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The causality relationship between energy consumption and GDP in G-11 countries revisited

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Abstract

This paper explores whether energy conservation policies can be implemented in countries with the same level of development. That is, is restraining energy consumption without compromising economic growth feasible in all industrialized countries? A new Granger non-causality testing procedure developed by Toda and Yamamoto [1995, Journal of Econometrics 66, 225–250] is applied to re-investigate the relationship, if any, between energy consumption and income in 11 major industrialized countries. The results clearly do not support the view that energy consumption and income are neutral with respect to each other, except in the case of the United Kingdom, Germany and Sweden where a neutral relationship is found. Bi-directional causality in the United States and uni-directional running from energy consumption to GDP in Canada, Belgium, the Netherlands and Switzerland are found. This indicates that energy conservation may hinder economic growth in the latter five countries. Further, the causality relationship appears to be uni-directional but reversed for France, Italy and Japan which implies that, in these three countries, energy conservation may be viable without being detrimental to economic growth.

JEL classifications: Q43; C22

Keywords: Energy consumption; Income; Causality

1. Introduction

The nature of causal relationships between energy consumption and income has been one of the most hotly debated issues in the past three decades, yet never before has a consensus been reached as shown in Table 1. We find that even if the same causality test method is employed, the results vary. For instance, the results of Kraft and Kraft (1978) and Thoma (2004) both of whom have used the standard Granger causality test are contradictory, with each showing an opposing causal relationship between energy consumption and income for the United States (Table 1). Worth noting, however, is that the differences in the findings listed may very well be a product of the different econometric methods used, different combinations of and variations in the variables, the span and the characteristics of the sample.

In the present study, to re-examine these causal relationships, we compare the diversity of the causal relationship between energy consumption and GDP in industrialized countries by using the method recently developed by Toda and Yamamoto (1995, hereafter TY). We determine if energy conservation policies can be implemented in countries with more or less, the same level of development and if putting energy consumption under restraint without compromising economic growth is workable in industrialized countries.

Evidence of causality between energy consumption and income in either direction may have significant bearings upon policy. For example, if uni-directional

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Table 1
Comparison of the empirical results from various causality tests

Authors	Empirical method	Period	Country	Causal relationship
Kraft and Kraft (1978)	Standard Granger causality test (1969)	1947–1974	United States	Energy ← Income
Yu and Choi (1985)		1954–1976	South Korea	Energy ← Income
			Philippines	Energy → Income
Erol and Yu (1987)		1950–1982	Japan	Energy → Income
Thoma (2004)		1973–2000	United States	Energy → Income
Cheng and Lai (1997)	Hsiao's Granger Causality Test (1981)	1955–1993	Taiwan	Energy ← Income
Yang (2000)		1954–1997	Taiwan	Energy ↔ Income
Stern (2000)	Vector autoregressive model	1948–1994	United States	Energy → Income
Soytas and Sari (2003)	Error-correction model	1950–1992	Argentina	Energy ↔ Income
			Italy	Energy ← Income
			South Korea	Energy ← Income
			Turkey, France, Germany and Japan	Energy → Income
			United States, United Kindgom and Canada	Non-cointegrated
Oh and Lee (2004)		1970–1999	South Korea	Energy ↔ income
Paul and Bhattacharya (2004)		1950–1996	India	Energy ↔ income
Jumbe (2004)		1970–1999	Malawi	Energy ← Income

Notes: Energy → Income denotes causality runs from energy consumption to income. Energy ← Income denotes causality runs from income to energy consumption. Energy ↔ Income denotes bi-directional causality between income and energy consumption.

causality runs from energy consumption to income, then this is indicative of energy-dependent economy in which energy is an impetus for growth, strongly implying that a reduction in the amount of energy available may negatively affect income. Stated briefly, in this case, energy conservation would be expected to harm economic growth (Masih and Masih, 1998). By contrast, if uni-directional causality runs from income to energy, then this denotes a less energy-dependent economy, one where the implementation of energy conservation policies would have few, if any, adverse effects on income (Jumbe, 2004). Finally, as for the finding of no causality in either direction, this, the so-called 'neutrality hypothesis', would signify that energy consumption does not affect income, and as such, energy conservation policies may be pursued without adversely affecting income (Yu and Choi, 1985).

Using data for the 1947–1974 period, the original study by Kraft and Kraft (1978) found evidence of causality running from GNP to energy consumption in the United States, indicating that energy conservation policies may be initiated without causing deteriorating economic side effects. Empirical studies were later extended to cover other industrialized countries (Yu and Choi, 1985; Erol and Yu, 1987). However, the findings have been empirically challenged. Akarca and Long (1980), Yu et al. (1988) and Yu and Jin (1992), for example, held the view that energy consumption and income have a neutral relationship; this further led Akarca and Long (1980) to claim that Kraft and Kraft's (1978) were misleading due to temporary sample instability.

Although empirical findings vis-'a-vis causal relationships are mixed if not downright contradictory, the most studies (based on the standard Granger test) have investigated lead- and lag- relations (Erol and Yu, 1987; Hwang and Gum, 1992). Besides this, taking into consideration the non-stationarity of macroeconomic variables, Soytas and Sari (2003) have employed cointegration and error-correction modeling techniques to estimate the causal relationships in the G-7 countries which make allowances for channels through the error correction mechanism for the 1950–1992 period. Their results indicate causality running from GDP to energy consumption in Italy, and from energy consumption to GDP in France, Germany and Japan. What's more, they reject the cointegration vector for the United States, the United Kingdom and Canada. However, according to Movrotas and Kelly (2001) and Chowdhury and Mavrotas (2003), testing for stationary and cointegration before Granger causality testing may actually have the effect of inducing an over-rejection of the non-causal null, thereby leaving open the possibility of distorting the facts in the inference procedure.

This paper's modeling procedures follow that of TY (1995), which allow us to draw conclusions with regard to the above relationships which are much more robust.[2] The benefit here is that the testing does not require knowledge as to the cointegration properties of the system and can be applied when there is no cointegration. Furthermore, the method can be used when stability and rank requirements are not satisfied. Finally, the model estimation procedures are quite simple, particularly in cases where there are more than two cointegrating vectors and where the OLS is valid.

[2] Zapata and Rambaldi (1997) further extended and interpreted TY's (1995) method.

The purpose of this paper is to re-examine causality between energy consumption (hereafter LEC) and real income (hereafter LGDP) for 11 major industrialized countries, referred to as the G11 countries. We employ the TY (1995) procedure which is a modified Wald (MWALD) test with restrictions on the parameters of the VAR model.[3] This procedure overcomes those problems inherent in hypothesis testing which are often encountered when VAR processes have some unit-roots. Moreover, we conduct a Granger causality tests with an allowance, which allow for the long-run information to be ignored in systems that require first-differencing and pre-whitening. This method is also valuable because it eliminates the need for potentially biased pre-tests for unit-roots and cointegration. We compare these results with those of the G-11 countries.

The paper is organized as follows: In Section 2, we briefly describe the TY (1995) procedure, and in Section 3, we present the empirical results. In Section 4, we discuss the policy implications, while in Section 5, we review the conclusions we draw.

2. Methodology

TY (1995) considered the n-vector time series Z_t generated by the kth order VAR model:

$$Z_t = \Phi_0 + \Phi_1 t + \Phi_2 t^2 + \Pi_1 Z_{t-1} + \ldots + \Pi_k Z_{t-k} + E_t,\quad t = 1, \ldots T, \tag{1}$$

where$E_t \sim N(0, \Omega)$; $Z_t = (LGDP_t,\ LEC_t)$; and t represents a deterministic time trend. Economic hypotheses can be expressed as restrictions on the coefficients in the model in accordance with the following:

$$H_0 : F(\pi) = 0, \tag{2}$$

where $\pi = vec(P)$ is a vector of the parameters in model (1); $P = (\Pi_1 \ldots \Pi_k)$; and $F(\cdot)$ is a twice continuously differentiable m-vector valued function.

TY (1995) developed a simple procedure that facilitates testing for Granger non-causality in level VARs estimated by the OLS with integrated variables. The augmented $(k+d)$ VARs are estimated, where d is the maximal order of integration. To test their hypothesis (2), TY (1995) confirmed that the Wald statistic converges in distribution to an χ^2 random variable with m degrees of freedom regardless of whether the process Z_t is stationary, possibly around a linear trend, or whether it is cointegrated. This methodology minimizes the risks perhaps associated with misidentifying the orders of integration of the series, or the presence of cointegration, while additionally, it minimizes the possibility of distorting the test size which frequently results from pretesting.

3. Empirical investigation

We obtain annual data for real GDP per capita and energy use in kilotons of equivalent oil from the *World Development Indicators* (WDI, 2004). The sample countries are the United States (US), the United Kingdom (UK), Germany (GM), France (FR), Italy (IT), Canada (CA), Japan (JP), Belgium (BL), the Netherlands (NT), Sweden (SD) and Switzerland (SZ). Since the empirical period depends on the availability of data, the time period we use is 1960–2001, except for GM (1971–2001) and CA (1965–2001). All of the variables used are in natural logarithms.

In the first step, we employ the Augmented Dickey Fuller (ADF) test to examine the possibility of a unit-root among these variables, and the results of the unit-root test are presented in Table 2. We follow the determining rule of Doldado et al. (1990) to establish the appropriate model for the unit-root tests.[4] Aside from this, we adopt the newly developed Modified Akaike's Information Criterion (MAIC), as suggested by Ng and Perron (2001), in order to select the optimal number of lags based on the principle of parsimony.

Standard ADF tests are not appropriate for testing for the stationarity of a series which encounters a structural change. Thus, we further take the structure-break into account when employing the unit-root test. Zivot and Andrews (1992) (hereafter ZA) developed a unit-root test with an endogenous structure-break, which is widely regarded as being more suitable to test for the order of integration of a series. Table 3 presents the results of the ZA tests we perform here. The ADF and ZA tests indicate that the series are integrated of order one $I(1)$ at the 5% level of significance and, hence, follow stochastic trends. The exception is the variable LEC for IT and JP, which requires second differencing to achieve stationarity.

We then employ Akaike's Information Criterion (AIC) and Schwartz's Bayesian Information Criterion (SBC) to select the lag-lengths of the VARs. We start by estimating VAR(4) and then drop one lag at a time. The optimum order of the VARs(k) are reported in Table 4. Next, we determine the optimal lag lengths and thoroughly examine the congruency of the VARs by performing the usual misspecification tests, which we carry out for serial correlations, normality, and the ARCH structure of the residuals of the VARs. The

[3]The Monte Carlo experiments presented in Zapata and Rambaldi (1997) provide evidence that the MWALD test has a comparable performance in size and power to the likelihood.

[4]Doldado et al. (1990) tested the significance of a trend coefficient in the τ_τ model first and then tested for the significance of the drift coefficient in the τ_μ model. If both results are insignificant, then the τ model is selected.

Table 2
Results of the ADF unit-root tests

Country	Variable	Level model	Level	First difference model	First difference
US	LGDP	τ_τ	−2.731(0)	τ_μ	−4.995(0)**
	LEC	τ_μ	−2.647(2)	τ_μ	−3.520(0)**
UK	LGDP	τ_μ	−0.359(2)	τ_τ	−4.629(0)**
	LEC	τ_μ	−2.115(0)	τ_μ	−6.073(0)**
GM	LGDP	τ_τ	−1.975(0)	τ_μ	−4.019(0)**
	LEC	τ_τ	−2.972(0)	τ	−4.679(0)**
FR	LGDP	τ_μ	−2.399(1)	τ_τ	−3.131(1)
	LEC	τ_τ	−2.166(0)	τ_τ	−3.953(1)**
IT	LGDP	τ_τ	−2.130(0)	τ_τ	−6.009(0)**
	LEC	τ_μ	−2.340(3)	τ	−2.628(2)
CA	LGDP	τ_τ	−2.144(0)	τ_μ	−4.361(0)**
	LEC	τ_τ	−2.919(0)	τ_τ	−4.128(0)**
JP	LGDP	τ_μ	−2.727(3)	τ_τ	−4.240(0)**
	LEC	τ_μ	−2.856(3)	τ	−1.752(2)
BL	LGDP	τ_τ	−1.839(0)	τ_μ	−2.328(3)
	LEC	τ_μ	−2.722(0)	τ_μ	−4.636(0)**
NT	LGDP	τ_μ	−2.464(1)	τ_τ	−5.179(0)**
	LEC	τ_τ	−2.190(0)	τ	−1.426(6)
SD	LGDP	τ_τ	−2.920(0)	τ_μ	−3.730(0)**
	LEC	τ_τ	−2.151(0)	τ_τ	−7.069(0)**
SZ	LGDP	τ_τ	−2.734(0)	τ_μ	−4.716(0)**
	LEC	τ_τ	−3.276(0)	τ_τ	−6.327(0)**

Notes: The number in parentheses indicates the appropriate order of the ADF model based on the MAIC, as suggested by Ng and Perron (2001). ** indicates significance at the 5% level. τ, τ_μ and $\tau_\tau$are the test statistics for a unit-root without a constant, with a constant and with both a constant and time trend, respectively. The appropriate model was determined by Doldado et al. (1990). The critical values for the ADF t statistics are from Mackinnon (1991).

results are reported in Table 5. In general, the tests show that with none of the assumptions of the econometric model rejected, the model specifications used in the estimation are appropriate.

In this case, the variables are $I(1)$ or $I(2)$, and thus, we augment the bivariate VARs by one or two lags and then test for non-causality zero restrictions on the parameters of the original VAR by carrying out a standard Wald test on the first k coefficient matrix. TY's (1995) MWALD test results are reported in Table 6. Since all the variables are in levels, the results provide information about the long-run causal relationships among the non-stationary variables in the system.

The results presented in Table 6 provide convincing evidence of a uni-directional causality running from LEC to LGDP for Canada, Belgium, the Netherlands and Switzerland at the 10% level of significance. It is that energy conservation that may very well be a hindrance to economic growth in these countries. Contrast this with the causality in France, Italy and Japan, which is reversed, and for the United States, which is bi-directional. In none of the other countries does LGDP or LEC significantly enter into each other's equation, indicative of a lack of causality.

Our results are highly consistent with those of Soytas and Sari (2003) who have found evidence of a uni-directional causality running from LGDP to LEC but in Italy only; our results do not support this for the other G-6 countries, i.e., France, Germany, Japan, the United States, the United Kingdom, and Canada. With respect to the energy-income relationship, the results negate the neutrality hypothesis previously advanced by Erol and Yu (1987) and Yu and Jin (1992) for the United States. It is only in the United Kingdom, Germany and Sweden that neutrality between energy and income is observed. The differences in the results of this paper and those from previous studies might be attributable to the choice of the sample period, the different combinations of the variables or the differences in the econometric methods.

4. Policy implications

The United Nations' *Framework Convention on Climate Change*'s *Kyoto Protocol* came into force on

Table 3
Results of the ZA unit-root tests with a structural break

Country	Variable	Level ($t(\hat{\lambda}_{\text{inf}})$)	Break	First difference ($t(\hat{\lambda}_{\text{inf}})$)	Break
US	LGDP	−4.820(C)	1969	−5.106(B)**	1971
	LEC	−3.159(B)	1969	−5.274(B)**	1982
UK	LGDP	−3.974(B)	1995	−5.674(C)**	1983
	LEC	−2.569(B)	1966	−6.903(B)**	1976
GM	LGDP	−4.601(C)	1990	−4.10(B)	1975
	LEC	−5.018(C)	1992	−5.647(A)**	1981
FR	LGDP	−3.982(B)	1974	−5.483(C)**	1974
	LEC	−4.647(C)	1970	−7.457(C)**	1974
IT	LGDP	−3.310(C)	1967	−6.351(C)**	1971
	LEC	−5.624(B)**	1971	−3.748(A)	1974
CA	LGDP	−3.440(C)	1976	−4.737(B)**	1992
	LEC	−4.512(C)	1972	−5.883(C)**	1984
JP	LGDP	−3.538(B)	1969	−5.902(C)**	1971
	LEC	−4.470(C)	1969	−4.510(A)	1974
BL	LGDP	−4.552(C)	1969	−6.482(B)**	1983
	LEC	−3.268(B)	1970	−5.536(B)**	1981
NT	LGDP	−2.848(B)	1995	−7.047(C)**	1984
	LEC	−4.148(C)	1969	−6.780(A)**	1974
SD	LGDP	−3.588(C)	1991	−5.089(B)**	1993
	LEC	−4.557(C)	1968	−8.087(C)**	1971
SZ	LGDP	−3.873(C)	1969	−4.899(B)**	1976
	LEC	−4.544(C)	1970	−7.861(C)**	1974

Notes: The critical value for the 5% levels are −4.80, −4.42, and −5.08 for Model A, Model B and Model C, respectively, from Zivot and Andrews (1992). Model A allows for a change in the level of the series; Model B allows for a change in the slope of the trend of a series, while Model C combines both the changes in the level and the slope of the trend. The letters in parentheses indicate the appropriate model based on the results from the ADF test. Break denotes the time of the structure change. ** indicates significance at the 5% level.

Table 4
Selection of the order of the VARs(k)

Country	AIC				SBC				Optimal
	1	2	3	4	1	2	3	4	(k*)
US	−10.087	−10.023	−10.002	−10.013	−9.825	−9.588	−9.392	−9.229	1
UK	−9.477	−9.449	−9.287	−9.190	−9.216	−9.013	−8.677	−8.406	1
GM	−9.823	−9.592	−9.405	−9.323	−9.533	−9.108	−8.728	−8.452	1
FR	−9.645	−9.479	−9.340	−9.237	−9.384	−9.044	−8.730	−8.453	1
IT	−9.848	−9.972	−9.855	−9.697	−9.586	−9.537	−9.245	−8.914	2
CA	−9.525	−9.534	−9.450	−9.299	−9.250	−9.076	−8.809	−8.475	2
JP	−8.796	−8.777	−8.831	−8.712	−8.535	−8.342	−8.222	−7.928	3
BL	−8.937	−8.831	−8.658	−8.698	8.676	−8.396	−8.049	−7.914	1
NT	−9.041	−8.988	−8.803	−8.686	−8.779	−8.552	−8.193	−7.902	1
SD	−8.347	−8.231	−8.220	−8.057	−8.086	−7.796	−7.611	−7.273	1
SZ	−8.755	−8.670	−8.483	−8.379	−8.494	−8.234	−7.874	−7.596	1

Notes: AIC and SBC stand for the Akaike and Schwartz Information Criteria, respectively. Term k* is the selected order of the VARs. In the case of conflicting results between the AIC and SBC, we use the AIC results, as suggested by Stock (1994).

February 16, 2005. The developed countries agreed to limit their greenhouse gas emissions relative to the levels emitted in 1990. For instance, the United States, although it has not ratified the treaty, agreed to reduce emissions from its 1990 levels by 7 percent during the 2008-2012 period. Under the Protocol, the developed

Table 5
Misspecification tests for the VARs(k^*)

Country	AR	NORM	ARCH
US	17.260[0.14]	4.408[0.35]	15.966[0.19]
UK	9.694[0.22]	5.165[0.27]	29.534[0.20]
GM	9.885[0.18]	6.350[0.17]	31.675[0.13]
FR	5.701[0.62]	3.956[0.41]	25.973[0.35]
IT	5.78[0.62]	0.668[0.95]	33.653[0.09]
CA	4.791[0.74]	2.725[0.60]	30.248[0.17]
JP	9.757[0.23]	11.770[0.01]	24.233[0.44]
BL	12.109[0.09]	1.265[0.86]	21.668[0.59]
NT	6.344[0.55]	4.259[0.37]	30.569[0.16]
SD	7.818[0.38]	6.157[0.24]	30.993[0.15]
SZ	8.809[0.28]	6.096[0.19]	34.050[0.08]

Notes: AR is the portmanteau test for the autocorrelations of the residuals (Lutkepohl, 1991). NORM is the residual normality test of orthogonalization: Cholesky (Lutkepohl, 1991) and ARCH is the Doornik (1995) test for the null hypothesis that the residuals do not have an ARCH structure. The figures in parentheses are the p-values.

Table 6
Granger causality test results based on the TY procedures

Modified Wald Statistics			
Country	LEC Granger causes LGDP	LGDP Granger causes LEC	Direction of causality
US	4.415[0.03]**	4.046[0.04]**	$LEC \Rightarrow LGDP$ $LGDP \Rightarrow EC$
UK	0.131[0.71]	0.497[0.48]	$LEC \neq > LGDP$ $LGDP \neq > EC$
GM	2.270[0.13]	0.023[0.87]	$LEC \neq > LGDP$ $LGDP \neq > EC$
FR	0.370[0.54]	4.109[0.04]**	$LEC \neq > LGDP$ $LGDP \Rightarrow EC$
IT	1.420[0.49]	4.925[0.08]*	$LEC \neq > LGDP$ $LGDP \Rightarrow EC$
CA	7.585[0.02]**	4.098[0.12]	$LEC \Rightarrow LGDP$ $LGDP \neq > EC$
JP	6.123[0.11]	14.045[0.00]**	$LEC \neq > LGDP$ $LGDP \Rightarrow EC$
BL	9.691[0.00]**	2.009[0.15]	$LEC \Rightarrow LGDP$ $LGDP \neq > EC$
NT	3.503[0.06]*	2.115[0.14]	$LEC \Rightarrow LGDP$ $LGDP \neq > EC$
SD	0.195[0.65]	0.688[0.40]	$LEC \neq > LGDP$ $LGDP \neq > EC$
SZ	7.583[0.00]**	0.523[0.46]	$LEC \Rightarrow LGDP$ $LGDP \neq > EC$

Note: The $[k + d_{\max}]$th-order level VAR is estimated with $d_{\max}$ being 1 or 2. The reported estimates are asymptotic Wald statistics. The values in parentheses are p-values. $\neq >$ denotes statistical insignificance and, hence, fails to reject the null hypothesis of non-causality. $\Rightarrow$ denotes the rejection of the null hypothesis of non-causality. ** and * indicate significance at the 5% and 10% level, respectively.

countries, including the G-11 countries, are expected to cut their greenhouse gas emissions, especially carbon dioxide (CO_2) emissions, to meet the standards stipulated in the *Kyoto Protocol*. However, will these cuts in CO_2 emissions brought about by decreasing energy consumption lead to a reduction in income? For the most part, these countries strongly feel that economic development must be considered in the formulation of any climate change response strategy. This paper provides the answer to this question and discusses possible policy implications.

First, we find that uni-directional causality running from energy consumption to GDP exists in Canada, Belgium, the Netherlands and Switzerland, suggesting that energy serves as an engine of economic growth. That is, current as well as earlier changes in energy consumption had a significant impact on income. It follows then that the cuts in energy consumption from the enactment of the *Kyoto Protocol* will actually harm the economy in the four countries where this form of causality exists.

Second, bi-directional causality between energy consumption and GDP exists in the United States, which indicates the level of economic activity and energy consumption mutually influence each other in that a high level of economic growth leads to a high level of energy consumption and vice versa. This suggests that energy consumption and income are endogenous and, therefore, any single equation forecast of one or the other could be misleading. Furthermore, in order not to adversely affect economic growth, energy conservation policies that aim at curbing energy use must also, at the same time, find ways to reduce consumer consumption.[5]

Third, the results indicate that uni-directional causality running from GDP to energy consumption exists in France, Italy and Japan. This means that continuous economic growth simultaneously generates a continuous rise in energy consumption. In this case, energy consumption is fundamentally driven by income, and as such, taking measures to conserve energy may be feasible without compromising economic growth. Beyond this, it is implied that a strategy for sustainable development with a lower level of CO_2 emissions may, indeed, be appropriate in these three countries.[6]

Fourth, as a country tries to estimate its demand for energy, it must identify the explanatory variables which affect the demand function of energy consumption. Income is always a necessary variable when it comes to explaining the demand for energy consumption (Dahl and Erdogan, 1994; Burney, 1995; Bentzen and Engsted, 2001). However, will the explanatory variable really affect energy demand? We can conclude that the

[5]See Asafu-Adjaye (2000) for a detailed discussion.
[6]See Oh and Lee (2004) for a detailed discussion.

causality relation from income to energy consumption exists in France, Italy and Japan. In the three countries, the demand function of energy consumption can contain income as an explanatory variable. Therefore, if the causality relation does not exist in the test, the energy demand estimation equation with income as an explanatory variable to estimate energy usage will result in a spurious relationship between energy consumption and income.

Finally, the results do not identify any causality relationship between energy consumption and income in the United Kingdom, Germany or Sweden. We accept the ''neutrality hypothesis'' in these countries. This implies that decoupling the limitations on CO_2 emissions from economic growth can be achieved. That is, sustainable development strategies with lower levels of CO_2 emissions from fossil fuel combustion may be reached. Simply put, the United Kingdom, Germany and Sweden may take greater responsibility to reduce their CO_2 emissions because such a reduction in energy consumption would not significantly affect economic growth.

5. Concluding remarks

This paper uses the TY (1995) causality testing procedure to re-examine the causal relationships between energy consumption and GDP in the G-11 countries. This method makes it possible to estimate the level of VARs and to test the general restrictions on the parameter matrices even if the processes are integrated or cointegrated in an arbitrary order. We determine whether energy conservation policies can be implemented in countries with approximately the same level of development, that is, whether restraining energy consumption is feasible without compromising economic growth in industrialized countries.

With the exception of the United Kingdom, Germany and Sweden where neutral causality is observed, the results do not support the view that in the other countries, energy consumption and income are neutral with respect to each other. What we discover, in fact, is bi-directional causality in the United States but uni-directional causality running from energy consumption to GDP in Canada, Belgium, the Netherlands and Switzerland. This indicates that energy conservation may harm economic growth in these five countries. Further, the causality relationship is seemingly just the opposite in France, Italy and Japan, indicating that energy conservation policies can be implemented with very few adverse, or even no effects whatsoever, on income. In other words, sustainable development strategies with lower levels of CO_2 emissions from fossil fuel combustion can safely be put into practice in the latter three countries.

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