CHUNG-HUA INSTITUTION FOR ECONOMIC RESEARCH

ESTIMATION OF THE AR(1) MODEL CONTAINING A DUMMY VARIABLE

AN-LOH LIN

DISCUSSION PAPER SERIES No.9601

January 1996

Discussion Paper Series No. 9601

Estimation of the AR(1) Model Containing a Dummy Variable

by

An-loh Lin

Research Fellow

Chung-Hua Institution for Economic Research

January 1996

CHIER

Chung-Hua Institution for Economic Research

75 Chang-Hsing St., Taipei, Taiwan 106

Republic of China

AN-LOH LIN[*]

Estimation of the AR(1) Model Containing a Dummy Variable

Abstract

This paper examines a specification error which might have been committed by numerous authors in using a dummy variable in the AR(1) model. Theoretical and simulation results are obtained for the misspecified model, which omits a relevant lagged dummy variable.

Keywords: Dummy Variables, Dummy Functions, Distributed Lag Models, Specification Errors, Lagged Dependent Variables.

I. Introduction

This paper examines a specification error which might have been committed by numerous authors in using a dummy variable in the AR(1) model. A simple example is

---

[*] The author is a research fellow at Chung-Hua Institution for Economic Research, Taipei, Taiwan. He is thankful to Ping-Wen Chiu for research assistance, Nancy Zigmund for editorial improvements, and Chi Chow of Chung-Hua for comments.

$$Y_t=a+bX_t+cY_{t-1}+dD_t+v_t, \qquad ($$

where v_t is an error term and D_t, a dummy variable, may assume the val 1 for $t=t_1$ (type A), $t_2 \leq t \leq t_3$ (type B), or $t \geq t_4$ (type C), and 0 otherwis Some actual examples using this type of equation are Margo (1984), Bo and Giannini (1985), Bernanke (1986), Blecker (1989), Garman a Richards (1992), and Ramirez (1994).

However Equation (1) will not be appropriate if the effect of t dummy variable added does not decline exponentially as implied by t model. In particular, if its effect is limited totally to the current period, many outliers or unusual events will be, the following equation shou apply:

$$Y_t=a+bX_t+cY_{t-1}+dD_t-cdD_{t-1}+w_t, \qquad ($$

which has an additional term for the lagged dummy variable. Equation (is thus misspecified if Equation (2) is the correct model. It is shown this paper the OLS estimate of the coefficient d based on the misspecifi model will be inconsistent if the dummy variable is of type B or C.

The purpose of this paper is to examine the misspecification proble and compare the simulation results of (1) and (2).

II. Specification

The dynamic impact of a dummy variable can be expressed by a dumn function $f(D_t)$ for D_t as defined above. The function, following Jorgens (1966) and Box and Tiao (1975), can generally assume a ratior distributed lag form of

$$f(D_t)=[N(L)/D(L)]D_t \qquad ($$

with N and D being two polynomial functions of the lag operator L. F our purpose, we let $N(L)=d$ and $D(L)=1$ or $1-cL$. Thus we examine or two cases: dD_t and $[d/(1-cL)]D_t$. The effect of the dummy variable la only one period for the first case while it diminishes exponentially for t second case.

We consider the Koyck distributed-lag model for demonstration. The model can be specified as:

$$Y_t=a^*+[b/(1\text{-}cL)]X_t+f(D_t)+u_t. \tag{4}$$

A substitution of $[d/(1\text{-}cL)]D_t$ into (4) for $f(D_t)$ yields Equation (1), with $a=a^*(1\text{-}c)$ and $v_t=u_t\text{-}cu_{t-1}$, by making the rates of decline (c) for both X_t and D_t identical in order to stay with the AR(1) model. Likewise, substituting dD_t into (4) then yields Equation (2), a similar version of which was used by Gregory and MacKinnon (1980) in their estimation of the demand for money in Canada. These two equations thus imply two different courses of dynamic impact for the dummy variable D_t.

III. Estimation

It is well known that in the presence of Y_{t-1} the OLS estimates for (1) or the restricted LS estimates for (2), assuming each to be correctly specified, cannot be said to be unbiased but will be consistent if v_t or w_t is well-behaved. However, it can be shown that the OLS estimate of the coefficient d for (1), as a misspecified model of (2), will be inconsistent if the dummy variable is of type B or C.

To demonstrate this, let w_t be white noise and let the relevant lagged dummy term be omitted from (2) so that: $v_t=w_t\text{-}cdD_{t-1}$ and $E(v_t)=\text{-}cdD_{t-1}$ for (1). The OLS estimator of (1) is then given by

$$\hat{\beta}=(Z'Z)^{-1}Z'Y=\beta+(Z'Z)^{-1}Z'w\text{-}cd(Z'Z)^{-1}Z'D_{-1}, \tag{5}$$

where $\hat{\beta}=(\hat{h}\ \hat{d})'$, $h=(\hat{a}\ \hat{b}\ \hat{c})'$, Y, $Z=(H\ D)$, $H=(1\ X\ Y_{-1})$, and w are all in vector or matrix form.

Since both Y_{-1} and w are stochastic, the multiplicative terms in (5) cannot be separated out when the mathematical expectation of $\hat{\beta}$ is taken. Thus $\hat{\beta}$ cannot be said to be unbiased and will probably be biased for small sample sizes, as the last two terms of (5) will not be likely to vanish or cancel out.

To obtain the probability limit (plim) of $\hat{\beta}$, we first evaluate the inverse of $Z'Z$ by partitioning before seeking any plim because plim $(1/n)(Z'Z$ which involves a dummy variable, is a singular matrix and hen $[\text{plim}(1/n)(Z'Z)]^{-1}$ does not exist. Let $B=H'H-H'D(D'D)^{-1}D'H=H'M$ and $M=[I-D(D'D)^{-1}D']$, M being a symmetric idempotent matrix f $M'M=M$. Since MH is a nx3 matrix whose ith column consists of estimated residuals from the regression of the ith variable of H on t dummy variable D, $B=(MH)'(MH)$ is a 3x3 matrix of squared a cross-product sums of the estimated residuals and $\text{plim}[(1/n)(B)]^{-1}=\Sigma_{hh}^{-1}$ assumed to exist. Thus

$$(Z'Z)^{-1}(Z'w) = \begin{bmatrix} H'H & H'D \\ D'H & D'D \end{bmatrix}^{-1} \begin{bmatrix} H'w \\ D'w \end{bmatrix}$$

$$= \begin{bmatrix} B^{-1} & -B^{-1}H'D(D'D)^{-1} \\ -(D'D)^{-1}D'HB^{-1} & (D'D)^{-1}+(D'D)^{-1}D'HB^{-1}H'D(D'D)^{-1} \end{bmatrix} \begin{bmatrix} H'w \\ D'w \end{bmatrix}$$

$$= \begin{bmatrix} B^{-1}(MH)'w \\ -(D'D)^{-1}D'HB^{-1}(MH)'w+(D'D)^{-1}D'w \end{bmatrix}$$

and,

$$\text{plim}[(Z'Z)^{-1}(Z'w)] = \begin{bmatrix} \text{plim}[(1/n)B]^{-1}\text{plim}(1/n)[(MH)'w] \\ \{-\text{plim}[(1/n)(D'D)^{-1}]\text{plim}[(1/n)(D'H)] \\ \text{plim}[(1/n)B]^{-1}\text{plim}(1/n)[(MH)'w] \\ +\text{plim}[(1/n)(D'D)]^{-1}\text{plim}[(1/n)(D'w)]\} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

since MH and w are uncorrelated as assumed and so are D and w. By same token, we have:

$$\text{plim}[(Z'Z)^{-1}(Z'D_{-1})] = \begin{bmatrix} \text{plim}[(1/n)B]^{-1}\text{plim}(1/n)[(MH)'D_{-1}] \\ \{-\text{plim}[(1/n)(D'D)^{-1}]\text{plim}[(1/n)(D'H)] \\ \text{plim}[(1/n)B]^{-1}\text{plim}(1/n)[(MH)'D_{-1}] \\ +\text{plim}[(D'D)^{-1}(D'D_{-1})]\} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1-1 \end{bmatrix}$$

where m is the duration of the dummy, with m=1 for type A, m=m type B, and m=∞ for type C, since $\text{plim}[(D'D)^{-1}(D'D_{-1})]=\text{plim}[(1/m)(m-$

$=\text{plim}[1-(1/m)]=1-(1/m)$ for finite duration and 1 for infinite duration as n tends to infinity. Also, $\text{plim}(1/n)[(MH)'D_{-1}]=0$ for MH is a matrix consisting of the estimated OLS residuals.

As a result, the probability limit of $\hat{\beta}$ is given by

$$\text{plim}(\hat{\beta})=\beta+\text{plim}[(Z'Z)^{-1}(Z'w)]-cd\,\text{plim}[(Z'Z)^{-1}(Z'D_{-1})]$$

$$=\begin{bmatrix} a \\ b \\ c \\ d[1-(1-1/m)c] \end{bmatrix} \tag{6}$$

Thus consistency of the OLS estimates of a, b, and c is not affected by the omission of the lagged dummy variable irrespective of the type of the dummy variable used. However the estimated coefficient of the dummy variable is consistent only for type A (or any similar type such that $D'D_{-1}=0$) but not for type B or C. As shown, $\text{plim}(\hat{d})=d[1-(1-1/m)c]$ for type B and $\text{plim}(\hat{d})=d(1-c)$ for type C, both of which are smaller than d in absolute value since $0<c<1$ is assumed.

IV. Simulation

To examine the issues of bias and consistency for the models (1) and (2), a simulation experiment is performed. We first generate Y^*_t, without a dummy variable, using the following two equations:

$$Y^*_t=2+X_t+cY^*_{t-1}+v_t, \tag{7}$$

$$Y^*_0=[7/(1-c)]+[1/\sqrt{(1-c^2)}]v_0, \tag{8}$$

where X_t and v_t are normal random variables and independently, identically distributed, with means equal to 5 and 0, respectively, and both having a unit standard deviation. As specified, Y^*_0 (initial value) has the same normal distribution as Y^*_t with the mean given by $7/(1-c)$ and the variance by $1/(1-c^2)$. We let c (rate of decline) take three different values, 0.8, 0.5 and 0.2, to examine their effect on estimation.

Next, three types of dummies are created: $D_t=1$ for $t=6$ (type A), $6\leq t\leq 8$

(type B), or t≥6 (type C), and 0 otherwise. Each Y_t, with a dummy, is the given by

$$Y_t=Y^*_t+8D_t.$$ (9

where Y^*_t is dummy-free. Thus the impact of the dummy in each perio is assumed to last only one period. The assumed coefficient of the dumm in (9) is about 23% of the mean of Y_t for c=0.8 (or 57% if c=0.5, or 91 if c=0.2).

We let n (sample size) be: 25, 100, 400, 800, and 3,000. In all, 4 cases are considered depending on n, c, and D. To examine the samplin properties of (1) and (2), 500 samples are taken in each case. For a give n, values of X are fixed irrespective of c, the type of D, and samples, b v_t changes with each sample, though not with c and the type of Equation (1) is estimated by the ordinary least squares method (OLS) an Equation (2) by the restricted or nonlinear least squares method (RLS).

V. Results

We first compare the size of bias for (1) and (2). The bias, if it exists, caused by the presence of Y_{t-1} for (2), but it is also caused by the missin lagged dummy for (1) as well. Table 1 presents the average and standar deviation (in parentheses) of 500 estimates of each parameter for the thre types of dummies (A, B, and C) under each c (0.8, 0.5, and 0.2), for n=2

The results indicate, first, that the intercept (a=2) is grossly overstate particularly for (1), when the adjustment is slow (c=0.8). Take dummy for example, the averaged estimate of a is 18.8 for (1) and 5.3 for (2), compared with the assumed value of 2. The true value is three standar deviations below 18.8 but only 0.65 of a standard deviation below 5. Thus the misspecification causes the bias to increase greatly. The bia however is sizably reduced for a small c (0.2) and does not seem to diff very much among the three types of dummies. Second, the bias for c downward for both equations and is extremely large for (1). Moreover, appears to increase relatively when c is small. Third, the estimated b essentially unbiased for (2) regardless of c and D. This is also true for (with the exception of type A with c=0.8 or 0.5. Finally, the estimated is seen to be unbiased for (2). But it is biased downward for (1), with the bias increasing for lengthier dummy and decreasing with smaller c.

We next examine the issue of consistency and the speed of convergence in view of the simulation results. The averaged estimates and the standard deviations are given in Table 2 for four sample sizes (100, 400, 800 and 3,000) for c=0.8. The estimates for c=0.5 or 0.2 are not provided because of their similarity. Since the estimated b and d for (2) and the estimated b for (1) are unbiased as noted above, our focus will be on the rest of the estimated coefficients.

First, the estimated a and c are seen to converge to the assumed values for (2) when n=800 for the three types of dummies. But the convergence is very slow, requiring n>3,000, for the misspecified model. Second, the estimated d converges to 8 for (1) when n=800 in the case of dummy A, but it decreases as n increases for dummies B and C. Again it requires n>3,000 for the estimated d to converge to its probability limit of 3.73, as given by d[1-(2/3)c], for dummy B, or 1.6, which is equal to d(1-c), for dummy C. Thus, the estimates of d for types B and C are found to be clearly inconsistent for the misspecified model.

VI. Conclusion

This paper examines the dynamic impact of a dummy variable in the AR(1) model. It argues that the impact may not diminish exponentially as generally assumed. In many cases the impact may be short-lived, lasting for one period, and the addition of a one-period restricted lagged dummy is thus required. Failing to do this will result in a specification error which will gravely bias the estimates of the intercept and the rate of decline, and will also make the estimated coefficient of the dummy variable inconsistent unless the dummy is of the type such that $D_t' D_{t-1}=0$, where D_t is the vector of dummy values. The simulation results also indicate that the convergence of the above-mentioned parameters to their probability limits is very slow for the misspecified model. Thus consistency seems to be a virtue of cold comfort to practitioners even if it exists despite misspecification.

Table 1 Average (Standard Deviation) of 500 Estimates of Each Parameter for Equations (1) and (2) Under the Three Types of Dummies for n=25

Equation:	(1)$Y_t=a+bX_t+cY_{t-1}+dD_t+v_t$ estimated by OLS				(2)$Y_t=a+bX_t+c_{t-1}+dD_t\text{-}cdD_{t-1}+w_t$ estimated by RLS			
Dummy(D)	a=2	b=1	c	d=8	a=2	b=1	c	d=8
				c=0.8				
A	18.807	0.746	0.370	7.614	5.296	0.979	0.713	7.8
	(5.540)	(0.245)	(0.146)	(1.352)	(5.084)	(0.232)	(0.127)	(0.8
B	19.682	1.057	0.301	6.268	5.609	0.978	0.704	7.9
	(5.630)	(0.319)	(0.121)	(1.421)	(5.507)	(0.266)	(0.136)	(0.8
C	18.052	0.997	0.344	6.021	6.078	0.962	0.692	8.0
	(5.903)	(0.277)	(0.134)	(1.519)	(6.309)	(0.271)	(0.158)	(1.3
				c=0.5				
A	7.313	0.862	0.183	7.677	2.870	0.996	0.443	7.8
	(1.996)	(0.239)	(0.110)	(1.323)	(2.849)	(0.239)	(0.157)	(1.0
B	7.213	0.984	0.145	7.352	3.240	0.981	0.422	8.0
	(2.453)	(0.266)	(0.096)	(1.065)	(5.507)	(0.264)	(0.166)	(0.9
C	6.378	1.007	0.187	6.781	3.239	0.977	0.420	8.0
	(2.512)	(0.256)	(0.107)	(1.163)	(3.198)	(0.258)	(0.177)	(1.0
				c=0.2				
A	3.424	0.955	0.069	7.864	2.250	1.007	0.169	7.9
	(1.502)	(0.245)	(0.097)	(1.243)	(2.197)	(0.246)	(0.174)	(1.2
B	3.406	0.992	0.048	7.840	2.534	0.993	0.145	8.0
	(1.912)	(0.260)	(0.091)	(0.917)	(2.334)	(0.251)	(0.174)	(0.7
C	3.123	1.009	0.066	7.576	2.509	0.992	0.145	8.0
	(1.900)	(0.252)	(0.102)	(1.028)	(2.203)	(0.241)	(0.170)	(0.6

Equation (1) is a misspecified model of equation (2). n=sample size. OLS=ordinary least squ RLS=restricted least squares. Values of X_t remain fixed irrespective of c, D, and samples. Fi shown are the average of 500 estimates and those in parentheses are the standard deviation o estimates. A: $D_t=1$ for t=6 and 0 otherwise. B: $D_t=1$ for $6\leq t\leq 8$ and 0 otherwise. C: $D_t=$ $6\leq t$ and 0 otherwise.

Table 2 Average (Standard Deviation) of 500 Estimates of Each Parameter for Equations (2) and (3) Under the Three Types of Dummies for Various Sample Sizes for c=0.8

Equation:	(1) $Y_t=a+bX_t+cY_{t-1}+dD_t+v_t$ estimated by OLS				(2)$Y_t=a+bX_t+cY_{t-1}+dD_t-cdD_{t-1}+w_t$ estimated by RLS			
n	a=2	b=1	c=.8	d=8	a=2	b=1	c=.8	d=8
				$D_t=1$ for t=6 and 0 otherwise				
100	6.887	0.920	0.669	8.223	2.717	0.995	0.780	8.011
	(2.416)	(0.103)	(0.065)	(0.975)	(1.784)	(0.101)	(0.049)	(0.748)
400	3.041	1.011	0.769	7.936	2.171	0.999	0.795	7.927
	(0.945)	(0.048)	(0.025)	(1.023)	(0.853)	(0.048)	(0.023)	(0.801)
800	2.467	0.997	0.787	8.050	2.044	1.001	0.799	8.046
	(0.652)	(0.038)	(0.017)	(1.023)	(0.617)	(0.038)	(0.016)	(0.778)
3000	2.152	0.998	0.796	8.077				
	(0.292)	(0.018)	(0.008)	(0.995)				
				$D_t=1$ for $6 \leq t \leq 8$ and 0 otherwise				
100	8.886	0.936	0.609	5.082	2.741	0.995	0.779	8.047
	(2.714)	(0.105)	(0.073)	(0.877)	(1.797)	(0.102)	(0.049)	(0.747)
400	3.382	1.038	0.755	4.024	2.175	0.999	0.795	7.952
	(0.985)	(0.048)	(0.026)	(0.665)	(0.854)	(0.048)	(0.023)	(0.783)
800	2.951	0.993	0.774	3.906	2.045	1.001	0.799	8.025
	(0.686)	(0.038)	(0.018)	(0.603)	(0.617)	(0.038)	(0.016)	(0.770)
3000	2.201	1.002	0.794	3.824				
	(0.297)	(0.018)	(0.008)	(0.602)				
				$D_t=1$ for $6 \leq t$ and 0 otherwise				
100	6.055	1.030	0.680	2.578	2.757	0.995	0.779	8.014
	(2.496)	(0.105)	(0.068)	(0.852)	(1.837)	(0.102)	(0.050)	(1.059
400	2.970	1.020	0.769	1.880	2.189	0.999	0.795	7.963
	(0.984)	(0.048)	(0.025)	(0.552)	(0.904)	(0.048)	(0.023)	(1.137
800	2.498	1.013	0.783	1.787	2.028	1.000	0.799	8.096
	(0.751)	(0.038)	(0.017)	(0.493)	(0.662)	(0.038)	(0.016)	(1.112
3000	2.085	1.001	0.798	1.652				
	(0.521)	(0.018)	(0.008)	(0.452)				

See explanations given in table 1

References

Bernanke, B.S., 1986, "Employment, Hours, and Earnings in t Depression: An Analysis of Eight Manufacturing Industries *American Economic Review* 76, pp.82-109.

Blecker, R.A., 1989, "Markup Pricing, Import Competition, and t Decline of the American Steel Industry," *Journal of Post Keynesi Economics* 12, pp.70-87.

Bodo, G. and C. Giannini, 1985, "Average Working Time and t Influence of Contractual Hours: An Empirical Investigation for t Italian Industry" (1970-1981), *Oxford Bulletin of Economics a Statistics* 47, pp.131-151.

Box, G.E.P. and G.C. Tiao, 1975, "Intervention Analysis with Applications to Economic and Environmental Problems," *Journal the American Statistical Association* 70, pp.70-79.

Garman, D.M. and D.J. Richards, 1992, "Wage-Price Flexibility, Mark Power, and the Cyclical Behavior of Real Wages, 1959-1980 *Quarterly Journal of Economics* 107, pp.1437-1449.

Gregory, A.W. and J.G. MacKinnon, 1980, "Where's My Cheque?: Note on Postal Strikes and the Demand for Money in Canada *Canadian Journal of Economics* 13, pp.683-687.

Jorgenson, D.W., 1966, "Rational Distributed Lag Functions *Econometrica* 34, pp.135-149.

Margo, R.A., 1984, "Accumulation of Property by Southern Blacks Befo World War I: Comment and Further Evidence," *American Econom Review* 74, pp.768-776.

Ramirez, M.D., 1994, "Public and Private Investment in Mexico 1950-90: An Empirical Analysis," *Southern Economic Journal* *pp.1-17.*

Discussion Paper Series

1. Kang Chao and Ellen S. S. Chien. "The Relative Real GDP and Price Structure of Mainland China," 1981. ***(No.8101)***
2. Kang Chao. "Economic Readjustment in Mainland China," 1981. ***(No.8102)***
3. Mingshu Hua. "The Inflationary Effect on the Structure of Trade," 1981. ***(No.8103)***
4. Kang Chao and P. C. Chang. "A Study of Regional Factor Productivities in Chinese Agriculture," 1982. ***(No.8201)***
5. Chun-yuan Wang. "The Spillover Monetary Effect of Devaluation: A Disequilibrium Interpretation of the Cooper Paradox and the 'Reversed'," 1982. ***(No.8202)***
6. Chihwa Kao. "Second-Order Efficiency in the Estimation of Heteroscedastic Regression Models," 1984. ***(No.8401)***
7. Chihwa Kao. "An Em Algorithm for the Heteroscedastic Regression Models with Censored Data," 1984. ***(No.8402)***
8. Hak Choi. "Methods of Generating Demand Functions - A Tabular Review," 1984. ***(No.8403)***
9. Chihwa Kao. "Robust Regression with Censored Data," 1984. ***(No.8404)***
10. Chihwa Kao. "The Bootstrap and the Censored Regression," 1984. ***(No.8405)***
11. San, Gee. "The Early Labor Force Experience of College Students and Their Post-College Success," 1984. ***(No.8406)***
12. Chihwa Kao. "Small Sample Studies of Estimating, the Regression Models with Multiplicative Heteroscedasticity: The Results of Some Monte Carlo Experiments," 1984. ***(No.8407)***
13. San, Gee. "Student Financial Aid, In-School Employment, and Educational and Labor Market Outcomes," 1984. ***(No.8408)***
14. An-loh Lin and Scott A. Monroe. "The Structure of Gasoline Demand Across the United States," 1985. ***(No.8501)***
15. Hak Choi. "Why the EEC-ROC Trade Remains Unimportant," 1985. ***(No.8502)***
16. Hak Choi, J. Chou and D. E. Nyhus. "A Disaggregated Exports Forecasting Model for Taiwan," 1985. ***(No.8503)***

17. Diagee Shaw. ''On-site Samples' Regression: Problems of Nonnegati Integers, Truncation, and Endogenous Stratification,'' 1987. ***(No.8701)***
18. Li-min Hsueh and Su-wan Wang. ''The Implicit Value of Life in the Lab Market in Taiwan,'' 1988. ***(No.8801)***
19. Chien-hsun Chen. ''Modernization in Mainland China: Self-Reliance a Dependence,'' December, 1990. ***(No.9001)***
20. Tain-jy Chen & Wen-thuen Wang. ''The Effects of Production Quotas Economic Efficiency: The Case of Taiwan's Canned Food Industry, December 1990. ***(No.9002)***
21. Ya-hwei Yang. ''The Influence of Preferential Policies on Strateg Industries: An Empirical Study of Taiwan,'' December 199 ***(No.9003)***
22. Solomon W. Polachek & Charng Kao. ''Lifetime Work Expectations a Estimates of Sex Discrimination,'' January 1991. ***(No.9101)***
23. Ke-jeng Lan. ''Inflation Effects on the Labor Market: A Transition R Model,'' April, 1991. ***(No.9102)***
24. Hui-lin Wu, Quen-leng Miao, and Ke-jeng Lan. ''Wage Differentials: Amo College-and-Above Graduates in Taiwan,'' April 1991. ***(No.9103)***
25. George J. Y. Hsu and Tser-yieth Chen. ''Uncertainty and Asymmet Information in the Modelling of Electric-Utility Tariff Regulation,'' M 1991. ***(No.9104)***
26. Ya-hwei Yang. ''An Analysis on the Structure of Interest Rate in the Banki Sector, the Money Market and the Curb Market,'' June 1991. ***(No.9105)***
27. Jiann-chyuan Wang. ''Quota Restriction Policies and Their Impact on Firm Quantity Setting Decision Under 'Learning-By-Doing','' June 199 ***(No.9106)***
28. Jiann-chyuan Wang. ''Cooperative Research in Taiwanese Manufacturing October 1991. ***(No.9107)***
29. Mo-huan Hsing. ''The Empirical Relevance of the Orthodox Dema Theory,'' October 1991. ***(No.9108)***
30. Hui-lin Wu and Ke-jeng Lan. ''Labor Shortage and Foreign Workers Taiwan,'' October 1991. ***(No.9109)***
31. Ji Chou and De-min Wu. ''The Cost of Capital and the Effective Tax R in Taiwan: 1961 - 1985,'' October 1991. ***(No.9110)***
32. George J. Y. Hsu, Pao-long Chang, and Tser-Yieth Chen. ''Industrial Outa Costs in Taiwan: Estimation from a Proposed Curtailable Rate Program Taiwan,'' January 1992. ***(No.9201)***
33. Charng Kao, Solomon W. Polachek, and Phanindra V. Wunnava. ''Ma

Female Wage Differentials in Taiwan: A Human Capital Approach,'' Feb. 1992. ***(No.9202)***

34. Lee-in Chen Chiu. ''The Economic Reunion of Taiwan and the Mainland China: The Impact on Industrial Development,'' May 1992. ***(No.9203)***
35. Yi Chou, Pao-long and Chyan Tuan. ''TQC Chinese Style and Its Management Implication -- Taiwan V.S. Mainland China,'' June 1992. ***(No.9204)***
36. Chung-hua Shen and Lee-rong Wang. ''Testing Efficiency of the Coffee Futures Market -- A Markov Switching Model,'' June 1992. ***(No.9205)***
37. Tain-jy Chen and Hsien-yang Su. ''On-the-Job Training as a Cause of Brain Drain'' July 1992. ***(No.9206)***
38. George J. Y. Hsu, Pao-long Chang and Tser-yieth Chen. ''A Priority Service Program and Power Outage Costs: The Case of Taiwan's Cement Industry,'' October 1992. ***(No.9207)***
39. George J. Y. Hsu and Ai-chi Hsu. ''Energy Intensity in Taiwan's Industrial Sectors: Divisia Index vs. Laspeyres Index,'' October 1992. ***(No.9208)***
40. Lee-in Chen Chiu. ''Regional Differential of Enterprise Efficiency and Labor Productivity in Coastal China,'' December 1992. ***(No.9209)***
41. Chi-ming Hou & Chien-nan Wang. ''Globalization and Regionalization -- Taiwan's Perspective,'' March 1993. ***(No.9301)***
42. Yi Chou. ''The Practice Beyond Property Right Boundaries -- Quality Management in Chinese State-owned Enterprises and Rural Enterprises,'' March 1993. ***(No.9302)***
43. Tzong-shian Yu. ''Economic Development in Transition -- The Case of Taiwan,'' June 1993. ***(No.9303)***
44. Tzong-shian Yu. ''An Analysis of the Effects of Economic Policies on Taiwan's Economic Growth and Stability,'' June 1993. ***(No.9304)***
45. Ke-jeng Lan. ''An Evaluation of the Effectiveness of Government Automation Promotion Schemes in the Electrical Component Industry,'' June 1993. ***(No.9305)***
46. Yi Chou. ''Measurement of Technical Efficiency and Its Management Implications -- The Example of Taiwan Sugar Corporation,'' June 1993. ***(No.9306)***
47. Chien-nan Wang. ''On the Choice of Exchange Rate Regimes,'' June 1993. ***(No.9307)***
48. Yi Chou & Chyau Tuan. ''Quality Management of Chinese Township Enterprises in Inland and in Coastal Areas,'' November 1993. ***(No.9308)***
49. Lee-in Chen, Chiu and Jr-tsung Huang. ''Improvement of Capital Productivity

and Technical Efficiency via DFI: Evidence from the Industrial Interact
between

50. An-loh Lin. "Trade Effects of Direct Foreign Investment: The Bilate
Case," February 1994. ***(No.9401)***
51. Jiann-chyuan Wang and Homin Chen. "The Impact of North Ameri
Economic Integration on Taiwan," March 1994. ***(No.9402)***
52. Joseph S. Lee. "Is There a Bona Fide Labor Movement in Taiwan?" Ap
1994. ***(No.9403)***
53. Jiann-chyuan Wang and Kuen-hung Tsai. "An Evaluation of the Effect
Government Research and Development Promotion Schemes in the Electri
Component Industry," June 1994. ***(No.9404)***
54. Anthony H. Tu. "The Dynamic Self-Hedged Behavior During the Period
1987 Crash: Evidence from the U.S. Stock Market," August 1994. ***(No.94***
55. Ji Chou, Yun-peng Chu & Shiu-tung Wang. "Effects of Trade Liberalizat
on Taiwan -- A Computable General Equilibrium Analysis," October 19
(No.9406)
56. Ya-hwei Yang. "Economic Crime and Business Cycles in Taiwan," Janu
1995. (***No.9501)***
57. Jiann-chyuan Wang & Homin Chen. "An Evaluation of the Effectivenes
Government R&D Tax Credits," March 1995. ***(No.9502)***
58. Tzong-shian Yu. "Policies for Industrial Development and Evaluation of t
Achievements in the Republic of China on Taiwan," April 1995. ***(No.95***
59. King-min Wang. "Grazig Management and Rehabilitation of Degra
Rangeland in Western Australia," August 1995. ***(No.9504)***
60. Hui-lin Wu, Chia-hui Lin, & Ke-jeng Lan. "An Empirical Study of Yo
Mobility in Taiwan," November 1995. ***(No.9505)***
61. Mo-huan Hsing. "A Demand System with Homothetic Utility Functi
Measurability and Empirical Relevance," November 1995. ***(No.9506)***
62. An-loh Lin. "Dummy Functions in the Koyck Distributed-lag Mode
December 1995. ***(No.9507)***
63. An-loh Lin. "Estimation of the AR(1) Model Containing a Dummy Variab
January 1996. ***(No.9601)***

財團法人中華經濟研究院

CHUNG-HUA INSTITUTION FOR ECONOMIC RESEARCH
75 Chang-Hsing St., Taipei, Taiwan, 106
Republic of China
TEL : 886-2-735-6006
FAX : 886-2-735-6035