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Energy Consumption and Economic Growth: A Causality Analysis for Croatia

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Abstract

This paper investigates the causal relationship between economic growth and energy consumption in Croatia for the period 1952-2010. Using Chow breakpoint test we identified a structural break in the year 1989. Therefore, we have conducted our analysis on two sub-samples. The first one refers to the period 1952-1989 while the second one refers to the period 1993-2010. The years between 1990 and 1992 have been omitted from the analysis due to massive damage to the Croatian economy caused by the war at that time. Our findings suggest that there is a bidirectional feedback in the short-run and that causality runs from energy consumption to economic growth in the long-run in the first sub-sample. At that time, especially in mid 1970s, Croatia became a medium developed industrial country with the industry sector as the biggest consumer of energy so energy consumption played an important role in the growth process. After the structural break, we found a unidirectional causality running from economic growth to energy consumption. In this case, energy conservation policies may be feasible with little or no detrimental side effects to economic growth.

Keywords: Economic growth; Energy consumption; Croatia; Chow breakpoint test; Granger causality

JEL classification: Q43, C52, O13

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Appendices

Table 1: Comparison of selected empirical studies regarding causality between energy consumption and economic growth in the last thirty years

Authors[2]	Analyzed country and period	Results
Kraft and Kraft (1978)	USA (1947-1974)	GDP→Energy
Ackra and Long (1980)	USA (1950-1970)	no causality
Yu and Hwang (1984)	USA (1947-1979)	no causality
Yu and Choi (1985)	South Korea (1954-1976) Philippines (1950-1976) USA (1947-1979), United Kingdom and Poland (both 1950-1976)	GDP→Energy GDP←Energy no causality
Abosedra and Baghestani (1989)	USA (1947-1987)	GDP→Energy
Hwang and Gum (1991)	Taiwan (1961-1990)	GDP↔Energy
Yu and Jin (1992)	USA (1974-1990)	no causality
Masih and Masih (1996)	Malaysia (1955-1990), Philippines (1955-1991) and Singapore (1960-1990) India (1955-1990) Indonesia (1960-1990) Pakistan (1955-1990)	no causality GDP←Energy GDP→Energy GDP↔Energy
Cheng (1997)	Brazil (1963-1993) Mexico (1949-1993) and Venezuela (1952-1993)	GDP←Energy no causality
Cheng and Lai (1997)	Taiwan (1955-1993)	GDP→Energy
Glasure and Lee (1997)	South Korea and Singapore (1961-1990)	GDP↔Energy
Masih and Masih (1997)	Korea (1961-1990) Taiwan (1961-1990)	GDP←Energy GDP↔Energy
Masih and Masih (1998)	Sri Lanka and Thailand (1955-1991)	GDP←Energy
Asafu-Adjaye (2000)	India, Indonesia and Turkey (1973-1995) Thailand and Philippines (1971-1995)	GDP←Energy GDP↔Energy
Stern (2000)	USA (1948-1994)	GDP←Energy
Yang (2000)	Taiwan (1954-1997)	GDP↔Energy
Aqeel and Butt (2001)	Pakistan (1955-1996)	GDP→Energy
Glasure (2002)	Korea (1961-1990)	GDP↔Energy
Hondroyiannis et al. (2002)	Greece (1960-1999)	GDP↔Energy
Soytas and Sari (2003)	Argentina (1950-1990) Korea and Italy (both 1953-1991) Turkey, France, Japan and Germany (all 1950-1992) Indonesia (1960-1992), Poland (1965-1994), Canada, UK and USA (all 1950-1992)	GDP↔Energy GDP→Energy GDP←Energy no causality
Fatai et al. (2004)	India and Indonesia (1960-1990) Australia and New Zealand (1960-1990) Thailand and Philippines (1960-1990)	GDP←Energy GDP→Energy GDP↔Energy
Oh and Lee (2004)	Korea (1970-1999)	GDP↔Energy
Paul and Bhattacharya (2004)	India (1950-1996)	GDP↔Energy
Wolde-Rufael (2004)	Shanghai (1952-1999)	GDP←Energy
Hatemi-J and Irandoust (2005)	Sweden (1965-2000)	GDP→Energy

[2] The numbers in the parentheses refer to the year when the articles were published.

Lee (2005)	18 developing countries (1975-2001)[3]	GDP←Energy
Lee (2006)	11 developed countries[4]	mixed results
Jobert and Karanfil (2007)	Turkey (1960-2003)	no causality
Akinlo (2008)	11 Sub-Sahara African countries (1980-2003)[5]	mixed results
Chiou-Wei et al. (2008)	Philippines and Singapore (1971-2003) USA (1960-2003), Thailand and Korea (both 1971-2003) Indonesia and Malaysia (1971-2003) Taiwan (1954-2006) and Hong Kong (1971-2003)	GDP→Energy no causality GDP↔Energy GDP←Energy
Erbaykal (2008)	Turkey (1970-2003)	GDP←Energy
Odhiambo (2009)	Tanzania (1971-2006)	GDP←Energy
Gelo (2009)	Croatia (1953-2005)	GDP→Energy
Odhiambo (2010)	South Africa and Kenya (1972-2006) Congo (1972-2006)	GDP←Energy GDP→Energy
Tsani (2010)	Greece (1960-2006)	GDP←Energy
Imran and Siddiqui (2010)	Bangladesh, India and Pakistan (1971-2008)	GDP←Energy
Vlahinić-Dizdarević and Žiković (2010)	Croatia (1993-2006)	GDP→Energy
Žiković and Vlahinić-Dizdarević (2011)	Belgium, Denmark, Ireland, Norway, Sweden, Croatia, Latvia, Lithuania, Moldova, Slovenia	GDP→Energy
	Austria, Czech Republic, Slovakia, Malta, Bulgaria, Bosnia and Herzegovina[6]	GDP←Energy
Ying et al. (2011)	China (1954-1997)	GDP→Energy
Kakar and Khilji (2011)	Pakistan (1980-2009)	GDP←Energy
Borozan (2013)	Croatia (1992-2010)	GDP←Energy

Source: made by the author[7]

[3] The list of selected developing countries: Korea, Singapore, Hungary, Argentina, Chile, Colombia, Mexico, Peru, Venezuela, Indonesia, Malaysia, Philippines, Thailand, India, Pakistan, Sri Lanka, Ghana i Kenya

[4] The results for selected developed countries:

Canada, Belgium, Netherlands and Switzerland (GDP←Energy)
France, Italy and Japan (GDP→Energy)
United States of America (GDP↔Energy)
United Kingdom, Germany and Sweden (no causality)

The analysed period spans from 1960 to 2001, except Canada (1965-2001) and Germany (1971-2001).

[5] The results for eleven countries in sub-Saharan Africa:

Congo, Sudan and Zimbabwe (GDP→Energy)
Gambia, Ghana and Senegal (GDP↔Energy)
Cameroon, Cote D'Ivoire, Nigeria, Kenya and Togo (no causality)

[6] Their paper examines the existence and the direction of causality between the oil consumption and the economic growth in small European countries over the period 1980-2007 for the developed countries and 1993-2007 for the transition countries. For more details see Žiković and Vlahinić-Dizdarević (2011).

[7] According to Borozan (2013), Žiković and Vlahinić-Dizdarević (2011), Ying et al. (2011), Kakar and Khilji (2011), Vlahinić-Dizdarević and Žiković (2010), Imran and Siddiqui (2010), Tsani (2010), Odhiambo (2010), Odhiambo (2009), Gelo (2009), Erbaykal (2008), Chiou-Wei et al. (2008), Erdal et al. (2008), Akinlo (2008), Jobert and Karanfil (2007), Lee (2006), Lee (2005), Hatemi-J and Irandoust (2005) and Aqeel and Butt (2001).

Table 2: Unit root test results using ADF, PP and DF-GLS

	Variables	ADF		PP		DF-GLS	
		Level	First difference	Level	First difference	Level	First difference
First sub-sample (1952-1989)	LGDP	-0.164584	-9.314902	0.299522	-9.178940	0.197922	-8.328359
	LTEC_PJ	-0.341880	-6.225172	-0.302573	-6.228722	-0.731989	-5.697186
	1% critical value	-4.226815	-4.234972	-4.226815	-4.234972	-3.770000	-3.770000
	5% critical value	-3.536601	-3.540328	-3.536601	-3.540328	-3.190000	-3.190000
	10% critical value	-3.200320	-3.202445	-3.200320	-3.202445	-2.890000	-2.890000
Second sub-sample (1993-2010)	LGDP	-2.697324	-2.537853	-1.073212	-2.375248	-3.309772*	-2.496142
	LTEC_PJ	-0.933899	-3.926046**	-0.772751	-4.204544**	-1.538123	-4.278158
	1% critical value	-4.667883	-4.728363	-4.616209	-4.667883	-3.770000	-3.770000
	5% critical value	-3.733200	-3.759743	-3.710482	-3.733200	-3.190000	-3.190000
	10% critical value	-3.310349	-3.324976	-3.297799	-3.310349	-2.890000	-2.890000

Note: *, **, *** indicates signification at 1%, 5% and 10%

Source: author's calculation

Table 3: Results of Johansen's cointegration tests

	Variables	H_0	Trace statistics	Max-Eigen statistics
First sub-sample (1952-1989)	LGDP LTEC_PJ	None*	31.75502 (20.26)	25.62642 (15.89)
		At most 1	6.128602 (9.16)	6.128602 (9.16)
Trace test and Maximum Eigenvalue test indicate 1 cointegration equation at the 5% level				
Second sub-sample (1993-2010)	LGDP LTEC_PJ	None	13.13169 (20.26)	9.591088 (15.89)
		At most 1	3.540607 (9.16)	3.540607 (9.16)
Trace test and Maximum Eigenvalue test indicate no cointegration at the 5% level				

Note: * denotes rejection of the hypothesis at the 5% level
critical values are in ( ) and are taken from MacKinnon, Haug and Michelis (1999)

Source: author's calculation

Table 4: Results of the error correction model for the first sub-sample (1952-1989)

Dependent variable	D(LGDP)	D(LTEC_PJ)
CointEq1	0.018442	0.013664
	[5.38987]	[3.44326]
D(LGDP(-1))	-0.384805	0.000707
	[-2.55599]	[0.00405]
D(LTEC_PJ(-1))	0.328654	0.028273
	[2.39518]	[0.17766]
R-squared	0.443179	0.130178
Adj. R-squared	0.409433	0.077462
Sum sq. resids	0.039756	0.053475
S.E. equation	0.034709	0.040255
F-statistic	13.13252	2.469408
Log likelihood	71.47149	66.13519
Akaike AIC	-3.803972	-3.507511
Schwarz SC	-3.672012	-3.375551
Mean dependent	0.046718	0.043382
S.D. dependent	0.045166	0.041911

Note: t-statistics are in [ ]

Source: author's calculation

Table 5: Results of the pairwise Granger causality test – second sub-sample (1993-2010)

Null Hypothesis:	Obs	F-Statistic	Probability
DLTEC_PJ does not Granger Cause DLGDP	16	2.22979	0.1592
DLGDP does not Granger Cause DLTEC_PJ		5.32165	0.0382

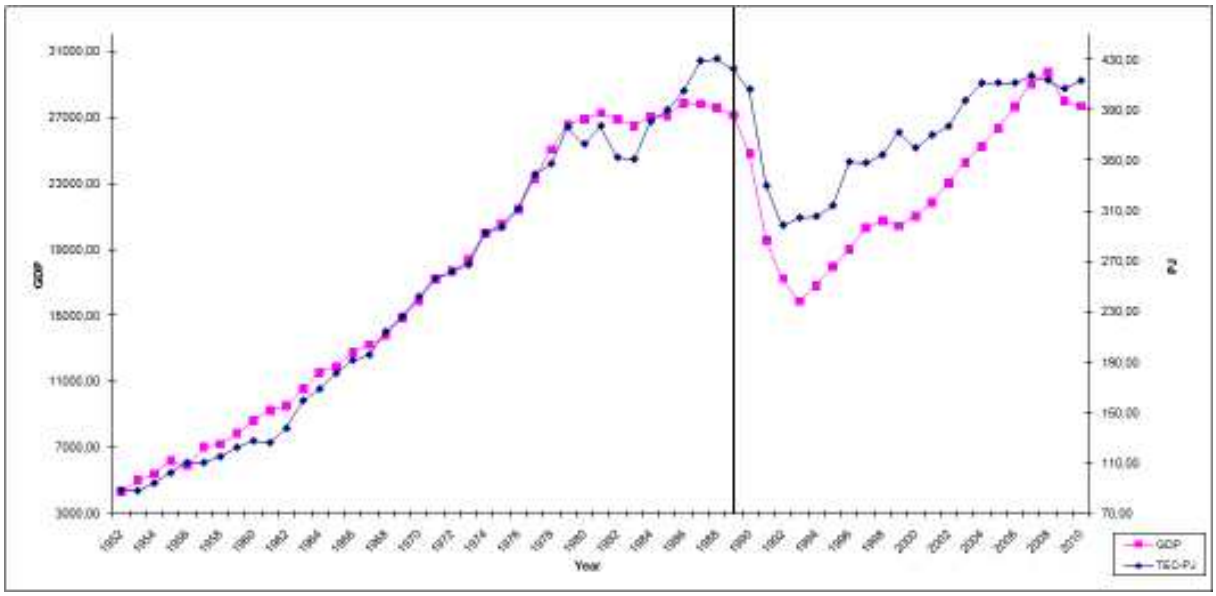
Source: author's calculation

Table 6: Results of the VAR model – second sub-sample (1993-2010)

Dependent variable	D(LGDP)	D(LTEC_PJ)
D(LGDP(-1))	-0.030966	0.575073
	[-0.09938]	[2.30687]
D(LTEC_PJ(-1))	0.491281	-0.059689
	[1.49325]	[-0.22677]
C	0.027080	-0.004806
	[1.59001]	[-0.35269]
R-squared	0.146921	0.292341
Adj. R-squared	0.015678	0.183471
Sum sq. resids	0.021804	0.013956
S.E. equation	0.040954	0.032764
F-statistic	1.119460	2.685216
Log likelihood	30.08302	33.65272
Akaike AIC	-3.385377	-3.831589
Schwarz SC	-3.240517	-3.686729
Mean dependent	0.035581	0.016126
S.D. dependent	0.041279	0.036259

Source: author's calculation

Figure 1: Total energy consumption and real GDP in Croatia for the period 1952-2010



Source: Družić and Tica (2002); Croatian Bureau of Statistics (2008-2010); Croatian Chamber of Commerce (2011); Energy Institute Hrvoje Požar (2009a; 2009b; 2010)

Table A1: Chow breakpoint test for LBDP

Breakpoint year: 1989				
Statistic	Value			Probability
F-statistic	2.830059		F(4,49)	0.0344
Log likelihood ratio	11.84730		$\chi^2(4)$	0.0185
Wald Statistic	9.324856		$\chi^2(4)$	0.0535

Null Hypothesis: No breaks at specified breakpoints

Source: author's calculation

Table A2: Chow breakpoint test for LTEC_PJ

Breakpoint year: 1989				
Statistic	Value			Probability
F-statistic	2.853957		F(3,52)	0.0460
Log likelihood ratio	8.840462		$\chi^2(3)$	0.0315
Wald Statistic	76.44257		$\chi^2(3)$	0.0000

Null Hypothesis: No breaks at specified breakpoints

Source: author's calculation

Table A3: VEC/VAR Granger causality – block exogeneity Wald test

	Dependent variable D(LGDP)					Dependent variable D(LGDP)			
VEC	Excluded	Chi-sq	df	Probability	VAR	Excluded	Chi-sq	df	Probability
	D(TEC_PJ)	5.736908	1	0.0166		D(TEC_PJ)	2.229787	1	0.1354
	Dependent variable D(LTEC_PJ)					Dependent variable D(LTEC_PJ)			
	Excluded	Chi-sq	df	Probability		Excluded	Chi-sq	df	Probability
	D(LGDP)	1.64E-05	1	0.9968		D(LGDP)	5.321647	1	0.0211

Source: author's calculation

Table A4: VEC/VAR residual Portmanteau test for autocorrelation

	Lag	Q-stat	Prob.	Adj. Q-stat	Prob.		Lag	Q-stat	Prob.	Adj. Q-stat	Prob.
VEC	1	0.252178	NA*	0.259383	NA*	VAR	1	2.227386	NA*	2.375879	NA*
	2	1.155289	0.9919	1.215618	0.9906		2	3.021130	0.8830	3.283014	0.8576
	3	4.789698	0.9409	5.180428	0.9221		3	6.997695	0.7993	8.177248	0.6973
	4	6.771125	0.9637	7.409534	0.9453		4	8.821997	0.8866	10.60965	0.7797
	5	9.658577	0.9609	10.76270	0.9316		5	12.64773	0.8561	16.17435	0.6456
	6	10.39480	0.9886	11.64617	0.9756		6	14.66988	0.9061	19.40980	0.6772
	7	12.09327	0.9939	13.75462	0.9835		7	15.66888	0.9590	21.18580	0.7775
	8	14.95554	0.9933	17.43467	0.9761		8	16.65581	0.9833	23.15965	0.8433

Note: H_0 – no residual autocorrelation up to lag h

Source: author's calculation

Table A5: VEC/VAR residual normality test

	Component	Jarque-Bera	df	Prob.		Component	Jarque-Bera	df	Prob.
VEC	1	20.58988	2	0.0000	VAR	1	0.682254	2	0.7110
	2	0.604627	2	0.7391		2	1.404450	2	0.4955
	Joint	15.71383	9	0.0731		Joint	6.878059	9	0.6498

Note: orthogonalization – residual covariance (Urzua)

H_0 – residuals are multivariate normal

Source: author's calculation