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APPENDIX

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่

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Appendix A: Unit Root Test

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
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Appendix A.1 Augmented Dickey –Fuller Test for CO₂

Null Hypothesis: D(LNCO2) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.591537	0.0043
Test critical values: 1% level	-4.252879	
5% level	-3.548490	
10% level	-3.207094	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LNCO2,2)

Method: Least Squares

Date: 06/27/17 Time: 23:37

Sample (adjusted): 1982 2015

Included observations: 34 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNCO2(-1))	-0.813666	0.177210	-4.591537	0.0001
C	0.001435	0.046130	0.031113	0.9754
@TREND("1980")	0.000205	0.002206	0.092988	0.9265
R-squared	0.405066	Mean dependent var		-0.001344
Adjusted R-squared	0.366683	S.D. dependent var		0.158332
S.E. of regression	0.126002	Akaike info criterion		-1.220936
Sum squared resid	0.492174	Schwarz criterion		-1.086257
Log likelihood	23.75591	Hannan-Quinn criter.		-1.175006
F-statistic	10.55330	Durbin-Watson stat		1.935678
Prob(F-statistic)	0.000319			

Appendix A .2 Augmented Dickey –Fuller Test for GDP per capita

Null Hypothesis: D(LNGDP) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-4.835315	0.0023
Test critical values: 1% level	-4.252879	
5% level	-3.548490	
10% level	-3.207094	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LNGDP,2)

Method: Least Squares

Date: 06/27/17 Time: 23:40

Sample (adjusted): 1982 2015

Included observations: 34 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGDP(-1))	-0.866650	0.179233	-4.835315	0.0000
C	-0.013906	0.047195	-0.294646	0.7702
@TREND("1980")	0.004161	0.002424	1.716661	0.0960
R-squared	0.430066	Mean dependent var		0.000606
Adjusted R-squared	0.393296	S.D. dependent var		0.164946
S.E. of regression	0.128479	Akaike info criterion		-1.182012
Sum squared resid	0.511709	Schwarz criterion		-1.047334
Log likelihood	23.09421	Hannan-Quinn criter.		-1.136083
F-statistic	11.69613	Durbin-Watson stat		2.012169
Prob(F-statistic)	0.000164			

Appendix A.3 Augmented Dickey –Fuller Test for urban population

Null Hypothesis: D(LNURBAN) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 1 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-5.054741	0.0014
Test critical values: 1% level	-4.262735	
5% level	-3.552973	
10% level	-3.209642	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LNURBAN,2)

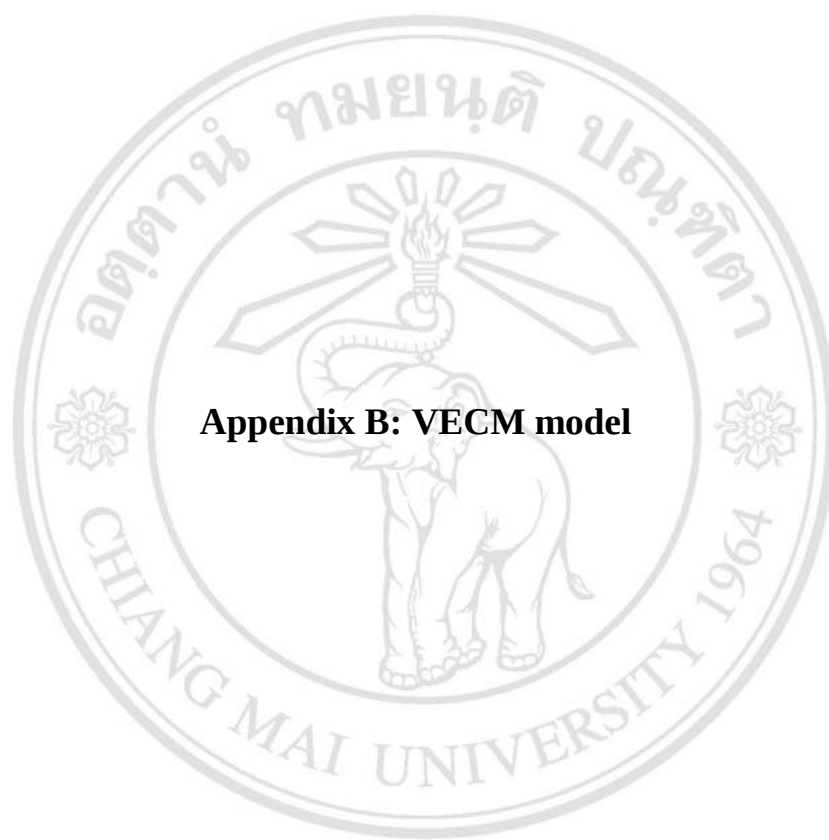
Method: Least Squares

Date: 06/27/17 Time: 23:42

Sample (adjusted): 1983 2015

Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNURBAN(-1))	-0.143978	0.028484	-5.054741	0.0000
D(LNURBAN(-1),2)	0.863997	0.076404	11.30835	0.0000
C	0.003021	0.000604	5.006111	0.0000
@TREND("1980")	1.38E-05	4.65E-06	2.965410	0.0060
R-squared	0.848819	Mean dependent var		4.05E-05
Adjusted R-squared	0.833179	S.D. dependent var		0.000486
S.E. of regression	0.000199	Akaike info criterion		-14.09756
Sum squared resid	1.14E-06	Schwarz criterion		-13.91617
Log likelihood	236.6098	Hannan-Quinn criter.		-14.03653
F-statistic	54.27422	Durbin-Watson stat		1.472539
Prob(F-statistic)	0.000000			



Appendix B: VECM model

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Appendix B.1 Lag Length Selection for Vector Error Correction Model

VAR Lag Order Selection Criteria

Endogenous variables: LNCO2 LNGDP

LNURBAN

Exogenous variables: C

Date: 06/27/17 Time: 23:44

Sample: 1980 2015

Included observations: 34

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1.105356	NA	0.000256	0.241492	0.376170	0.287421
1	246.9706	437.7812	2.00e-10	-13.82180	-13.28309	-13.63809
2	279.2425	51.25525*	5.17e-11*	-15.19073*	-14.24798*	-14.86923*

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Appendix B .2 Johansen Test for co-integration

Date: 06/27/17 Time: 23:44

Sample: 1980 2015

Included observations: 33

Series: LNCO2 LNGDP

LNURBAN

Lags interval: 1 to 2

Selected

(0.05

level*)

Number of

Cointegrati

ng

Relations

by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	2	2	1	1	1

Max-Eig	2	2	1	1	1
---------	---	---	---	---	---

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend

	Log Likelihood by Rank (rows) and Model (columns)				
0	277.0780	277.0780	285.7668	285.7668	290.7689
1	296.5941	296.6104	303.1153	303.1714	304.5220
2	304.4097	304.8852	306.8081	307.8999	309.1876
3	304.5690	307.9933	307.9933	310.9641	310.9641

	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	-15.70170	-15.70170	-16.04647	-16.04647	-16.16781
1	-16.52086	-16.46124	-16.73426*	-16.67706	-16.63770
2	-16.63089	-16.53850	-16.59443	-16.53939	-16.55682
3	-16.27691	-16.30262	-16.30262	-16.30085	-16.30085

	Schwarz Criteria by Rank (rows) and Model (columns)				
0	-14.88542	-14.88542	-15.09415	-15.09415	-15.07944
1	-15.43249	-15.32752	-15.50985*	-15.40729	-15.27724
2	-15.27043	-15.08734	-15.09792	-14.95218	-14.92427
3	-14.64435	-14.53402	-14.53402	-14.39621	-14.39621

Appendix B .3 Johansen Test for co-integration

Date: 06/27/17 Time: 23:45

Sample (adjusted): 1983 2015

Included observations: 33 after adjustments

Trend assumption: Linear deterministic trend

Series: LNCO2 LNGDP LNURBAN

Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.650561	44.45300	29.79707	0.0005
At most 1	0.200529	9.755884	15.49471	0.3000
At most 2	0.069309	2.370318	3.841466	0.1237

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.650561	34.69711	21.13162	0.0004
At most 1	0.200529	7.385565	14.26460	0.4446
At most 2	0.069309	2.370318	3.841466	0.1237

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

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Appendix B .4 Johansen Test for co-integration

Unrestricted Cointegrating Coefficients (normalized by $b'S_{11}b=I$):

LNCO2	LNGDP	LNURBAN
10.68108	-1.433763	4.577115
-1.061794	3.127271	-12.01073
-7.799968	1.777118	2.122752

Unrestricted Adjustment Coefficients (alpha):

D(LNCO2)	D(LNGDP)	D(LNURBAN)
-0.048450	0.042537	0.000108
-0.018712	-0.045633	0.000108
0.021884	-0.002952	1.37E-05
		3.61E-05

1 Cointegrating
Equation(s):

Log
likelihood 303.1153

Normalized cointegrating coefficients (standard error in parentheses)

LNCO2	LNGDP	LNURBAN
1.000000	-0.134234 (0.04116)	0.428525 (0.17259)

Adjustment coefficients (standard error in parentheses)

D(LNCO2)	D(LNGDP)	D(LNURBAN)
-0.517504 (0.21273)	0.454337 (0.22891)	0.001158 (0.00034)

2 Cointegrating
Equation(s):

Log
likelihood 306.8081

Normalized cointegrating coefficients (standard error in parentheses)

LNCO2	LNGDP	LNURBAN
1.000000	0.000000	-0.091175 (0.15282)
0.000000	1.000000	-3.871600 (0.88934)

Adjustment coefficients (standard error in parentheses)

D(LNCO2)	-0.497636 (0.20997)	0.010950 (0.06730)
D(LNGDP)	0.502790 (0.20813)	-0.203694 (0.06671)
D(LNURBAN)	0.001144 (0.00035)	-0.000113 (0.00011)

Appendix B.5 Vector Error Correction estimation

Vector Error Correction Estimates

Date: 06/27/17 Time: 23:46

Sample (adjusted): 1983 2015

Included observations: 33 after adjustments

Standard errors in () & t-statistics in []

Cointegrating Eq:	CointEq1
LNCO2(-1)	1.000000
LNGDP(-1)	-0.134234 (0.04116) [-3.26133]
LNURBAN(-1)	0.428525 (0.17259) [2.48291]
C	-3.614170

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Appendix B.6 Vector Error Correction estimation

Error Correction:	D(LNCO2)	D(LNGDP)	D(LNURBAN)
CointEq1	-0.517504 (0.21273) [-2.43269]	0.454337 (0.22891) [1.98483]	0.001158 (0.00034) [3.35756]
D(LNCO2(-1))	0.408577 (0.20036) [2.03925]	0.227736 (0.21559) [1.05633]	-0.000572 (0.00032) [-1.76050]
D(LNCO2(-2))	-0.113546 (0.20961) [-0.54169]	-0.245616 (0.22555) [-1.08895]	-7.66E-05 (0.00034) [-0.22521]
D(LNGDP(-1))	0.432614 (0.17688) [2.44578]	0.068740 (0.19033) [0.36116]	-0.000225 (0.00029) [-0.78401]
D(LNGDP(-2))	0.255522 (0.19099) [1.33785]	-0.163270 (0.20552) [-0.79443]	-0.000112 (0.00031) [-0.36229]
D(LNURBAN(-1))	121.0174 (52.9580) [2.28516]	-79.18352 (56.9849) [-1.38955]	1.623109 (0.08588) [18.9008]
D(LNURBAN(-2))	-76.18986 (45.6558) [-1.66879]	41.73653 (49.1274) [0.84956]	-0.874306 (0.07403) [-11.8095]
C	-1.067310 (0.69473) [-1.53630]	0.935451 (0.74756) [1.25135]	0.005753 (0.00113) [5.10667]
R-squared	0.356678	0.363959	0.989112
Adj. R-squared	0.176547	0.185868	0.986063
Sum sq. resids	0.327249	0.378908	8.60E-07
S.E. equation	0.114411	0.123111	0.000186
F-statistic	1.980108	2.043666	324.4335
Log likelihood	29.29846	26.88001	241.3023
Akaike AIC	-1.290816	-1.144243	-14.13954
Schwarz SC	-0.928026	-0.781453	-13.77675

Mean dependent	0.007853	0.073925	0.022797
S.D. dependent	0.126081	0.136442	0.001572

Determinant resid covariance (dof adj.)	4.85E-12
Determinant resid covariance	2.11E-12
Log likelihood	303.1153
Akaike information criterion	-16.73426
Schwarz criterion	-15.50985



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