allow the tree nurseries to change their inputs such as land and full time labor to achieve higher output and lower average unit cost. It will result in more labor absorption and higher output at lower cost. These two goals are very desirable for a country like China.

The results of the research contain one immediate policy implication for agriculture in China. Li Peng's sweeping change in state-owned industry is very desirable but so to deregulation of land sales in agriculture. Therefore, the land users can justify the economic scale.

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Appendix I

Transcendental Logarithmic Production Function (Translog function)
If the production function has n inputs, given the n-input production $y = f(x1, \ldots, xn)$, the translog function is defined as:

$$\ln y = \ln a0 + \quad ai \ln xi + 1/2 \quad Bij \ln xi \ln xj$$
$$(i, j = 1, \ldots, n)$$

For this study the translog production function can be expressed as:

ln y=log A0 + A1 * log x1 + A2 * log x2 + A3 * log x3 + A4 * log x4 + A5 * logx5
+ A* log x1 * logx2 + A7 * log x1 * log x3 +A8* log x1 * log x4 + A9 * log x1 * log x5
+A10 * log x2 * log x3 + A11 * log x2 * log x4 + A12 * logx2 * logx5 + A13 * logx3 * log x4 + A14 * log x3 * logx5 + A15 * logx4 * logx5
+ A16 * 1/2 *(log x1) **2 + A17 * 1/2 * (log x2) **2 + A18 * 1/2 *(log x3)**2 + A19 * 1/2 * (log x4)2 +
A20 * (logx5)**2 (2)

Where

"Log" is abbreviation term for logarithmic.

A0, A1, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18, A19, and A20 are parameters to be estimated.

TABLE A1 TRANSCENDENTAL LOGARITHMIC SPECIFICATION

R-SQUARE = 0.9000 R-SQUARE ADJUSTED = 0.8001

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 25 DF
LX1	2.2715	0.8864	2.563
LX2	2.1396	1.448	1.478
LX3	-0.17557E-01	0.1318	-0.1333
LX4	2.6966	0.9631	2.800
LX5	0.26768	0.2928	0.9141
A6	-0.44303	0.2595	-1.708
A7	-0.68336E-01	0.2736E-01	-2.497
A8	0.32299	0.2044	1.580
A9	0.44386E-01	0.2265E-01	.960
A10	0.76678E-01	0.3037E-01	2.525
A11	0.35194	0.2481	1.418
A12	-0.72991E-01	0.3062E-01	-2.384
A13	0.22545E-01	0.1699E-01	1.327
A14	-0.25993E-02	0.2455E-02	-1.059
A15	0.71754E-01	0.2963E-01	2.422
A16	0.76822	0.4256	1.805
A17	0.42412	0.4007	1.059
A18	-0.14934E-01	0.1273E-01	-1.173
A19	-0.20596E-01	0.3076E-01	-0.6695
A20	0.56801E-02	0.2758E-01	0.2060
DM1	-1.4667	0.3322	-4.415
DM2	-1.2749	0.4104	-3.107
DM3	1.3292	0.3957	3.359
DM4	1.3687	0.4131	3.313
T2	-0.56809E-03	0.1886E-03	-3.012
CONSTANT	12.108	3.421	3.539

Table A2. Multicollinearity Test: Auxrsqr-test results (Translog Function)

R-SQUARE = 0.9000

R-SQUARE OF LX1	ON OTHER INDEPENDENT VARIABLES =	0.9913
R-SQUARE OF LX2	ON OTHER INDEPENDENT VARIABLES =	0.9955
R-SQUARE OF LX3	ON OTHER INDEPENDENT VARIABLES =	0.9957
R-SQUARE OF LX4	ON OTHER INDEPENDENT VARIABLES =	0.9995
R-SQUARE OF LX5	ON OTHER INDEPENDENT VARIABLES =	0.9990
R-SQUARE OF A6	ON OTHER INDEPENDENT VARIABLES =	0.9919
R-SQUARE OF A7	ON OTHER INDEPENDENT VARIABLES =	0.9721
R-SQUARE OF A8	ON OTHER INDEPENDENT VARIABLES =	0.9991
R-SQUARE OF A9	ON OTHER INDEPENDENT VARIABLES =	0.9507
R-SQUARE OF A10	ON OTHER INDEPENDENT VARIABLES =	0.9862
R-SQUARE OF A11	ON OTHER INDEPENDENT VARIABLES =	0.9994
R-SQUARE OF A12	ON OTHER INDEPENDENT VARIABLES =	0.9888
R-SQUARE OF A13	ON OTHER INDEPENDENT VARIABLES =	0.9962
R-SQUARE OF A14	ON OTHER INDEPENDENT VARIABLES =	0.9551
R-SQUARE OF A15	ON OTHER INDEPENDENT VARIABLES =	0.9986
R-SQUARE OF A16	ON OTHER INDEPENDENT VARIABLES =	0.9861
R-SQUARE OF A17	ON OTHER INDEPENDENT VARIABLES =	0.9935
R-SQUARE OF A18	ON OTHER INDEPENDENT VARIABLES =	0.9970
R-SQUARE OF A19	ON OTHER INDEPENDENT VARIABLES =	0.9975
R-SQUARE OF A20	ON OTHER INDEPENDENT VARIABLES =	0.9994
R-SQUARE OF DM1	ON OTHER INDEPENDENT VARIABLES =	0.5269
R-SQUARE OF DM2	ON OTHER INDEPENDENT VARIABLES =	0.4186
R-SQUARE OF DM4	ON OTHER INDEPENDENT VARIABLES =	0.5211
R-SQUARE OF DM6	ON OTHER INDEPENDENT VARIABLES =	0.7318
R-SQUARE OF Y2	ON OTHER INDEPENDENT VARIABLES =	0.5347
R-SQUARE OF CONSTANT	ON OTHER INDEPENDENT VARIABLES =	0.0000

Table A3. HETEROSKEDASTICITY TESTS (Translog Funtion)

CRITICAL CHI-SQUARE = 18.3070 AT 5 pecent erro LEVEL

E**2 ON X (B-P-G) TEST:	CHI-SQUARE =	20.683 WITH 25 D.F.
LOG(E**2) ON X (HARVEY) TEST:	CHI-SQUARE =	26.500 WITH 25 D.F.
ABS(E) ON X (GLEJSER) TEST:	CHI-SQUARE =	26.605 WITH 25 D.F

Table A4. RAMSEY RESET SPECIFICATION TESTS USING POWERS OF YHAT (Translag function)

RESET(2) = 0.99407E-02	F WITH DF1 = 1 AND DF2 = 24
RESET(3) = 0.85559E-02	F WITH DF1 = 2 AND DF2 = 23
RESET(4) = 0.19039	F WITH DF1 = 3 AND DF2 = 22

Appendix II

Table A5. Basic Information of Henan Province's State Tree Nursery

Number of Total Acres/mu	Number of Acres/Mu in Nursery Production	Number of Employees Total	Full Time	Part Time	Retired Worker		Management Situation (ss-self-supporting, sp-surplus, ls-loss)	Other property (H-square meter housing, D-meter long ditch, W-well, T-truck, FA-farm animal)
1	120	110	10	4	6		ss	H390, D200, W1, T1.
2	70	18	16	16			ss	H500, D350, W1
3	70	64	18	2	15	1	ss	H405, W2, T1
4	125	75	12	12			ss	H500, D100, W1, T1
5	50	50	10	9	1		ss	H400, W1
6	80	60	8	8			ss	H500, W1
7	72	60	18	18			ss	H400, W1
8	500	250	31	31			ss	H450, W1, T1
9	145	110	33	9	24		ss	H1120, W2
10	247	100	38	36		2	ls	H740, W3, T1
11	102	80	18	14	4		ls	H903
12	100	80	33	30	3		sp	H2000, W3 T1
13	250	250	22	22			ss	H300, W2, T1
14	1575	350	55	54		1	ss	H945, W1, T1
15	248	136	24	22		2	ss	H900, W2, 1T
16	120	100	16	11	4	1	ss	H220, W1
17	360	170	16	12	3	1	ls	H400, W2
18	135	95	22	20	2		ls	H330, W1, T1
19	600	600	24	13	10	1	ss	H1500, W3, T2
20	400	250	42	17	23	2	ss	H1200, W5, T3
21	392	160	30	26	2	2	ss	W3, T2
22	800	650	115	75	25	15	sp	H2100, W8, T2
23	420	120	80	15	60	5	ss	H219, W5, T3
24	410	410	34	6	26	2	ss	H720, W8, T3
25	300	260	46	35	10	1	ss	H1575, D300, W4
26	400	100	73	73			ss	H400, W3
27	327	216	50	20	25	5	ss	H642, W4
28	200	140	13	13			ss	H570, W1, T1
29	245	131	14	14			ss	H870, W2, T1
30	2095	1198	83	62	18	3	ss	H3075, T4
31	550	450	46	26	18	2	ss	H795, W2
32	800	650	50	40	8	2	ss	H1080, W4
33	3190	1030	91	69	20	2	ss	H2145, W2, T5
34	98	88	11	11			ss	
35	909	250	50	44	5	1	sp	H1288, D600, W7, T1
36	250	190	18	10	8		ss	H518, W1, T2
37	50	31	18	12	4	2	ss	H360, D150, W1
38	153	90	30	28	2		ls	H320, D200
39	107	71	30	26	2	2	ss	H250, D490, W1

Table a 5 continues

40	650	300	81	61	15	5	ss	H600, D200, W2, G1
41	134	90	36	36		2	sp	H900, D600, W2, T6
42	975	250	45	32	10	5	ss	H1100, D400, W6, T1
43	380	245	47	39	8		ss	H480, D2000, W2
44	194		15	15			ss	H150, W1
45	427	242	29	28		1	sp	H3100, D400, W3, T3
46	205	120	34	22	10	2	sp	H832, W6, T3
47	220	130	29	25		4	SP	H880, D376, W3, T2
48	150	105	20	15	5		SS	H500, D500, W5
49	94	70	12	12			SS	H1127, D1750, W1
50	250	200	26	9	15	2	SS	H1240, W3, T1
51	78	78	16	12	3	1	SS	H300, D300, W2, T1
52	1350	550	42	34	6	2	SS	H1600, W8, T2
53	408	180	70	9	61		SP	H3275, W2, D1300, T4
54	184	100	22	22			SS	H460
55	438	114	34	8	26		SS	H720, W1, T1
56	52	33	9	7		2	SS	H615, W1
57	208	140	15	14	1		SS	H424
58	64	40	17	17			SS	W1
59	88	56	18	16	2		SS	H420, W2, D150
60	50	18	9	9			SS	H360
61	284	130	40	19	19	2	SP	H44, W2, T1, FA4
62	200	145	20	15	5		SS	H982
63	180	100	36	26	8	2	SP	H1050, W3, D700, T1
64	120	56	29	20	7	2	SP	H900, W2, D200, T2
65	375	260	53	31	17	5	SS	H1760, W3, D300, T1
66	720	550	72	9	58	5	SS	H1265, W4, D1820, T3
67	310	235	58	25	28	5	SS	H92, D2000, W2
68	250	150	40	30	8	2	SP	H90, W3, D1500, FA2, T1
69	1340	300	25	18	4	3	SS	H600, W4, D300, T2
70	180	100	30	15	15		SP	H640, W3, T1
71	40	40	33	33			SS	H1500, W1, T1
72	1500	300	84	28	50	6	SP	H1223, W4
73	81	78	16	16			LS	H252, W1, T1
74	160	70	23	23			SP	H1098, D450, W2, T2
75	150	52	24	23		1	SS	H700, W2, D100
76	220-	118	50	25	23	2	SP	H864, D700, W2, T2
77	2500	600	127	77	45	5	SP	H300, D2000,W18, T4
78	160	150	20	19		1	LS	H500, W1, T1
79	250	75	17	17			SS	H400, W1, T1
80	225	140	33	24	9		SS	H925, W2, T2
81	1200	300	67	46	2	19	SP	H9200, D200, W15, T3
82	216	205	23	17	5	1	SS	H360, W2
83	870	300	18	18			SS	H440, D300, W4, T1
84	102	60	10	10			SS	H20, W1
85	260	220	28	26	10	2	SS	H150, W6, D30

Table a 5 Continues

86	172	145	15	12	3		SS	H82, D120, W1
87	108	100	10	10			SS	H150, D200, W1
88	100	75	20	14	4	2	SP	H906, D500, W2
89	51	35	13	13			SS	H450, D300, W2
90	100	60	11	9	2		SS	H210, D70, W1, T1
91	402	72	20	15	11	1	SS	H450
93	6305	1500	185	185			SP	H2500, D8000,W18,T3
94	303	124	61	36	23	2	SS	H1428, D200, W2, T2
95	301	200	45	44		1	SP	H1098, W1
96	429	210	67	57	5	5	SS	H1050, D580, W2
97	105	80	36	28	6	2	SS	H372, D50, W1
98	100	60	16	12	3	1	SS	H340, W1
99	322	110	46	40		6	SP	H1070, W1, T1
100	285	65	32	30	2		SS	H648, D250, W2
101	200	60	18	16	1	1	SS	H556, D350, W1
102	25	150	25	20	5		SS	H500, W2
103	60	30	6	6			LS	H50, W1
104	50	45	18	18			SS	H200, W1
105	105	70	8	8			SS	H300, W1
TOTAL	45308	20242	3602	2575	864	163		

Table A6. BASIC PRODUCTION INFORMATION ABOUT HENAN PROVINCE STATE TREE NURSERY

January, 1994 Unit: mu*, 10,000 trees

	Seedling Area Capacity (Mu)	New Seedling Area (Mu)	Seedling Area From Last Year (Mu)	Total Area Seedling (Mu) ?	Total Number Seedling (Seedling)	Total Seedling Field: Area	Total Seedling Field: Seedlines	Total Seedling Field: Amount the Last year Output Landscaping	Management situation	Output
	2	4		3	6	5	7	11		
	70	70		70	23.5	25	19			
04	35	22.5	12.5	30.5	17.5	22.5	12.5	0.3		
05	31	25	6	31	25	28	3	10		
06	40	20	20	40	68	29	9			
13	80	80		80	50	80	40			
14	228	170	58	228	59.02	191	50.34	3.1		
15	70	65	5	70	24	60	13	1		
16	23	17	6	22	24.9	22	23.5	1.4		
17	43	43		41	20.3	38	17.2	0.9		
18	14	13	1	13	3.06	14	2.66	0.4		
19	150	120	30	150	3	30	3	3		
20	207	163	44	207	40.5	207	40.5	40.5		
21	110	102	8	110	65	80	54	1.5		
22	430.5	145.5	285	430.5	105.5	350.5	69	48.8		
23	40	31	9	40	10.1	36	5.4	1.6		
24	650		650	650	118.8	650	89.5	33.2		
25	222	105	117	222	26	182	18.4	18.4		
26	26	26		19	21	18	21	1		
27	219	145	74	219	38.6	106	15.9	10		
28	20		20	20	3	20	3	3		
30	54	37	17	52	25	54	21	5		
32	268	103	165	268	64	193	59			
33	310	160	150	293	173	160	65	55		
46	21	15	6	21	55	20	50.9	3		
47	70	50	20	70	28	20	3			
48	50	30	35	41	45	35	35			
49	45	45		8	82	25	43	0.5		
50	80	65	15	80	40	65	40	4.5		
51	72	70	2	72	32.9	72	32.9			
52	110	106	4	110	75	60	46			
53	175	37.5	137.5	160	40.6	158	40	3		
54	81.5	48.5	33	67.5	57.7	46.5	40.6	11.6		
55	20	12	8	20	16	20	10	1		
56	4	3	1	4	3.9	3	2.1			
68	40.5		40.5	40.5	3.55	40.5	3.55			
70	36	22	14	36	9.55	36	8.85	2.1		
71	157	67	90	157	56	50	15	15		

Table a 6 continues

73	45	15	30	45	180	20	80	1.5
74	42	28	14	42	189.2	42	186.8	
75	10	4	6	10	12	8	9.6	
76	200	50	150	150	64	150	62	5
76	70	20	50	50	16	50	12	9
78	59	12	47	59	21	47	13	8
80	167	73	94	107	71	102	52.6	28
81	66	8	58	66	21.3	58	16.9	
82	180	120	60	165	25	150	17	
83	123	60	63	103	46.3	98	44.3	6.8
84	120	40	80	80	26	75	22.5	1
85	150	50	100	150	60	150	60	30
86	180	80	100	136	30	10	20	5
87	34	34		33.2	44	18	20	
88	70	60	10	70	50	70	50	
102	11	5	6	11	7	8	5.5	

* I hectare = 15 mu
* 1 mu = 0.1647 ac

Table a 7. CHARACTERISTICS OF SEEDLING-SPECIFIC VARIABLES.

NAME	MEAN	ST.DEV	VARIANCE	MINIMUM	MAXIMUM
Y (10,000 seedlings per mu)	0.23549	0.36707	0.13474	0.50000E-02	2.2222
X1 (Seedling land per mu)	0.35019	0.26437	0.69893E-01	0.25776E-01	1.0000
X2 (F Labors per mu)	0.82980E-01	0.49557E-01	0.24559E-02	0.92308E-02	0.19753
X3 (P Labors per mu)	0.25858E-01	0.35177E-01	0.12374E-02	0.63492E-10	0.14951
X4 (Wells per mu)	0.10351E-01	0.71633E-02	0.51312E-04	0.47733E-10	0.33333E-01
X5 (Trucks per mu)	0.33721E-02	0.42041E-02	0.17674E-04	0.66667E-10	0.14634E-01

Table a 8. SIMPLE CORRELATION.

NAME	N	MEAN	ST. DEV	VARIANCE	MINIMUM	MAXIMUM
LX1	51	-1.3852	0.89858	0.80745	-3.6583	0.00000
LX2	51	-2.7254	0.76677	0.58793	-4.6852	-1.6219
LX3	51	-9.8952	8.5575	73.231	-23.480	-1.9004
LX4	51	-5.4673	3.5799	12.816	-23.765	-3.4012
LX5	51	-12.276	8.0130	64.209	-23.431	-4.2244

CORRELATION MATRIX OF VARIABLES - 51 OBSERVATIONS

LX1	1.0000				
LX2	0.29363	1.0000			
LX3	0.89079E-01	-0.35238	1.0000		
LX4	0.27908	0.17065	0.76713E-01	1.0000	
LX5	-0.24951	-0.14240	-0.16364E-01	-0.13437E-01	1.0000
	LX1	LX2	LX3	LX4	LX5

Table a 9. CONDITION INDEX

PRINCIPAL COMPONENTS ON 5 VARIABLES
MAXIMUM OF 5 FACTORS RETAINED

EIGEN VALUES	3676.9	3206.9	640.47	38.689	19.576

SUM OF EIGENVALUES = 7582.6

CUMULATIVE PERCENTAGE OF EIGENVALUES	0.48492	0.90785	0.99232	0.99742	1.0000
VARIANCE REDUCTION BENCHMARK FUNCTION	100.00	99.656	99.262	97.287	64.601
CONDITION NUMBERS	1.0000	1.1466	5.7410	95.038	187.83
CONDITION INDEXES	1.0000	1.0708	2.3960	9.7488	13.705

Appendix III. Shazam Program and plots
a) Program

*Ted B:HN9518.prg Shazame <B:HN95718.prg> B: 95718.out

TLD=	TOTAL LAND (MU, 1 HECTARE=15MU)
NLD=	NURSERY LAND (MU)
PLD=	SEEDLING LAND (MU)
TLAB=	NUMBER OF TOTAL LABOR
FLAB=	NUMBER OF FULL TIME LABOR
PLAB=	NUMBER OF PART TIME LABOR
RLAB=	NUMBER RETIRED LABOR
TY=	TOTAL NUMBER OF SEEDLING & YOUNG TREE (IN 10,000)
YS=	TOTAL NUMBER OF SEEDLING & YOUNG TREE USED OR SOLD (IN 1O,000)
YTREE =	YOUNG TREE (IN 10,000)
MNGM=	MANAGEMENT
LCT=	LOCTION

```
read(B:hn94F11.dat) ID YEARS TLD NLD PLD tLab flab plab rlab Well Truck TY YS YTREE MNGM LCT
Stat/ all


SKIPIF(ID.EQ.68)

IF(tld.eq.nld) DM1=1
IF(TY.eq.YTREE) DM2=1
if(years.le.10) dm4=1
if(nld.le.70) dm6=1


GEN y=TY/TLD

GEN x1=(pld/TLD)
GEN x2=(FLAB/TLD)
GEN x3=((plab+0.0000001)/TLD)
gen x4=((well+0.0000001)/tld)
gen x5=((truck+0.0000001)/tld)

GEN LY=LOG(y)
GEN lx1=LOG(x1)
GEN Lx2=LOG(x2)
GEN Lx3=LOG(x3)
GEN Lx4=LOG(x4)
GEN Lx5=LOG(x5)

Stat Lx1 Lx2 Lx3 Lx4 Lx5/pcor
Pc Lx1 Lx2 Lx3 Lx4 Lx5

gen y2=years**2

gen a6=lx1*lx2
gen a7=lx1*lx3
GEN a8=lx1*lx4
GEN a9=lx1*lx5
GEN a10=Lx2*lx3
gen a11=lx2*lx4
gen a12=lx2*lx5
gen a13=lx3*lx4
gen a14=lx3*lx5
gen a15=lx4*lx5
```

```
gen a16=(1/2)*Lx1**2
gen a17=(1/2)*Lx2**2
gen a18=(1/2)*Lx3**2
gen a19=(1/2)*Lx4**2
gen a20=(1/2)*Lx5**2

gen b1=0.76926
gen b2=0.30124
gen b3=-0.0063046
gen b4=-0.032297
gen b5=0.015887


gen f1=(y/x1)*b1
gen f2=(y/x2)*b2
gen f3=(y/x3)*b3
gen f4=(y/x4)*b4
gen f5=(y/x5)*b5

gen f11=-(y*(1-b1)*b1)/(x1**2)
gen f22=-(y*(1-b2)*b2)/(x2**2)
gen f33=-(y*(1-b3)*b3)/(x4**2)
gen f44=-(y*(1-b4)*b4)/(x4**2)
gen f55=-(y*(1-b5)*b5)/(x5**2)

gen f12=b1*(1-b1)*y/x1*x2
gen f13=b1*(1-b1)*y/x1*x3
gen f14=b1*(1-b1)*y/x1*x4
gen f15=b1*(1-b1)*y/x1*x5

gen f21=b2*(1-b2)*y/x1*x2
gen f23=b2*(1-b2)*y/x3*x2
gen f24=b2*(1-b2)*y/x4*x2
gen f25=b2*(1-b2)*y/x5*x2

gen f31=b3*(1-b3)*y/x1*x3
gen f32=b3*(1-b3)*y/x2*x3
gen f34=b3*(1-b3)*y/x4*x3
gen f35=b3*(1-b3)*y/x5*x3

gen f41=b4*(1-b4)*y/x1*x4
gen f42=b4*(1-b4)*y/x2*x4
gen f43=b4*(1-b4)*y/x3*x4
gen f45=b4*(1-b4)*y/x5*x4

gen f51=b5*(1-b5)*y/x1*x5
gen f52=b5*(1-b5)*y/x2*x5
gen f53=b5*(1-b5)*y/x3*x5
gen f54=b5*(1-b5)*y/x4*x5

gen H2=(b1**2*(1-b1)+b1*(1-b1)**2)*y**3/(x1**2)*(x2**2)
gen H3=-f1*(f1*f22-F12*f2)+f2*(f1*f21-F11*f2)

gen c1=2.2715
gen c2=2.1396
gen c3=-0.017557
gen c4=2.6966
gen c5=0.26768
gen c6=-0.44303
```

```
gen c7=-0.068336
gen c8=0.32299
gen c9=0.044386
gen c10=0.076678
gen c11=0.35194
gen c12=-0.072991
gen c13=0.022545
gen c14=-0.0025993
gen c15=0.071754
gen c16=0.76822
gen c17=0.42412
gen c18=-0.014934
gen c19=-0.020596
gen c20=0.0056801

gen f1X=(y/x1)*(c1+(c6*lx2)+(c7*lx3)+(c8*lx4)+(c9*lx5)+(0.5*c16*lx1))
gen f2X=(y/x2)*(c2+(c6*lx1)+(c10*lx3)+(c11*lx4)+(c12*lx5)+(0.5*c17*lx2))
gen f3X=(y/x3)*(c3+(c7*lx1)+(c10*lx2)+(c13*lx4)+(c14*lx5)+(0.5*c18*lx3))
gen f4X=(y/x4)*(c4+(c8*lx1)+(c11*lx2)+(c13*lx3)+(c15*lx5)+(0.5*c19*lx4))
gen f5X=(y/x5)*(c5+(c9*lx1)+(c12*lx2)+(c14*lx3)+(c15*lx4)+(0.5*c20*lx5))

stat / all
OLS LY Lx1 lx2 lx3 lx4 lx5 dm1 DM2 dm4 dm6 y2/auxrsqr

OLS LY Lx1 lx2 lx3 lx4 lx5 dm1 DM2 dm4 dm6 y2/het
dia/het

OLS ly Lx1 lx2 lx3 lx4 lx5 dm1 DM2 dm4 dm6 y2/exactdw
dia/reset het


OLS ly lx1 lx2 lx3 lx4 lx5 a6 a7 a8 a9 a10 a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 dm1 DM2 dm4 dm6 y2 /auxrsqr
OLS ly lx1 lx2 lx3 lx4 lx5 a6 a7 a8 a9 a10 a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 dm1 DM2 dm4 dm6 y2 /het
dia/Het
OLS ly lx1 lx2 lx3 lx4 lx5 a6 a7 a8 a9 a10 a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 dm1 DM2 dm4 dm6 y2
/exactdw
dia/reset het
OLS ly lx1 lx2 lx3 lx4 lx5 a6 a7 a8 a9 a10 a11 a12 a13 a14 a15 a16 a17 a18 a19 a20 dm1 DM2 dm4 dm6 y2

OLS LY Lx1 lx2 lx3 lx4 lx5 dm1 DM2 dm4 dm6 y2
TEST Lx1+ lx2+ lx3 +lx4+ lx5 =1
end

plot y x1
plot y x2
plot y x3
plot y x4
plot y x5
stop
```

b) Plots:

```
REQUIRED MEMORY IS PAR=  40 CURRENT PAR=  500
FOR MAXIMUM EFFICIENCY USE AT LEAST PAR=   41 51 OBSERVATIONS
*=Y   M=MULTIPLE POINT
        2.4000  |
        2.2737  |
        2.1474  |                  *
        2.0211  |
        1.8947  |
        1.7684  |
        1.6421  |
        1.5158  |
        1.3895  |
        1.2632  |
        1.1368  |    *
        1.0105  |
        0.88421 |
        0.75789 |                **
        0.63158 |
        0.50526 |
        0.37895 |     *     * *    *
        0.25263 | *    *  *     *    *
        0.12632 |  * * MM*  * **        *
0.66613E-15     |*MMMM** **M  *  *   *  *  *

                 ----------------------------------------
                  0.000   0.300   0.600   0.900   1.200
                                                          X1
```

```
REQUIRED MEMORY IS PAR=  40 CURRENT PAR=  500
FOR MAXIMUM EFFICIENCY USE AT LEAST PAR=   41
                        51 OBSERVATIONS
                                              *=Y   M=MULTIPLE POINT
        2.4000  |
        2.2737  |
        2.1474  |                              *
        2.0211  |
        1.8947  |
        1.7684  |
        1.6421  |
        1.5158  |
        1.3895  |
        1.2632  |
        1.1368  |                        *
        1.0105  |
        0.88421 |
        0.75789 |                    *  *
        0.63158 |
        0.50526 |
        0.37895 |      *        * *  *
        0.25263 |                    MM *
        0.12632 |* * *  M*  MM  **
0.66613E-15     | *MM*M*** ** *** *  M  * **   *

                 ----------------------------------------
                 0.000   0.050  0.100   0.150   0.200
                                                          X2
```

```
                    *=Y    M=MULTIPLE POINT


        2.4000   |
        2.2737   |
        2.1474   |*
        2.0211   |
        1.8947   |
        1.7684   |
        1.6421   |
        1.5158   |
        1.3895   |
        1.2632   |
        1.1368   |*
        1.0105   |
        0.88421  |
        0.75789  |M
        0.63158  |
        0.50526  |
        0.37895  |  * *  M
        0.25263  |M     ** *
        0.12632  |M*  *  *** *  *
0.66613E-15      |MMM***  M       M  * *    *     * *
                 ____________________________________
                  0.000   0.040   0.080   0.120   0.160
                                                          X3
```

```
REQUIRED MEMORY IS PAR=  40 CURRENT PAR=  500
FOR MAXIMUM EFFICIENCY USE AT LEAST PAR=   41
                         51 OBSERVATIONS
                              *=Y   M=MULTIPLE POINT
        2.4000          |
        2.2737          |
        2.1474          |     *
        2.0211          |
        1.8947          |
        1.7684          |
        1.6421          |
        1.5158          |
        1.3895          |
        1.2632          |
        1.1368          |     *
        1.0105          |
        0.88421         |
        0.75789         |    * *
        0.63158         |
        0.50526         |
        0.37895         |    *      M    *
        0.25263         |*    **          *  *
        0.12632         |  **MM** * *      *
        0.66613E-15     |M M MM M** MMM  M *
                        ______________________________
                            0.000   0.010   0.020   0.030   0.040
                                                             X4
```

```
                                                  *=Y
                                                  M=MULTIPLE POINT
      2.4000    |
      2.2737    |
      2.1474    |                         *
      2.0211    |
      1.8947    |
      1.7684    |
      1.6421    |
      1.5158    |
      1.3895    |
      1.2632    |
      1.1368    |                         *
      1.0105    |
      0.88421   |
      0.75789   |M
      0.63158   |
      0.50526   |
      0.37895   |M                *
      0.25263   |M           *       *
      0.12632   |M *  * M * *  * *
0.66613E-15     |M* M*** ** **  *M  **
                 ________________________________________
                 0.000   0.004   0.008   0.012   0.016
                                                          X5
```