

AN AGGREGATE IMPORT DEMAND FUNCTION FOR GREECE: A COINTEGRATION APPROACH

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Abstract

This study estimates the aggregate import demand function for Greece using annual data for the period 1951-92. There are two methodological novelties in this paper. First, unlike the previous studies on import demand, this study uses the cointegration methodology. Second, we test for the appropriate form of the import demand function before estimation. We find that the variables used in the aggregate import demand function are not stationary but these are cointegrated. Thus, there exists a long-run equilibrium relationship among these variables during the period under study. The inelasticity of import with respect to import price implies that during the period under study, imported goods (a) were mostly essential goods and or (b) imports were largely determined by non-price factors. Import was found to be income elastic. This implies that, *ceteris paribus*, trade deficit for Greece is likely to get worse.

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I:INTRODUCTION

The purpose of this study is two-fold: (1) to study the determinants of import demand in Greece using post World War II data (2) to estimate the responsiveness of import with respect to import price, domestic price and gross domestic product using the recently developed methodology of cointegration.

Greece is a relatively high import country. The value of imports as a percentage of GDP has fluctuated around 30 per cent in recent years. The value of exports as a percentage of GDP has been around 13 per cent in recent years. Greece has faced a negative balance of trade consistently during the 1950s to early 1990s. Greece had a long history of foreign investment and high imports. Unlike many other countries in Europe, Greece did not enjoy rapid growth in manufacturing between 1840 and 1930. Greece did not have any kind of land reforms. Greece remained a feudally managed agrarian economy. By the time of the end of the Second World War, Greece experienced large scale capital flight. Greece, like many other developing countries, followed a protectionist policy to stem the tide of capital outflow. To preserve the value of drachma, Greece followed restricted import policies during the 1940s and early 1950s. At the end of the 1950s, the political ideology of the Greek government lurched from parliamentary one to extreme right wing military dictatorship. With the exception of Papandreou centrist administration between December 1963 and July 1965, successive Greek governments followed a largely laissez-faire policy on the trade front since the 1960s. Since 1973-74, the inflation has been running at high rates making Greek products and services uncompetitive in the world market (Paleologos, 1993).

The rest of the paper is divided into three sections. The second section looks at the theoretical issues and reviews related previous studies. The third section provides the empirical estimates. The fourth section provides the summary and conclusions.

Previous studies did not pay any attention to the question of stationarity while dealing with the time series. It is now well known that traditional ways of estimating time series models might suffer from spurious relationships because these methods do not test for stationarity of the time series before estimation.

II: THEORETICAL ISSUES AND LITERATURE REVIEW

In the literature, import demand function has taken several forms. Let

M_t = Import in time t.

PM_t = Import price in time t.

PD_t = Domestic price in time t.

Y_t = Real Gross Domestic Product in time t.

Two main forms have been used in the literature.

$$M_t = f (PM_t, PD_t, Y_t) \dots\dots(1)$$

$$M_t = f (PM_t/PD_t, Y_t) \dots\dots(2)$$

(1) and (2) are known as the absolute price and the relative price formulations respectively. Both forms have been used extensively in the literature. The two forms have been specified in both linear and log-linear formulations. Goldstein and Khan (1985) provide an excellent summary of the earlier studies. Formulations (1) and (2) assume instantaneous adjustments to import and domestic prices and real income on the part of the importers. Following Khan and Ross (1977), a partial adjustment model can be specified as follows:

$$\Delta M_t = \delta (M_t^* - M_{t-1}) \dots\dots (3)$$

$$M_t^* = \alpha_1 + \alpha_2 PM_t + \alpha_3 PD_t + \alpha_4 Y_t + e_t \dots (4)$$

where Δ is a first difference operator i.e., $\Delta M_t = M_t - M_{t-1}$, δ is the coefficient of adjustment, $0 \leq \delta \leq 1$ and M_t^* is the desired level of imports. Substituting (4) into (3) yields:

$$M_t = \delta \alpha_1 + \delta \alpha_2 PM_t + \delta \alpha_3 PD_t + \delta \alpha_4 Y_t + (1 - \delta) M_{t-1} + \delta e_t \dots (5)$$

This is the dynamic linear import demand equation.

The partial adjustment model can also be specified in log-linear form as follows:

$$\Delta \ln M_t = \phi [\ln M_t^* - \ln M_{t-1}], \quad 0 \leq \phi \leq 1 \quad \dots (6)$$

$$\ln M_t^* = \beta_1 + \beta_2 \ln PM_t + \beta_3 \ln PD_t + \beta_4 \ln Y_t \dots (7)$$

As in the linear case, substitution of (7) into (6) yields

$$\ln M_t = \phi \beta_1 + \phi \beta_2 \ln PM_t + \phi \beta_3 \ln PD_t + \phi \beta_4 \ln Y_t + (1 - \phi) \ln M_{t-1} + \phi \varepsilon_t \dots (8)$$

The above equation can be rewritten as

$$\ln M_t = a_1 + a_2 \ln PM_t + a_3 \ln PD_t + a_4 \ln Y_t + a_5 \ln M_{t-1} + u_t \dots (9)$$

where $a_1 = \phi \beta_1$; $a_2 = \phi \beta_2$; $a_3 = \phi \beta_3$; $a_4 = \phi \beta_4$; $a_5 = 1 - \phi$ and $u_t = \phi \varepsilon_t$.

The coefficients of equation (9) will give us the short run elasticities because of its log-linear formulation.. The coefficients of (7) will give the long run elasticities, (i.e., after the short run adjustments have taken place). However, the coefficients of (7) can be calculated directly from the coefficients of (9) as follows:

$$\phi = 1 - a_5 ; \quad \beta_1 = a_1 / (1 - a_5) ; \quad \beta_2 = a_2 / (1 - a_5) ; \quad \beta_3 = a_3 / (1 - a_5)$$

$$\text{and } \beta_4 = a_4 / (1 - a_5)$$

One can derive similar equations for the relative price and for the linear versions.

The choice between the linear and loglinear models is somewhat arbitrary. However, the Box-Cox test [see Box and Cox (1964) and Zarembka (1974) for details] can be used to choose between the two. This test estimates the general form

of regression equation:

$$(M^{\lambda}_t - 1) / \lambda = b_0 + b_1 [(PM^{\lambda}_t - 1) / \lambda] + b_2 [(PD^{\lambda}_t - 1) / \lambda] + b_3 [(Y^{\lambda}_t - 1) / \lambda] + \omega_t \dots (10)$$

If $\lambda = 0$, then we adopt the loglinear form and if $\lambda = 1$, then a linear function is more appropriate. Box and Cox suggest that the maximum likelihood method is used to estimate the above equation to avoid the problem of serial correlation.

We will do three types of unit root tests to check whether our variables are stationary or not. The first test is an augmented Dickey-Fuller (ADF) test which is an extension of the Dickey-Fuller test (See Dickey and Fuller, 1979 and 1981). The ADF test entails estimating the following regression equation (with an autoregressive process):

$$\Delta y_t = c_1 + \omega y_{t-1} + c_2 t + \sum_{i=1}^p d_i \Delta y_{t-1} + v_t \dots \dots \dots (11)$$

In the above equation, y is the relevant time series, Δ is a first-difference operator, t is a linear trend and v_t is the error term. The above equation can also be estimated without including a trend term (by deleting the term $c_2 t$ in the above equation). If $\omega = 0$, then there is no unit root.

The Phillips-Perron (1988) test is well suited for analysing time series whose differences may follow mixed ARMA (p,q) processes of unknown order in that it the test statistic incorporates a nonparametric allowance for serial correlation and heteroscedasticity in testing the regression. It involves estimating the following equation:

$$y_t = \tilde{c}_0 + \tilde{c}_1 y_{t-1} + \tilde{c}_2 (t - T/2) + v_t \dots \dots (12)$$

where T is the number of observations and v_t is the error term. If $\tilde{c}_1 - 1 = 0$, then there is no unit root. As in the ADF test, we can drop the trend term to test the stationarity of a variable without the trend.

The Kwiatkowski-Phillips-Schmidt-Shin (KPSS hereinafter) (1992) takes trend or level stationarity as the null hypothesis unlike the ADF and PP tests which take the unit root as the null. The test is based on the equation

$$y_t = c_t + c_2 t + v_t \dots\dots(13)$$

where v_t is the random error, t is the time trend as before and c_t follows the random walk $c_t = c_{t-1} + \mu_t$

with μ_t being a random error and having a variance σ_μ^2 . The null hypothesis is: $\sigma_\mu^2 = 0$. As with other tests, we can drop the trend term in (13) if we want to test the stationarity of a non-trended variable.

If any variable is found to be non-stationary, we will test whether such a variable is stationary in its first-differenced form. If each variable is stationary or achieves stationarity after first-differencing, we will proceed with the multivariate cointegration tests. These tests were pioneered by Johansen (1988) and Johansen and Juselius (1990). Dickey, Jansen and Thornton (1991) provide a step-by-step method of applying the Johansen procedure which we closely follow. Consider the vector autoregressive model

$$y_t = c_1 y_{t-1} + c_2 y_{t-2} + \dots\dots\dots + c_p y_{t-p} + v_t \dots\dots\dots(14)$$

Steps:

- (I) Choose an autoregressive order p .
- (II) Regress Δy_t on $\Delta y_{t-1}, \Delta y_{t-2}, \dots, \Delta y_{t-p+1}$, and output the residuals, D_t . For each t , D_t has n elements.
- (III) Regress y_{t-p} on $\Delta y_{t-1}, \Delta y_{t-2}, \dots, \Delta y_{t-p+1}$ and output the residuals, L_t . For each t , L_t has n elements.

(IV) Compute squares of the canonical correlations between D_t and L_t . Call these $\rho_1^2 > \rho_2^2 \dots > \rho_n^2$

(V) Let N denote the number of time periods available in the data,

$$\text{Trace test statistic} = -N \sum_{i=k+1}^n \ln(1 - \rho_i^2)$$

$$\text{Maximal eigenvalue test statistic} = -N \ln(1 - \rho_{k+1}^2)$$

We now review a number of important studies which estimated aggregate import demand function for Greece. In a study of Greek imports during the period 1953-64, Sarantides (1972) found that price elasticity of aggregate import and income elasticity of aggregate imports to be elastic. He used the absolute price version as given in equation (2). Prodromidis (1975) used the relative price version to estimate disaggregated import demand functions for many products separately as well as for total merchandise imports. Merchandise imports were found to be income elastic but not price elastic for the period 1961-69. Bahmani-Oskoei (1986) using the relative price version and an additional explanatory variable, export-weighted effective exchange rate, found relative price elasticity and income elasticity of imports to be inelastic for Greece both in the short and in the long run for the quarterly period 1973.I : 1979. III.

There is a serious drawback to all of these studies. None of them addressed the question of stationarity of the time series. Thus, as Granger and Newbold (1974) and Phillips (1986) show, it is possible that these studies estimated spurious regressions. In this study, we will first test the stationarity of the time series.

III: EMPIRICAL RESULTS

Let M_t be real import (c.i.f. import in billions of drachmas divided by the import price index), PM_t be the import price index (1990=100), PD_t be the wholesale price index (1990=100) and Y_t be the real GDP in billions of drachmas (in 1990 prices). Annual data for 1951-92 are used and all data came from *International Financial Statistics* (CD ROM version, December 1994). Hakkio and Rush (1991) argue that increasing the number of observations by using monthly or quarterly data do not add any robustness to the results in tests of cointegration. What matters more is the length of the period under consideration. Hence, we believe that 42-year period is sufficient for robustness of the estimates/tests..

First, we perform the Box-Cox test described earlier to see whether the log-linear or linear model should be pursued. Next, we check for the stationarity of the time-series. If the dependent variable and the independent variables are all stationary, we can estimate the model as described in the earlier section. If all the variables are non-stationary in levels (that is, they have unit roots), we have to test for cointegration. If we find that our variables are cointegrated, then we can also estimate the model by OLS. We can still get the short-run and long-run elasticities as discussed earlier.

Asseery and Peel (1991) used the model to estimate the import demand functions for five countries: Canada, Japan, United Kingdom, United States and West Germany. Doroodian, Koshal and Al-Muhanna (1994) used a similar model to study the aggregate import demand for Saudi Arabia.

Our Box-Cox test (using the maximum likelihood method) finds $\lambda = 0.14$. The test statistic is 35.6658 and the relevant critical value of χ^2 distribution with one degree of freedom at 5 percent level of significance is 3.84. Thus, we reject the null

hypothesis of the linear model and adopt the log-linear model. Other studies [Khan and Ross (1977) for US, Canada and Japan and Boylan, Cuddy and O'Muircheartaigh (1980) for Belgium, Denmark and Ireland] find the log-linear model more appropriate. Also, we use the absolute price version because as the relative price version assumes that the influence of import price and the domestic price to be equal in magnitude but opposite in sign. However, as Murray and Ginman (1976) showed, this is not borne out by empirical estimates.

Results of the Augmented Dickey-Fuller tests are in table 1.

Table 1: Augmented Dickey Fuller (ADF) Unit Root Tests

Variable	ADF Test Statistic *	Lag Order **
$\ln M_t$	$T_\tau = -2.0893$	1
$\ln PM_t$	$T_\mu = 0.7519$	1
$\ln PD_t$	$T_\mu = 1.0451$	1
$\ln Y_t$	$T_\tau = 0.1147$	0

* T_τ and T_μ are test statistics (1) with drift and trend and (2) with drift and no trend respectively. Critical values are from Fuller (1976), table 8.5.2, p. 373.

**The lag order was determined using the Akaike Information Criterion (AIC).

The above results indicate that the null hypothesis of a unit root cannot be rejected even at the 10 per cent level for any variable. Thus, ADF tests show all four variables are non-stationary. Results of the Phillips-Perron tests are in table 2.

Table 2: Phillips-Perron (PP) Unit Root Tests (Truncation lag^{*}=3)

Variable	Test Statistic
$\ln M_t$	-1.7796 ^(a)
$\ln M_t$	1.0022 ^(b)
$\ln PD_t$	3.5784 ^(b)
$\ln Y_t$	0.5626 ^(a)

The truncation lag was determined using the Schwert (1989) Criterion. The truncation lag = integer $[4(T/100)^{1/4}]$ where T stands for the number of observations (42 in our case).

(a) indicates test statistic with drift and trend and (b) indicates test statistics with drift and no trend. Critical values are from Fuller (1976), table 8.5.2, p. 373.

The above results also indicate that we cannot reject the null hypothesis of a unit root for all variables at the 10 per cent level. Table 3 gives the results of the KPSS unit root tests.

Table 3: Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Unit Root Tests (Truncation lag^{*}=3)

Variable	Test Statistic
$\ln M_t$	1.5888 ^(a)
$\ln M_t$	1.0138 ^(b)
$\ln PD_t$	1.0263 ^(b)
$\ln Y_t$	2.1185 ^(a)

The truncation lag was determined using the Schwert (1989) Criterion. The truncation lag = integer $[4(T/100)^{1/4}]$ where T stands for the number of observations (42 in our case).

(a) indicates test statistic with drift and trend and (b) indicates test statistics with drift and no trend. Critical values are from Kwiatkowski, Phillips, Schmidt and Shin (1992), table 1, p. 166.

We cannot accept the null hypothesis of no unit root. Thus, our model is robust as it gives the same results irrespective of the tests that are used. Extensive

tests were conducted to see whether all the variables are in the model are $I(1)$, i.e., whether the variables in their first differences are stationary. Each variable was found to be stationary in its first differenced form. Results are not reported here for brevity.

Next we apply the Johansen-Juselius test to see whether the variables in the Greek import demand function are cointegrated. Using a maximum likelihood method, one can get estimates of cointegrating vectors for a number of variables. All the reported results are for the transformed series using logarithms of the original series. Johansen-Juselius multivariate method of testing for cointegration is an improvement over the Engle-Granger (1987) method. Table 4 gives the results of the maximal eigenvalue tests and table 5 gives the results of the trace tests. Both tables give the values for the non-trended and no trend in data generating process cases. The lag of one was used to estimate the VAR model. Tests were also conducted using trended cases and with trend in data generating process cases. Tests were conducted with different lags as well. However, the qualitative nature of the results did not change.

Table 4: Maximal Eigenvalue Tests using Johansen-Juselius Maximum Likelihood Procedure (Non-trended case)

Null	Test Statistic	Critical Value*
$H_0: k = 0$	135.8748**	28.1380
$H_0: k \leq 1$	41.1147**	22.0020
$H_0: k \leq 2$	30.6311**	15.6720
$H_0: k \leq 3$	1.8575	9.2430

Note: Lag of 1 was used.

*Critical values are for the 95% quantile. These are from Johansen and Juselius (1990).

**Significant at the 5% level.

Table 5: Trace Tests using Johansen-Juselius Maximum Likelihood Procedure (Non-trended case)

Null	Test Statistic	Critical Value*
$H_0: k = 0$	209.4780**	53.1160
$H_0: k \leq 1$	73.6032**	34.9100
$H_0: k \leq 2$	32.4886**	19.9640
$H_0: k \leq 3$	1.8575	9.2430

Note: Lag of 1 was used.

*Critical values are for the 95% quantile. These are from Johansen and Juselius (1990).

**Significant at the 5% level.

Both the maximal eigenvalue and trace tests indicate that we can reject the null hypothesis of no cointegration. Both tests indicate that the number of cointegrating vectors is equal to 3. Therefore, we can estimate the import demand equation in level form even though the variables in our function are non-stationary. A linear combination of the variables is stationary. The results of estimating equation (9) by OLS are in table 6.

Table 6: OLS Estimates of Equation (9)

Variable	Coefficient	T ratio
$\ln PM_t$	-0.59132	-4.682*
$\ln PD_t$	0.61838	4.831*
$\ln Y_t$	1.3127.	6.300*
$\ln M_{t-1}$	0.050881	0.3433
Constant	-9.0517	-6.203*

$R^2 = 0.9970$ Adjusted $R^2 = 0.9967$ F ratio = 1344.121*

*Significant at the 1% level.

The appropriate test statistic for testing serial correlation where we have the lagged dependent variable as a regressor is Durbin's h-test (see Durbin 1970) where

$$h = \hat{\rho} \sqrt{\frac{n}{1 - n\hat{V}(\hat{\alpha})}}$$

In the above equation, $\hat{\rho}$ is the estimated first-order serial correlation from the OLS residuals, $\hat{V}(\hat{\alpha})$ is the estimated variance of the OLS estimate of α (the estimated coefficient on the lagged dependent variable) and n is the sample size. h is approximately normally distributed with unit variance. Thus, the test for first-order serial correlation can be done by using the standard normal distribution table.

However, in our case, $1 - n\hat{V}(\hat{\alpha})$ is negative and thus, h statistic cannot be estimated.

In such cases, Durbin suggests an alternative test. We need to regress the residuals from the OLS estimation on lagged residuals and other independent variables. There is first-order serial correlation if the coefficient of the lagged residual is significant. In our case, the coefficient is not significant at 5% per cent level. Thus, we cannot reject the null hypothesis of no serial correlation.

Since the equation is estimated in log-form, the coefficients give us the short run elasticities. Thus, in the short run, price elasticity and cross price elasticity (with respect to domestic price) of import demand are inelastic. However, income elasticity is in the elastic range. The estimated long run elasticities are given in table 7.

Table 7: Long run Elasticities of Import Demand

Price elasticity	-0.62302
Cross price elasticity	0.65153
Income elasticity	1.38307

Our results are similar to those of Prodromidis who also found Greek import demand to be price inelastic but income elastic. However, our methodology is much stronger as we take into account nonstationarity.

IV: SUMMARY AND CONCLUSIONS

This study estimates the aggregate import demand equation for Greece using annual data for the period, 1951-92. Unlike previous studies on import demand, this study uses the cointegration methodology. Also, we test for the appropriate form of the import demand function before estimation. We find that the variables used in the aggregate import demand function are not stationary but cointegrated. Thus, there exists a long run equilibrium relationship among these variables during the period under study. However, the long run estimates do not differ greatly from short term estimates.

The inelasticity of import with respect to import price implies that during the period under study, imports were largely determined by non-price factors. On the other hand, we find income elasticity to be positive and significant. Thus, the persistent trade deficit problem of Greece is unlikely to get better as real income goes up. However, since we do not estimate export elasticity, we cannot be sure whether

Marshall-Lerner condition is met. Since the long run import elasticity is not very high, there seems to be limited scope for using exchange rate policies to correct the balance of problem.

REFERENCES:

- Asseery, A. and Peel, D. A. (1991) "Estimates of a Traditional Aggregate Import Demand Model for Five Countries," *Economics Letters*, 35, 435-39.
- Bahmani-Oskoei, M., (1986) "Determinants of International Trade Flows," *Journal of Development Economics*, 20, 107-23
- Boylan, T., Cuddy, M. and O'Muircheartaigh. (1980) "The Functional Form of the Aggregate Import Demand Equation," *Journal of International Economics*, 10, 561-66.
- Box, G. E. P. and Cox, D. R. (1964) "An Analysis of Transformations," *Journal of the Royal Statistical Society, Series 26*, 211-43.
- Dickey, D. A. and Fuller, W. A. (1979) "Distributions of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association*, 74, 427-31.
- _____ (1981) "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root," *Econometrica*, 49, 1057-72.
- Dickey, D. A., Jansen, D. W. and Thornton, D. L. (1991) "A Primer on Cointegration with an Application to Money and Income," *Federal Reserve Bank of St. Louis*, March/April, 58-78.
- Doroodian, K., Koshal, R. K. and Al-Muhanna, S. (1994) "An Examination of the Traditional Aggregate Import Demand Function for Saudi Arabia," *Applied Economics*, 26, 909-15.
- Durbin, J. (1970) Testing for serial correlation in least squares regression when some of the regressors are lagged dependent variable, *Econometrica*, 38, 410-21.
- Engle, R. F. and Granger, C. W. J. (1987) "Cointegration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, 55, 251-76.
- Fuller, W. A. (1976) *Introduction to Statistical Time Series* (John Wiley, New York).
- Goldstein, M. and Khan, M. S. (1985) "Income and Price Effects in Foreign Trade," in Jones, R. W. and Kennen, P. B. (eds.), *Handbook of International Economics*, (North Holland, Amsterdam), Vol II, Ch. 20.
- Granger, C. W. J. and Newbold, P. (1974) "Spurious Regressions in Econometrics," *Journal of Econometrics*, 2, 111-20.

Hakkio, C. S. and Rush, M. (1991) "Cointegration: How Short is the Long Run?" *Journal of International Money and Finance*, 10, 571-81.

International Monetary Fund (1994) *International Financial Statistics*, CD-ROM version, December.

Johansen, S. (1988) "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, 12, 231-54.

Johansen, S. and Juselius, K. (1990) "The Maximum Likelihood Estimation and Inference on Cointegration -- with Application to Demand for Money," *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Khan, M. S. and Ross, K. (1977) "The Functional Form of the Aggregate Import Demand Equation," *Journal of International Economics*, 7, 149-60.

Kwiatkowski, D, Phillips, P. C. B., Schmidt, P. and Shin, Y. (1992) "Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root," *Journal of Econometrics*, 54, 159-78.

Murray, T. and Ginman, P. J. (1976) "An Examination of the Traditional Aggregate Import Demand Model," *Review of Economics and Statistics*, 58, 75-80.

Paleologos, J. M. (1993) "An Investigation on the Effectiveness of the Devaluation Policy in the Case of the Greek Economy: 1975 I - 1991 II," *Economia-Internazionale*, 46, 247-58.

Phillips, P. C. B. and Perron, P. (1988) "Time Series Regression with a Unit Root," *Biometrika*, 75, 335-46.

Phillips, P. C. B. (1986) "Understanding Spurious Regressions in Economics," *Journal of Econometrics*, 33, 311-40.

Prodromidis, K. P. (1975) "Greek Disaggregated Import and Export Demand Functions," *Weltwirtschaftliches-Archiv*, 111, 370-380.

Sarantides, S. A. (1972), "Import Demand Functions for Greece 1954-63," *Economia Internazionale*, 25, 107-14.

Schwert, G. W. (1989), "Test for Unit Roots: A Monte Carlo Investigation," *Journal of Business and Economic Statistics*, 7, 147-60.

Zarembka, P. (1974) "Transformation of Variables in Econometrics," in Zarembka, P. (ed.) *Frontiers in Econometrics* (Academic Press, New York)