ECONOMIC OPTIMISATION OF RICE AND SOYBEAN PRODUCTION IN JOGYAKARTA PROVINCE

JOKO MARIYONO AND NUR K. AGUSTIN
Centre for Analysis of Socio-Economics and Agricultural Policy Indonesian Research and Development Agency of MoA, Bogor-Indonesia

ABSTRAK

Fakta bahwa otonomi daerah telah diberlakukan, konsekuensinya adalah sumberdaya lokal perlu dimanfaatkan secara ekonomis. Kajian ini bertujuan untuk menguji kinerja produksi padi dan kedelai yang ditanam secara bersama-sama di lahan beririgasi sejak sebelas tahun yang lalu, dengan konsep skop ekonomi sebagai kerangka pemikiran. Estimasi berkelompok digunakan untuk menduga kurva kemungkinan produksi yang menjelaskan hubungan antara produksi kedelai dan produksi padi. Data yang terdiri atas empat kabupaten selama sebelas tahun dikumpulkan dari publikasi kantor statistik daerah. Hasil kajian ini menunjukkan bahwa produksi padi dan kedelai dalam setahun mempunyai keunggulan skop ekonomi, artinya memproduksi padi dan kedelai secara bersama lebih tinggi daripada memproduksi secara terpisah. Namun demikian, dengan harga pasar yang berlaku, produksi bersama secara ekonomi lebih rendah dibanding dengan hanya memproduksi padi. Hal ini disebabkan oleh produktivitas kedelai yang rendah, dan harga relatif kedelai yang tidak terlalu tinggi. Oleh karena itu dalam kasus ini akan lebih menguntungkan menanam padi seluas mungkin pada lahan beririgasi.

Kata Kunci: Skop Ekonomi, Kurva Kemungkinan Produksi, Padi dan Kedelai

INTRODUCTION

In some regions where agriculture dominates regional economy, it is capable of raising the welfare of human being better of since ‘regional income measures provide indications of personal and community welfare and economic growth, … a change in real income is usually taken to imply a change in welfare in the same direction’ (Bendavid 1974: 30). Unfortunately, the sector is frequently less favourable than other sectors such manufactures and services. This brings about the local governments do not focus seriously on the sector. In fact, in the 1990s agriculture still absorbs approximately 50% of employment and provides share around 20 % of Indonesian GDP (Hill 2000).

1) PhD Candidate in International and Development Economics The Australian National University, Canberra

2) Centre for Analysis of Socio-Economics and Agricultural Policy Indonesian Research and Development Agency of MoA, Bogor-Indonesia

In the era of decentralization in which the central government no longer get involve powerfully to the local governments, however, it is necessary for some local regions enhancing their own local endowments. One of the potential agricultural endowments that are interesting to consider is mixed cropping of food crops that has been conducted over ten years ago. Altieri (1987) has discussed the advantages of mixed cropping, consisting of both intercropping and sequential cropping. In terms of diversification, the ecological advantage is 'insurance against crop failure, … when one of the crops in a combination is damaged … the other crops may compensate for the loss' (Altieri 1987: 74-5), and the economic advantage is ability to 'protect the firm from the risk of price change and market losses for a single product' (Kohls and Uhl 1990: 209). It is therefore sensible to grow two or more commodities both in yearly spatial or temporal manners.

However, mixed cropping does not always provide more output both in physical and financial. It depends on condition whether or not the annual joint output is greater than that of single one. Furthermore, factor determining ability of mixed cropping to give high economic return associated with given market prices is the amount of portion of each annual production of commodity. Base on the proposition, the objective of study is to assess on whether or not the level of joint output in mixed cropping is technically higher than that of single cropping, and to test whether or not the portion of each production in mixed cropping is economically able to provide maximum return. This outcome is expected to be capable of providing significant contribution to the policy makers of the local government in which the study is carried out. Since this study is quite simple to do, further expectation is that the same study will be easily conducted by others local governments with a variety of comparatively advanced commodities.

THEORETICAL FRAMEWORK

With reference to the relationship between two commodities produced with the same fixed input; this study will employ the economies of scope as a fundamental theory. The centre to the theory is product transformation curve (Figure 1) i.e. a curved line that illustrates 'the different combinations of two outputs that can be produced with a fixed amount of production inputs' (Pindyck and Rubinfeld 1998: 228)

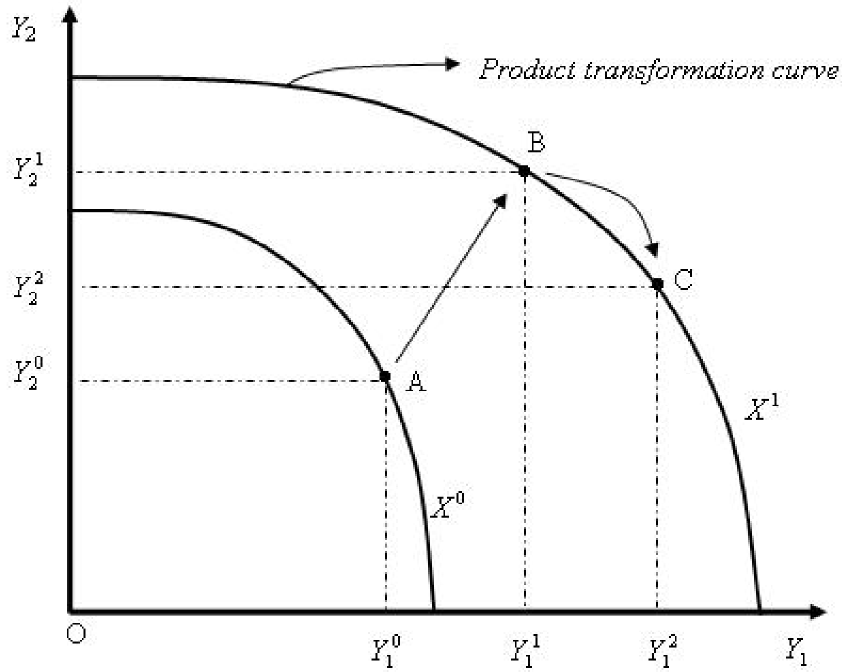

Figure 1. Product Transformation Curve

Figure 1 shows that goods of Y_1 and Y_2 are produced with the same input of X fixed. When there is a certain quantity of X^0, the levels of amount of products are Y_1^0 and Y_2^0. If there is an increase in X from X^0 to X^1 (from point A to pint B), the levels of goods Y_1 and Y_2 will increase from Y_1^0 to Y_1^1 and $Y_2^0$and Y_2^1 respectively.

Furthermore with the same level of X^1, to increase Y_2 from Y_2^1 to Y_2^2 (from point B to point C), producer must give up Y_1 from Y_1^1 to Y_1^2, and consequently the slope of curves is negative. The relationship between both products therefore can be mathematically expressed

$$Y_2 = g\,(X, Y_1) \quad \ldots\ldots \quad (1)$$

with $\partial Y_2/\partial X > 0$ and $\partial Y_2/\partial Y_1 < 0$.

Furthermore, the 'product transformation curves are concave to the origin because the firm's production resources are not perfectly adaptable in (i.e., cannot be perfectly transferred between) the production of products …' (Salvatore 1996: 460). It is therefore understandable that '…the joint output of a single firm is greater than the output that could be achieved by two different firms each producing a single product…' (Pindyck and Rubinfeld 1998: 227).

Figure 2 shows a certain fixed input X used to produce Y_1 and Y_2, and R is revenue attained from the productions under given market prices of Y_1, P_1 and Y_2, P_2. Lines of R_1 and R_2 is isorevenue when X is used to produce Y_1 or Y_2 correspondingly as single product, whereas R_3 is isorevenue line when X is used to produce Y_1 and Y_2 as joint product. If it is the case, the revenue of mixed joint product, R_3, is greater than that of single product, R_1 or R_2 at the same given prices P_1 and P_2. However, R_3 is not the maximum revenue. The maximum one is $R_{max.}$ It is reached when the isorevenue make a tangency point on the product transformation curve (point D). In other words, the marginal rate of product transformation (MRPT) —the quantity of product Y_2 that must be given up in order to get one unit of product Y_1— is equal to the slope of isorevenue R_{max}.

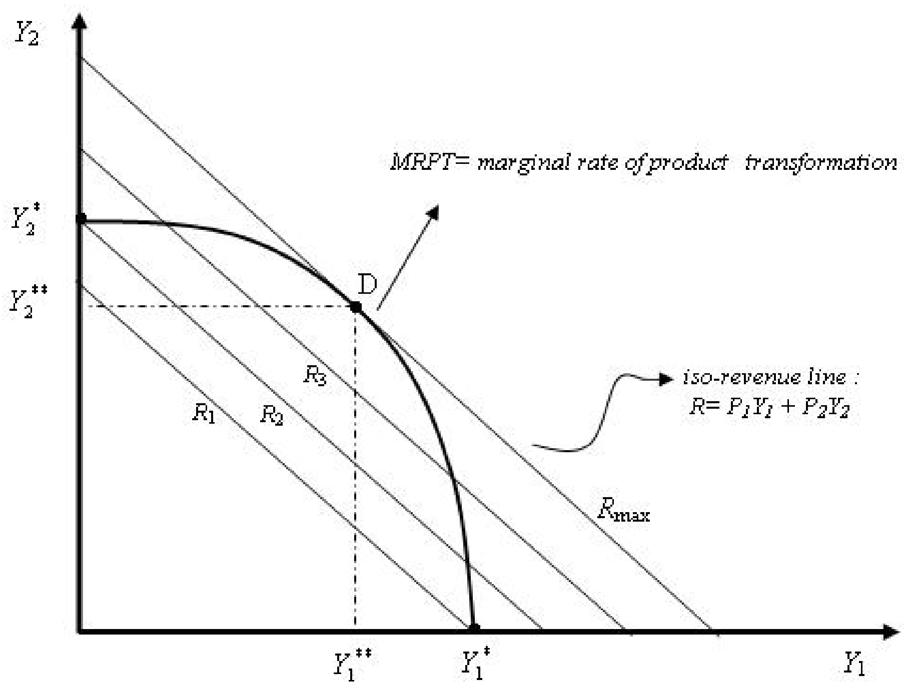

Figure 2. Revenue in joint production

In economic analysis, it is common that objective of the producers is assumed to be a maximization of revenue (R) subject to fixed input constraint X. If it is the case, the mathematical formulation of the objective is

$$\text{Max.} \quad R = P_1.Y_1 + P_2.Y_2 \quad \text{subject to} \quad X - g\,(Y_{1,}\ Y_2) = 0 \ \ldots\ldots\ldots\ldots\ldots \quad (2)$$

where P_1 and P_2 is prices of Y_1 and Y_2 respectively. The Lagrangian method postulates that objective function of the revenue is formulated as:

$$\text{Max.} \quad \Re = P_1.Y_1 + P_2.Y_2 \ - \ \lambda\{X - g\,(Y_1, Y_2)\} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (3)$$

To reach the maximum revenue, the partial 'derivative of the function must be zero' (Salvatore 1996:50), that is:

$$\Re_1 = \partial\Re/\partial Y_1 = P_1 - \lambda\ (\partial X/\partial Y_1) = 0 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (4a)$$

$$\Re_2 = \partial\Re/\partial Y_2 = P_2 - \lambda\ (\partial X/\partial Y_2) = 0 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (4b)$$

$$\Re_\lambda = \partial\Re/\partial\lambda = X - g\,(Y_1, Y_2) = 0 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (4c)$$

After some algebraic manipulations, solving equations of (4a) and (4b) results in

$$P_1/(\partial X/\partial Y_1) = P_2/(\partial X/\partial Y_2)$$

$$\Rightarrow \quad P_1/P_2 = (\partial X/\partial Y_1) / (\partial X/\partial Y_2) \ = \partial Y_2/\partial Y_1 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (5)$$

The optimum combination of each production leading to the maximum revenue, therefore, will be reached when the negative MRPT is equal to the ratio price of P_1/P_2.

MATERIAL DAN METHOD

Study site and data sources. This study takes place Jogjakarta Province as a case. The province consists of four districts namely Bantul, Gunung Kidul, Kulon Progo and Sleman. The location is preferred as the case of study since it has historically unique value in terms of decentralized region. Rice and soybean are preferred to analyse, because in one year both are planted as mixed cropping at the same time called intercropping system, and planted as mixed cropping in different time called sequential cropping. In view of the fact that both productions are major commodities that have politically and economically strategic values, it is reasonable that both contribute significantly to regional income.

This study analyses secondary cross-section and time-series data. The analysis is called panel or pooled analysis (Johnston and DiNardo 1997). The data comprises four districts and eleven-year period of 1990-2000. The data is collected from a series of regional figures published by centre for statistical offices (BPS). The data consists of annual productions of rice and soybean (tones), planted area of rice and soybean (ha), and average annual prices of rice and soybean (Rp per kg).

Econometric modelling. Since the product transformation curve is assumed to be concave to the origin, the first step of this analysis is to formulate the curve appropriately. In this case, a quadratic function is one of the suitable approaches (Chiang 1984). Y_1 and Y_2 is respectively so-called production of rice and soybean planted in the area L. Based on the equation (1), the product transformation curve reflecting the relationship between soybean and rice production that are cultivated in the same lands is formulated as:

$$Y_2 = \alpha L + \beta Y_1 + \delta Y_1^2 \qquad \text{………………………………………. (6)}$$

One of crucial assumptions to hold is that fertiliser use will be adjusted instantaneously with the change in land use. This is due reasonably to the fact that in 'the farm-field experiment … fertiliser application is not different to optimum level … that indicate that farmers were allocatively efficient' (Widodo 1989:133). This implies that production of rice is less stochastic than that of soybean, and therefore it is reliable to place production of rice as explanatory variable, instead of explained variable (Wooldridge 2000; Greene 2003).

The concavity of product transformation curve requires conditions of which α is positive, and β, δ is negative. The next step to do is to calculate the value of MRPT derived from the function. The MRPT is

$$dY_2/dY_1 = \beta + 2\,\delta Y_1 \quad \text{.......} \quad (7)$$

To identify whether the productions provide maximum revenue, the MRPT obtained is then tested to show that the value is equal to the price ratio of each product. The test is conducted by the following formulations:

$$dY_2/dY_1 = P_1/P_2$$

$$\rightarrow \; dY_2/dY_1 \bullet P_2/P_1 = \psi \quad \text{.......} \quad (8)$$

If the negative dY_2/dY_1 is equal to the price ratio, the value of ψ will be equal to unity.

Testing for hypothesis. Testing for degree of economies of scope is done by proofing the product transformation curve is strictly concave to origin. The product of transformation curve is econometrically modelled as:

$$Y_2 = \alpha L + \beta Y_1 + \delta Y_1^2 + \varepsilon \quad (9)$$

where ε is disturbance error. In the pooled data analysis it is required to know the homogeneity of disturbance errors. The equation (9) is estimated with pooled estimation provided in SHAZAM (White et al 1990). Since there is no intercept in the model, the estimation is suppressed through the origin. Testing for the homogeneity is performed by using one-way ANOVA provided in SPSS. Hypothesis testing for the economies of scope is formulated below.

Null hypothesis (H_0): $\alpha, \beta, \delta = 0$

Alternative hypothesis (H_a): $\alpha > 0$ and $\beta, \delta < 0$

The H_0 will be rejected if the value of t-ratio is greater than that of one-tailed t-table. If the H_0 is rejected, it means that there is strictly concave function indicating that degree of economies of scope exists.

Testing for optimal productions will be done by proofing that value of ψ_i in equation (8) is statistically equal to unity. Diekhoff (1992) suggests that testing for hypothesis follows procedures of one-sample *t*-test. Hypothesis testing formulation is

Null hypothesis (H_0): $\psi_i - 1 = 0$

Alternative hypothesis (H_a): $\psi_i - 1 \neq 0$

The H_0 will be rejected if the value of t-ratio is greater than that of two-tailed t-table. If the H_0 is rejected, this indicates that the combination of the products is not optimal.

RESULT AND DISCUSION

The product transformation function obtained from pooled estimation is follow:

$$\mathbf{Y_2 = 1.075\ L \ - \ 0.1628\ Y_1 \ - \ 0.7362 \cdot 10^{-7}\ Y_1^2}$$

$$(0.0215) \qquad (0.5832 \cdot 10^{-2}) \qquad (0.1967 \cdot 10^{-7})$$

$$[50.085] \qquad [-27.918] \qquad [-3.7432]$$

$R^2 = 0.98$; $F_{df: 3, 41} = 1393$; D-W stat. = 1.8681

figures in parentheses represent standard errors, figures in squared parentheses represent t-ratio
Disturbance error is homogenous and there is no serial correlation

It can be seen from Box 2 that around 98 % of variation in soybean production is determined by the variations in lands and rice production. Overall, the estimate of product transformation function is highly significant. One important feature is that the coefficient of $\mathbf{Y_1^2}$ is significantly negative. It means that the product transformation function is strictly concave. The concavity of function indicates that there is degree of economies of scope in producing rice and soybean simultaneously. In other words, the level of rice and soybean jointly produced is physically higher than that of either rice or soybean produced separately.

However, it does not mean that the revenue of joint product is always economically higher than that of single product. Identifying whether or not the joint production of rice and soybean is profitable needs to take into account given market prices of both commodities. Table 1 shows the result of testing for optimal combination of each product.

Table 1. The Average Value of MRPT and the Test of Optimal Production

-MRPT= dY_2/dY_1	Price ratio (P_2/P_1)	Average ψ_i = ($MRPT \bullet P_2/P_1$)	Average ψ_i-1	two-tailed t-value
0.184163	2.8034	0.516021	-0.48398*	-42.918

*) significant at degree of confidence 99%

It is clear that the value of ψ_i is statistically different from unity. It means that the value of negative MRPT is not equal to the ratio prices of products, by which the required condition of maximum revenue (equation (8)) is not satisfied. This implies that producing rice and soybean has not been economically efficient, despite the fact that there is advantage in terms of economies of scope. In other words, transforming from one product to another can still increase revenue generated from joint productions of rice and soybean. Nevertheless, the question is that which one that needs increasing can be determined by taking market prices of both into account.

It is obvious that the value of ψ_i is statistically less than one. It indicates that production of soybean is economically too high compared with optimal production at given market prices. In other words, portion of irrigated lands devoted for producing soybean is too high. Based on such condition, the level of soybean production needs to be reduced by replacing it with rice in irrigated lands in which soybean was already planted. Furthermore, it should be pointed out that converting soybean-planted lands to rice-planted ones should be followed with transferring variable inputs used in soybean to rice proportionately. The conversion of lands can be continued until the absolute value of MRPT equalises the price ratio.

If this is the case, however, there is no the absolute value of MRPT equal to the price ratio alongside positive value of rice and soybean productions. In order to be optimum, the production of rice should be 1,360,296 tonnes and the production of soybean is negative (see Figure 3). Such condition does not make sense in reality. There are some factors influencing the condition. First, technically, yield of soybean is too low compared with yield of rice at the same lands. The yield of soybean is, on average, 1.38 tonnes per hectare, whereas the yield of rice is, on average, 5.69 ton per hectare. Second, the market price of soybean is not too high relative to the market price of rice. Such factors bring about joint production that has degree of economies scope is unable to provide maximum returns.

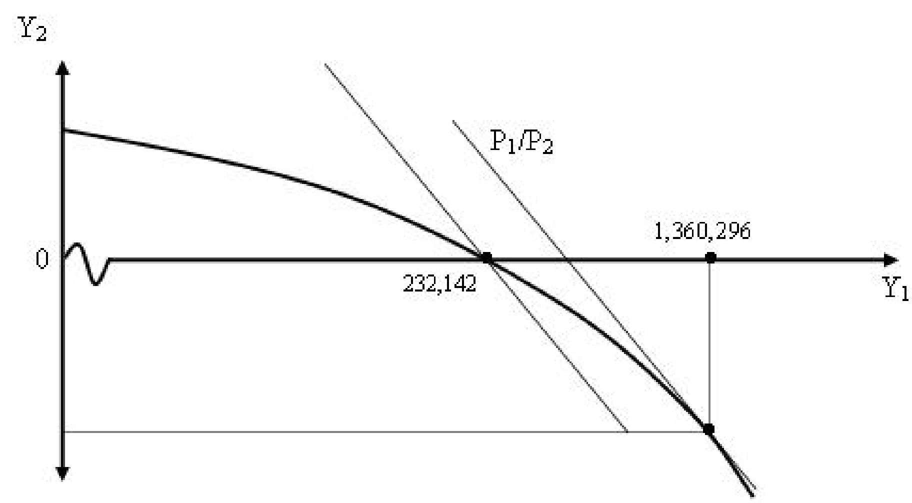

Figure 3. Corner Solution

According to Nicholson (2003), a ***corner solution*** in Figure 3 is the best way to get maximum return. In this sense, all irrigated lands planted by soybean are converted to cultivate rice. It will yield 232,142 tonnes of rice. However, it is impracticable to employ all irrigated land for growing rice because of scarcity in water irrigation. It is therefore reliable to do the second best option i.e. growing rice during a year as capable of carrying capacity of irrigated lands.

CONCLUSION AND POLICY IMPLICATION

Conclusion

As Jogjakarta is an agrarian region, the local government needs to identify the performance of agriculture, which has contributed regional income significantly. Rice and soybean that productions have been performed with mixed cropping method for more than a decade are expected to provide high return optimally. In fact, the production has not been optimal as expected, despite the fact that the production demonstrated degree of economies of scope, meaning that the level of output yielded in mixed cropping is physically higher than that in single cropping. This is due to the fact that yield of soybean is too low, and the relative price of soybean is not too high. In this case, the level of rice production is too low, and at the same time the level of soybean production is too high. In other words, irrigated lands devoted for growing soybean is excessively high.

Policy Implication

Based on the economic situation, growing rice during a year will be more money-making than mixed cropping. But, it is impracticable since the water irrigation is scarce. The second best alternative that can be done is to grow rice as much as possible in irrigated lands. Since there is degree of economies of scope, another way to enhance the performance is to increase yield of soybean. It can be done by improving agronomical practices, such as using high yield varieties, good maintenance, and adopting newly invented technologies suitable. It is expected can gain the degree of economies of scope, and will increase the revenue and automatically will lift up welfare at the end.

REFERENCE

Altieri, M.A, 1987. *Agroecology: the scientific basis of alternative agriculture*. Westview Press, Boulder

Bendavid, A., 1974. *Regional Economic Analysis for Practitioners*. Praeger Publisher New York.

Chiang, A. C., 1984. Fundamental Methods of Mathematical Economics. McGraw-Hill Co. Inc. New York.

Diekhoff, G., 1992. *Statistics for the Social and Behavioral Sciences: univariate, bivariate, multivariate*. Wm. C. Brown Publishers, Dubuque

Greene, W.H., 2003. *Econometric Analysis*. New Jersey: Prentice Hall.

Hill, H., 2000. *The Indonesian Economy*. Cambridge University Press, Cambridge.

Johnston, J. and DiNardo, J., 1997. *Econometric Methods*. The McGraw-Hill Co. Inc. New York.

Kohls, R.L. and Uhl, J.N., 1990. *Marketing of Agricultural Produ*cts. MacMillan Publishing Co., New York

Nichoson, W., 2003. *Microeconomics Theory: Basic principles and extensions*. The Dryden Press, Chicago.

Pindyck, R.S. and Rubinfeld, D.L. 1998. *Microeconomics*. Prentice Hall International, Inc. Upper Sadle River, New Jersey

Salvatore, D., 1996. *Managerial Economics in A Global Economy*. McGraw-Hill, New York

White, K. J.; Wong, S. D.; Whistler, D. and Haun, S. A., 1990. *Shazam, Econometrics Computer Program: User's reference manual version 6.2*. McGraw-Hill Book Co. New York.

Widodo, S., 1989. *Production Efficiency of Rice Farmers in Java, Indonesia*. Gadjah Mada Universisty Press, Yogyakarta.

Wooldridge, J.M., 2000. *Introductory Econometrics: A modern approach.* South-Western College Publishing, Australia

Appendix 1. Printout of Statistical Analysis

1. Pooled Estimation

```
UNIT  6 IS NOW ASSIGNED TO: c:\agsc.doc

|_POOL Y2 LT Y1 Y12 /NOCONSTANT NCROSS=4 FULL RSTAT ANOVA CORCOEF RESID=RESID
POOLED CROSS-SECTION TIME-SERIES ESTIMATION
     4 CROSS-SECTIONS AND     11 TIME-PERIODS
     44 TOTAL OBSERVATIONS
DEPENDENT VARIABLE = Y2

FINAL COEFFICIENTS
   1.0747      -53.262     -0.90191E+07
FINAL SSE =   29.724
BUSE R-SQUARE = 0.9892      BUSE RAW-MOMENT R-SQUARE = 0.9903
VARIANCE OF THE ESTIMATE-SIGMA**2 =  0.72498
STANDARD ERROR OF THE ESTIMATE-SIGMA =  0.85146
SUM OF SQUARED ERRORS-SSE=   29.724
MEAN OF DEPENDENT VARIABLE =   17198.
LOG OF THE LIKELIHOOD FUNCTION = -407.399


                     ANALYSIS OF VARIANCE - FROM ZERO
                      SS          DF            MS                 F
REGRESSION        3031.7          3.        1010.6             1393.908
ERROR             29.724         41.       0.72498
TOTAL             3061.4         44.        69.577


VARIABLE    ESTIMATED   STANDARD   T-RATIO    PARTIAL STANDARDIZED ELASTICITY
  NAME     COEFFICIENT    ERROR      41 DF      CORR.  COEFFICIENT  AT MEANS

LT          1.0747     0.21458E-01   50.085     0.9919  0.69583       2.4276
Y1        -0.16281     0.58318E-02  -27.918    -0.9747 -0.68365      -1.3736
Y12       -0.73618E-07 0.19667E-07  -3.7432    -0.5047 -0.10455     -0.12699

DURBIN-WATSON = 1.8681    VON NEUMANN RATIO = 1.9116    RHO = -0.06538
RESIDUAL SUM =   6.2330      RESIDUAL VARIANCE =  0.72498
SUM OF ABSOLUTE ERRORS=   28.951
R-SQUARE BETWEEN OBSERVED AND PREDICTED = 0.9848
RUNS TEST:   20 RUNS,   28 POSITIVE,   16 NEGATIVE, NORMAL STATISTIC = -0.4503
```

2. Testing for homogeneity of disturbance errors

Test of Homogeneity of Variances
RES2

Levene Statistic	df1	df2	Sig.
.567	3	40	.640

ANOVA

RES2	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.366	3	.122	.142	.934
Within Groups	34.455	40	.861		
Total	34.821	43			

3. Testing for $\psi_i - 1 = 0$

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
psi-1	44	-.48397852097857	.074801468376283	.011276745653262

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
psi-1	-42.918	43	.000	-.48397857	-.50672028	-.461236795