Trakya Üniversitesi İktisadi ve İdari Bilimler Fakültesi E-Dergi
Temmuz 2016 Cilt 5 Sayı 2

AN ANALYSIS OF ENVIRONMENTAL KUZNETS CURVE FOR JAPANESE ECONOMY

Ercan SARIDOĞAN*

Burak GÜRİŞ**,

Ayhan UÇAK***

Abstract

Japanese economy achieved a rapid economic development process for the period of 1950-1980 with environmental problems. By the by mid 1970s, Japan introduced important environmental regulatory reforms and environmental clean-up reforms. However, Japan faced challenged both environmental problems and economic stagnation since 1990s.

In this study, Environmental Kuznets curve is analysed for Japanese economy for the period 1960 to 2010 using annual data by using cointegration test with structural breaks by developed Maki (2012). Environmental Kuznets curve means there is an inverted-U relationship between environmental degradation and income per capita. In the study it is found that the N-shaped Kuznets curve confirmed for Japanese economy for the period.

Key words: Environmental Kuznets Curve, Japanese Economy, Cointegration Test with Structural Break

JAPON EKONOMİSİ İÇİN ÇEVRESEL KUZNETS EĞRİSİ ANALİZİ

Özet

Japon ekonomisi 1950-1980 döneminde hızlı bir ekonomik gelişme göstermiş fakat bu gelişme çevresel problemleri de beraberinde taşımıştır. 1970'lerin ortasından itibaren Japonya önemli çevresel düzenlemeler ve reformlar geliştirmiştir. Mamafih, 1990'lardan itibaren Japon ekonomisi hem durgunluk hem de artan çevre problemleri ile karşı karşıyadır. Bu çalışmada Çevresel Kuznets eğrisi Japon ekonomisi için 1960-2010 periyoduna ait yıllık veriler kullanılarak kointegrasyon testine tabi tutulmaktadır. Bu

* İstanbul Üniversitesi, İktisat Fakültesi, Ekonometri Bölümü, Doç.Dr.
** İstanbul Üniversitesi, İktisat Fakültesi, Ekonometri Bölümü, Doç.Dr.
*** Trakya Üniversitesi, İktisadi ve İdari Bilimler Fakültesi,İktisat Bölümü, Doç.Dr.

çalışmanın bulguları ışığında, N biçimli Kuznets eğrisi Japon ekonomisi için doğru sonuçlar vermektedir.

Anahtar Kelimeler: Çevresel Kuznets Eğrisi, Japon ekonomisi, Kointegrasyon testi

1. Introduction

Kuznets (1955) stated that income inequality and economic growth has an *inverted-U* relationship, means first stage of economic development, income inequality per capita increases as economic development increases, after a peak, then second stage economic development, income inequality per capita increases as economic development decreases. On the other hand, Acemoglu and Robinson (2002) claimed that development does not necessarily induce a Kuznets curve. Environmental Kuznets curve means there is an *inverted-U* relationship between environmental degradation and income per capita.

There is an important literature on the Environmental Kuznets curve covering different countries and periods. Dinda (2004) stated that that the common point of the related literature is that the environmental quality deteriorates at the early stages of economic development/growth and subsequently improves at the later stages but the controversial point in the literature is that there is no agreement on the income level at which environmental degradation starts declining. Dinda (2004) also claimed that the inverted-U relation or Environmental Kuznets curve cannot be generalized for all types of pollutants.

Some of the studies found inverted-U relation are as follows, Roberts and Grimes (1997, Carson et al.(1997), Schmalensee et al.(1998), Galeotti and Lanza(1999), Panayotou et al. (2000), Dijkgraaf and Vollebergh (2001), Lindmark (2002), Cole (2004), Aldy (2005), Coondoo and Dinda (2008), Lee et al. (2009), Dutt (2009), Jalil and Mahmud (2009), Narayan and Narayan (2010), Acararci and Ozturk (2010). On the other hand, Moomaw and Unruh (1997), Lee et al. (2009), Friedl and Getzner (2003) found a *N-shaped* Environmental Kuznets curve see for details, Kaika and Zervas (2013)

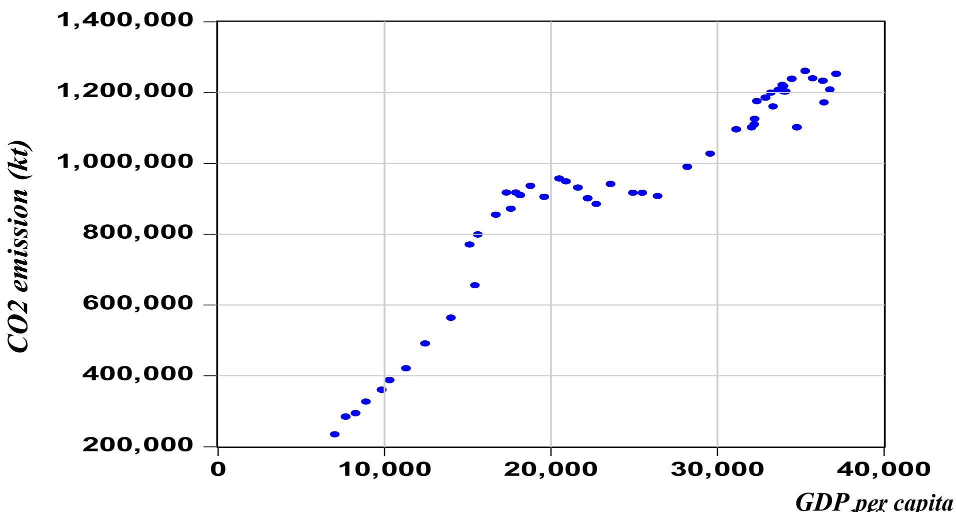
Apergis and Ozturk (2015) analysed the Environmental Kuznets Curve hypothesis for 14 Asian countries including Japan the period 1990–2011. They found that the estimates have the expected signs and are statistically significant, yielding empirical support to the presence of an Environmental Kuznets Curve hypothesis.

In this study, Environmental Kuznets curve is analysed for Japanese economy for the period 1960 to 2010 using annual data by using cointegration test with structural breaks by developed Maki (2012). The main contribution of the study is that the *N-shaped Kuznets curve* confirmed for Japanese economy for the period.

2. Environmental Kuznets Curve for Japanese Economy

Economic development process of Japan has been important negative and positive effects on the environment of Japan. Rapid growth process in the 1950s and 1960s had serious damages on the environment of Japan. After important economic, social, humanitarian and environmental costs from the environmental pollution, Japan introduced important environmental regulatory reforms and environmental clean-up reforms by developing environmentally-conscious technologies and programs by mid 1970s. Japan had important achievements for environmental pollution after the reforms. On the other hand, Japanese policy maker and society have challenged both environmental problems and economic stagnation since 1990s. (Imura and Schreurs, 2005:2).

Figure 1. CO_2 emissions per capita (kt) and GDP per capita (constant 2005 US$) for Japanese Economy



Source: World Bank, World Development Indicators

Figure 1 shows the relationship between CO2 emissions (kt) and GDP per capita (constant 2005 US$) for Japanese Economy for the period 1960-2010. It is clear that CO2 emissions (kt) rapidly increase as GDP per capita converges 20000 US$ for the years late 1970s. By the beginning of the 1980s environmental reforms had positive effect on the environment. However, by the 1990s, Japan faced to both environmental problems and economic stagnation. Figure 1 shows like *N-shaped Kuznets curve* for Japanese economy for the period.

3. Data, Model and Econometric Methodology

In this study, we explore presence of environmental Kuznets curve for Japanese economy for the period of 1960 to 2010 using annual data by using cointegration test with structural breaks by developed Maki (2012). Data source is World Bank, World Development Indicators database.

The model estimated for the Kuznets curve as follows,

$$\boldsymbol{lnCO_{2t} = \beta_0 + \beta_1 lnY_t + \beta_2 lnY_t^2 + \beta_3 lnY_t^3 + \beta_4 lnEN_t + u_t}$$
(1)

where $lnCO_{2t}$ is natural log of CO2 emissions (metric tons per capita), lnY_t is, real GDP per capita (constant 2005 US$), $lnEN_t$ is energy use (kg of oil equivalent per capita). The signs of the variables (Y_t, Y_t^2, Y_t^3) determine the shape of Kuznets Curve.

As a first step, we identify the order of integration of the variables by using unit root tests. Since Nelson and Plosser (1982) the issue of unit root test has received great interest. Using Dickey and Fuller tests, Nelson and Plosser (1982) found that unit root null hypothesis could not reject the 13 of 14 macroeconomic time series for US. Perron (1989) show that if there is a structural break in the series but we don't take into account this break, the result of unit root test leads to a biased results to reject a false unit root null hypothesis. To overcome this, Perron (1989) developed test which allows one exogenous structural break in the Augmented Dickey Fuller tests. Zivot and Andrews (1992) criticize Perron (1989) test procedure which allowing exogenous structural break and suggest a test which allowing one structural break determined endogenously. Lumsdaine and Papell (1997) extended the Zivot and Andrews (1992) model to accommodate two structural breaks. Lee and Strazicich (2003, 2004) propose an endogenous two-break Lagrange

Multiplier (LM) unit root test that is unaffected by structural breaks under the null.

Kapetanios (2005) extend previous studies for *m* breaks. Kapetanios (2005) uses three different model specification, like Zivot and Andrews (1992) test, in testing procedure. These specifications are as follows;

Model A : $Y_t = \mu + \Phi Y_{t-1} + \beta t + \gamma_i \sum_{i=1}^{m} DU_t(\hat{\lambda}_i) + \delta_i \sum_{i=1}^{p} \Delta y_{t-i} + \varepsilon_t$

where $DU_t = \begin{cases} 1 & t > T\lambda \\ 0 & otherwise \end{cases}$

$\lambda_i = T_{bi}/T$,T_{bi}: Structural break date, *m:* Number of maximum break

Model B: $Y_t = \mu + \Phi Y_{t-1} + \beta t + \gamma_i \sum_{i=1}^{m} DT_t(\hat{\lambda}_i) + \delta_i \sum_{i=1}^{p} \Delta y_{t-i} + \varepsilon_t$

where $DT_t = \begin{cases} t - T\lambda_i & t > T\lambda_i \\ 0 & otherwise \end{cases}$

Model C:
$Y_t = \mu + \Phi Y_{t-1} + \beta t + +\gamma_i \sum_{i=1}^{m} DU_t(\hat{\lambda}_i) + \alpha_i \sum_{i=1}^{m} DT_t(\hat{\lambda}_i) + \delta_i \sum_{i=1}^{p} \Delta y_{t-i} + \varepsilon_t$

where $DU_t = \begin{cases} 1 & t > T\lambda \\ 0 & otherwise \end{cases}$, $DT_t = \begin{cases} t - T\lambda_i & t > T\lambda_i \\ 0 & otherwise \end{cases}$

This test are based on testing procedure which is used Bai and Perron (1998). A Critical values which are used for this test are tabulated in Kapetanios (2005).

Two or more I(1) time series variables may have linear combinations which are stationary (I(0)). In this case, the variables are thought to be cointegrated.

The effects of structural break on the cointegration tests would be similar to unit root test. In other words, if there is a structural breaks and we don’t take into account this break, the result of cointegration test leads to a biased results.

To avoid this problem, Gregory and Hansen (1996) develop a test which allows one endogenous structural break. Hatemi-J (2008) extended the Gregory and Hansen (1996) model to accommodate two structural breaks. When the number of breaks are more than three, the tests of both Gregory and Hansen (1996) and Hatemi-J (2008) would perform poorly. Thus, it is desirable to take an unspecified number of breaks in the cointegration test. Such a test may perform better than standard cointegration tests and tests allowing for only one or two breaks when a cointegration relationship has an unknown number of breaks and multiple breaks. (Maki (2012)).

Maki (2012) introduces cointegration tests allowing for an unknown number of breaks. Maki (2012) considers the following regression models in order to test for cointegration allowing for multiple breaks.

Model 0: Model with Level Shift : $y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' x_t + u_t$

Model 1: Regime shifts model: $y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' x_t + \sum_{i=1}^{k} \beta' x_t D_{i,t} + u_t$

Model 2: Regime shifts model with trend : $y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \beta' x_t + \sum_{i=1}^{k} \beta' x_t D_{i,t} + u_t$

Model 3: Structural breaks of levels, trends, and regressors:

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \sum_{i=1}^{k} \gamma_i t D_{i,t} + \beta' x_t + \sum_{i=1}^{k} \beta' x_t D_{i,t} + u_t$$

Where $x_t = (x_1, \dots \dots x_{mt})'$ are I(1) variables k: Number of Maximum Break, T_{Bi} Structural Break Date and $D_{i,t}$ denotes; $D_{i,t} = \begin{cases} 1 & t > T_{Bi} \\ 0 & otherwise \end{cases}$

Determination of break points and mechanism of this test are based on Bai and Perron (1998) and Kapetanios (2005) procedures. Critical values of this test which are computed based on Monte Carlo simulation techniques are tabulated in Maki (2012). Where RV is number of regressors and *m* is number of breaks.

4. Empirical Results

We begin our analysis by providing the univariate properties of the variables of interest using the Kapetanios (2005) unit root test. Table 1. shows Kapetanios unit root test results. The results show that all series are not stationary in Level. For this reason, we take first differences of the series to create a stationary series. As can be seen Table 1, all the variables are stationary in first differences. Given that the order of the integration of the series is equal to one, we continued to test whether the series are cointegrated over the sample period.

Table 1. Kapetanios Unit Root Test Results

Level	Test Statistics	Break Dates
LCO2PC	-4.7619*	1966, 1972, 1989, 1996, 2002
LENERGYPC	-5.8998*	1966, 1972, 1987, 1993, 2003
LGDPC	-7.7764*	1967, 1973, 1982, 1988, 1997
$LGDPC^2$	-6.9903*	1967, 1973, 1987, 1997, 2004
$LGDPC^3$	-6.769*	1967, 1973, 1987, 1997, 2004

* indicates H_o accepted at **0.05** significant level for the model **C**

First Difference	Test Statistics	Break Dates
ΔLCO2PC	-9.5531*	1970, 1981, 1987, 1998, 2004
ΔLENERGYPC	-6.6876**	1967, 1977, 1985, 1991, 2001
ΔLGDPC	-9.8011*	1969, 1976, 1991, 1997, 2003
ΔLGDPC^2	-9.4878*	1969, 1976, 1984, 1991, 2002
ΔLGDPC^3	-9.3421*	1969, 1976, 1984, 1991, 2002

* indicates H_o rejected at at **0.05** significant level for the model **C**

** indicates H_o rejected at at **0.05** significant level for the model **B**

As a second step, in order to analyse the long run relationships among the variables, we conduct cointegration tests by allowing *m breaks* in the long run equation, following the approach suggested by Maki (2012).

Table 2. Maki Cointegration Test Results

Test Statistics		**Critical Values**		
		1%	5%	10%
-9.8229689		-9.441	-8.869	-8.541
		Break Dates		
1964	1969	1982	1985	2006

Critical values are taken from Maki (2012)

The findings obtained by Maki (2012) test indicate that the series are co-integrated in the long-run In the final step of empirical analysis, the methodology which allows the dynamic estimation of cointegrating vectors for systems involving deterministic components, developed Stock and Watson (1993) is used.

Table 3. Fully Modified OLS (FMOLS) Results

	Coefficients	Std.Err.
LGDPC	132.9429*	35.17366
LGDPC2	-13.28460*	3.595784
LGDPC3	0.443322*	0.122257
LENPC	0.596805*	0.051711
DT1	0.071300*	0.014035
DT4	0.016472*	0.003175
DT5	-0.007225**	0.003345
DU1	-0.054503*	0.015084
DU2	0.131076*	0.014990
DU4	-0.035356*	0.010615
DU3	-0.018910**	0.009660
C	-449.1890*	114.5415
@TREND	-0.091781*	0.012383

*, **, *** indicate 1%, 5%, 10% level of significance respectively.

FMOLS results which are taken into account the structural break date determined by Maki (2012) are indicate that in the model, the signs of the variables are as follows β_1,β_3, β_4 > 0 and β_2 < 0 ,which means the *N-shaped Kuznets curve* presence for Japanese economy for the analyse period.

Conclusion

Economic development process of Japan has been important negative and positive effects on the environment of Japan. Rapid growth process in the 1950s and 1960s had serious damages on the environment of Japan. Japan introduced important environmental regulatory reforms and environmental clean-up reforms by developing environmentally-conscious technologies and programs by mid 1970s. Japanese policy maker and society have challenged both environmental problems and economic stagnation since 1990s.

In this study, Environmental Kuznets curve is analysed for Japanese economy for the period of 1960 to 2010 using annual data by using cointegration test with structural breaks by developed Maki (2012). Environmental Kuznets curve means there is an *inverted-U* relationship between environmental degradation and income per capita. In the study it is found that the *N-shaped Kuznets curve* confirmed for Japanese economy for the period.

References

Acaravci, A.,Ozturk,I., On The Relationship Between Energy Consumption, Co2 Emissions And Economic Growth In Europe. Energy35, 2010, 5412–5420.

Acemoglu Daron and Robinson James A. "The Political Economy of the Kuznets Curve" Review of Development Economics, 6(2), 183–203, 2002

Aldy, J.E., an Environmental Kuznets Curve Analysis of U.S. State-Level Carbon Dioxide Emissions. The Journal of Environment development14, 2005, 48–72.

Apergis Nicholas, Ozturk Ilhan "Testing Environmental Kuznets Curve hypothesis in Asian countries", Ecological Indicators 52, 2015, 16–22

Bai, J., Perron, P., Estimating and Testing Linear Models with Multiple Structural Changes, Econometrica 66, 1998, 47–78.

Carson, R.T., Jeon,Y., Mccubbin, D.R., The Relationship between Air Pollution Emissions and Income: Us Data. Environment and Development Economics 2, 1997, 433–450.

Cole, M.A., Trade, The Pollution Haven Hypothesis and the Environmental Kuznets Curve: Examining the Linkages .Ecological Economics 48, 2004, 71–81.

Coondoo, D., Dinda, S., Carbondioxide Emissions and Income: A Temporal Analysis of Cross-Country Distributional Patterns. Ecological Economics 65, 2008, 375–385.

Dijkgraaf, E., Vollebergh, H.R.J., A Note on Testing For Environmental Kuznets Curves with Panel Data. Available from: ⟨http:/www.feem.it/web/activ/_activ.html⟩. 2001

Dinda Soumyananda, "Environmental Kuznets Curve Hypothesis: A Survey" Ecological Economics 49, 2004, 431– 455

Dutt, K., Governance, Institutions and the Environment-Income Relationship: A Cross-Country study. Environment, Development and Sustainability11, 2009, 705–723.

Friedl, B., Getzner, M., Determinants of Co2 Emissions in a Small Open Economy. Ecological Economics 45, 2003, 133–148.

Galeotti, M., Lanza, A., Richer and Cleaner? A Study on Carbon dioxide Emissions in Developing Countries. Energy Policy 27, 1999, 565–573.

Gregory A. W., Hansen B.E. Residual-based Tests for Cointegration in Models with Regime Shifts, Journal of Econometrics, 70, 1996, 99-126.

Hatemi-J, A., Tests for Cointegration with Two Unknown Regime Shifts with an Application to Financial Market Integration, Empirical Economics 35, 2008, 497–505.

Jalil, A.,Mahmud, S.F., Environment Kuznets Curve For Co2 Emissions: A Cointegration Analysis For China. Energypolicy37, 2009, 5167–5172.

Kaika Dimitra, Zervas Efthimios, The Environmental KuznetsCurve (EKC) theory—Part A: Concept,causes and the CO2 emissions case, Energy Policy, 62, 2013, 1392–1402

Kapetanios, G., Unit Root Testing Against the Alternative Hypothesis of up to m Structural Breaks, Journal of Time Series Analysis, Vol:26, No:1, 2005, 123-133.

Kuznets, Simon, “Economic Growth and Income Inequality,” American Economic Review 65, 1955, 1–28.

Lee, C-C., Chiu, Y-B., Sun, C-H.,.Does One Size Fit All? Are Examination Of The Environmental Kuznets Curve Using The Dynamic Panel Data Approach? Review of Agricultural Economics 31(4), 2009, 751–778.

Lee, J. and Strazicich, M.C., “Minimum LM Unit Root Test with One Structural Break”, Working Paper, Department of Economics, Appalachain State University, 2004.

Lee, J. and Strazicich, M.C., Minimum LM Unit Root Test with Two Structural Breaks, Review of Economics and Statistics, 63, 2003, 1082-1089.

Lindmark, M., Anekc-Pattern in Historical Perspective: Carbon dioxide Emissions, Technology, Fuel Prices and Growth in Sweden 1870–1997.Ecological Economics 42, 2002, 333–347.

Lumsdaine, R. L. and Papell, D. H., Multiple Trend Breaks and the Unit Root Hypothesis, Review of Economics and Statistics 79, 1997, 212–217.

Maki, D., Tests For Cointegration Allowing For an Unknown Number of Breaks. Economic Modelling. 29(5), 2012, 2011-2015.

Moomaw, W.R., Unruh, G.C., Are Environmental Kuznets Curves Misleading Us? The Case of Co2 Emissions. Environment and Development Economics 2, 1997, 451–463.

Narayan, P-K., Narayan, S., Carbondioxide Emissions and Economic Growth: Panel Data Evidence from Developing Countries. Energypolicy 38, 2010, 661–666.

Nelson, C. R. and Plosser, C. I., Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications, Journal of Monetary Economics 10, 1982, 139–162.

Panayotou, T., Peterson, A., Sachs, J., August. Is The Environmental Kuznets Curve Driven By Structural Change? What Extended Time Series May Imply For Developing Countries? CAERII Discussion Paper No.80. 2000

Perron, P., Further evidence on breaking trend functions in macroeconomic variables, Journal of Econometrics, Vol. 80, 1997, 355-385.

Perron, P., The Great Crash the Oil Price Shock and the unit root hypothesis, Econometrica 57, 1989, 1361–401.

Roberts, J.T., Grimes, R., Carbon intensity and Economic Development 1962–91: A Brief Exploration of the Environmental Kuznets Curve. World Development 25(2), 1997, 191–198.

Schmalensee, R.,Stoker, T.M.,Judson, R.A., World Carbon dioxide Emissions: 1950–2050. The Review of Economics and Statistics 80, 1998, 15–27.

Stock, J.H. and Watson, M., A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems, Econometrica, 61, 1993, 783-820.

Zivot, A. and Andrews, D. W. K., Further evidence on the Great Crash the Oil Price Shock and the unit root hypothesis, Journal of Business and Economic Statistics 10, 1992, 251–70.

Appendix-1 Critical Values of Kapetanios (2005) tests

		Significance level			
Model	m	0.10	0.05	0.025	0.01
A	1	−4.661	−4.930	−5.173	−5.338
	2	−5.467	−5.685	−5.965	−6.162
	3	−6.265	−6.529	−6.757	−6.991
	4	−6.832	−7.104	−7.361	−7.560
	5	−7.398	−7.636	−7.963	−8.248
B	1	−4.144	−4.495	−4.696	−5.014
	2	−4.784	−5.096	−5.333	−5.616
	3	−5.429	−5.726	−6.010	−6.286
	4	−5.999	−6.305	−6.497	−6.856
	5	−6.417	−6.717	−6.998	−7.395
C	1	−4.820	−5.081	−5.297	−5.704
	2	−5.847	−6.113	−6.344	−6.587
	3	−6.686	−7.006	−7.216	−7.401
	4	−7.426	−7.736	−7.998	−8.243
	5	−8.016	−8.343	−8.593	−9.039

Source: George KAPETANIOS, Unit Root Testing Against the Alternative Hypothesis of up to m Structural Breaks, Journal of Time Series Analysis, Vol:26, No:1, 2005, pp. 129.

Appendix-2 Critical Values of Maki (2012) Cointegration Test

	RV = 1			RV = 2			RV = 3			RV = 4		
	1%	5%	10%	1 %	5%	10%	1%	5%	10%	1%	5%	10%
Model = 0												
m = 1	−5.709	−4.602	−4.354	−5.541	−5.005	−4.733	−5.820	−5.341	−5.101	−6.139	−5.650	−5.386
2	−5.416	−4.893	−4.610	−5.717	−5.211	−4.957	−5.984	−5.517	−5.272	−6.303	−5.839	−5.575
3	−5.563	−5.083	−4.784	−5.943	−5.392	−5.125	−6.229	−5.704	−5.427	−6.501	−5.992	−5.714
4	−5.776	−5.230	−4.982	−6.075	−5.550	−5.297	−6.406	−5.871	−5.603	−6.640	−6.132	−5.892
5	−5.959	−5.426	−5.131	−6.296	−5.760	−5.491	−6.555	−6.038	−5.773	−6.856	−6.306	−6.039
Model = 1												
m = 1	−5.524	−5.038	−4.784	−5.840	−5.359	−5.117	−6.144	−5.645	−5.398	−6.361	−5.913	−5.686
2	−5.708	−5.196	−4.938	−6.011	−5.518	−5.247	−6.271	−5.796	−5.538	−6.556	−6.055	−5.805
3	−5.833	−5.373	−5.106	−6.169	−5.691	−5.408	−6.472	−5.957	−5.682	−6.741	−6.214	−5.974
4	−6.059	−5.508	−5.245	−6.329	−5.831	−5.558	−6.575	−6.086	−5.820	−6.845	−6.373	−6.096
5	−6.193	−5.699	−5.449	−6.530	−5.993	−5.722	−6.784	−6.250	−5.976	−7.053	−6.494	−6.220
Model = 2												
m = 1	−5.457	−4.895	−4.626	−6.020	−5.558	−5.287	−6.565	−6.035	−5.773	−7.021	−6.520	−6.242
2	−5.863	−5.363	−5.070	−6.628	−6.093	−5.833	−7.232	−6.702	−6.411	−7.756	−7.244	−6.964
3	−6.251	−5.703	−5.402	−7.031	−6.516	−6.210	−7.767	−7.155	−6.868	−8.336	−7.803	−7.481
4	−6.596	−6.011	−5.723	−7.470	−6.872	−6.563	−8.236	−7.625	−7.329	−8.895	−8.292	−8.004
5	−6.915	−6.357	−6.057	−7.839	−7.288	−6.976	−8.673	−8.110	−7.796	−9.441	−8.869	−8.541
Model = 3												
m = 1	−6.048	−5.541	−5.281	−6.523	−6.055	−5.795	−6.964	−6.464	−6.220	−7.400	−6.911	−6.649
2	−6.620	−6.100	−5.845	−7.153	−6.657	−6.397	−7.737	−7.201	−6.926	−8.167	−7.638	−7.381
3	−7.082	−6.524	−6.267	−7.673	−7.145	−6.873	−8.331	−7.743	−7.449	−8.865	−8.254	−7.977
4	−7.553	−7.009	−6.712	−8.217	−7.636	−7.341	−8.851	−8.269	−7.960	−9.433	−8.871	−8.574
5	−8.004	−7.414	−7.110	−8.713	−8.129	−7.811	−9.428	−8.800	−8.508	−10.08	−9.482	−9.151

Source: Daiki MAKI, Tests For Cointegration Allowing For an Unknown Number of Breaks. Economic Modelling. 29(5), 2012, pp: 2013.