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The Long-Run Relationship Between Energy Use and Export Sophistication in OECD Countries

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Abstract

The current research is an empirical investigation of the long-run and causal relation between energy consumption and export sophistication. It employs the panel cointegration analysis and cointegration regression using FMOLS and DOLS, for 31 OECD countries covering time span 1990–2016. The results show that there is strong bi-directional causality relation between variables. The energy consumption elasticities of high technology exports are comparatively high than medium and low tech export. The magnitude of the elasticity demonstrates that a 1% boost in energy consumption is expected to result in 0.81% growth in high technology export share. Moreover, any boost in a share of real investment is expected to have a powerful impact on high and medium tech export growth. It states that energy investment policies are expected to spur share of high technology exports in OECD countries. This paper is a pioneering study to investigated the relationship between energy consumption and export at the technology level.

Keywords: Export Sophistication, Energy Consumption, Panel Cointegration

JEL Codes: B23, F14, O13

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OECD Ülkelerinde Enerji Tüketimi ve İhracat Teknoloji Düzeyi Arasındaki Uzun Dönemli İlişki

Öz

Çalışma, uzun dönemde enerji tüketimi ve ihracatın teknoloji düzeyi arasındaki nedensel ilişkiyi 31 OECD ülkesi için 1990–2016 döneminde incelemektedir. Uzun dönem katsayılarının elde edilmesinde panel eşbütünleşme ve panel regresyon analizleri kullanılmıştır. Bulgular değişkenler arasında çift yönlü nedensellik ilişkisi olduğunu güçlü bir biçimde ortaya koymaktadır. Yüksek teknoloji ürün ihracatının enerji tüketimi esneklikleri orta ve düşük teknoloji ihracatına göre nispeten yüksektir. Esnekliğin büyüklüğüne göre, enerji tüketiminde% 1'lik bir artışın, yüksek teknoloji ihracat payında % 0.81 oranında bir artışa yol açmasının beklenmektedir. Dahası, reel yatırım düzeyinde meydana gelen herhangi bir artış, yüksek ve orta teknoloji ihracat ürünleri üzerinde güçlü bir etki yaratmaktadır. Elde edilen bulgulara göre, OECD ülkelerinde enerji sektörüne yapılan yatırımların uzun dönemde yüksek teknoloji ihracatını arttırdığı sonucuna ulaşılmaktadır. Bu çalışma, enerji tüketiminin ihracatın teknoloji düzeyi üzerindeki etkisini inceleyen öncü bir çalışmadır.

Anahtar Kelimeler: İhracatın Teknoloji Düzeyi, Enerji Tüketimi, Panel Eşbütünleşme

JEL Kodları: B23, F14, O13

Introduction

Global energy consumption has been gradually increasing related to technological development, trade, and population growth. According to IEA (2018) data, while per capita energy consumption was 1336 kg of oil equivalent in the early 1970s, it increased by 44% out to 2014 and amount to 1920 kg oil. The volume of total merchandise trade among countries has been rapidly increasing after 1980 owing to globalization. While the volume of total merchandise trade was US$ 3.91 trillion in 1980, it reached around US$ 36 trillion by ninefold increase out to 2017.

Figure 1. scatterplots the high-tech export nexus energy consumption by logarithmic scale in OECD countries. Fig. 1 clearly show that South Korea, Iceland, Chile and Mexico are relatively outlier countries in high technology export energy efficiency. South Korea and Mexico differ from OECD positively, while Chile and Iceland differ negatively. South Korea and Mexico appear to be the most energy efficient countries in high-tech exports. Although Iceland's energy consumption is high, the volume of technology intensive exports is quite small.

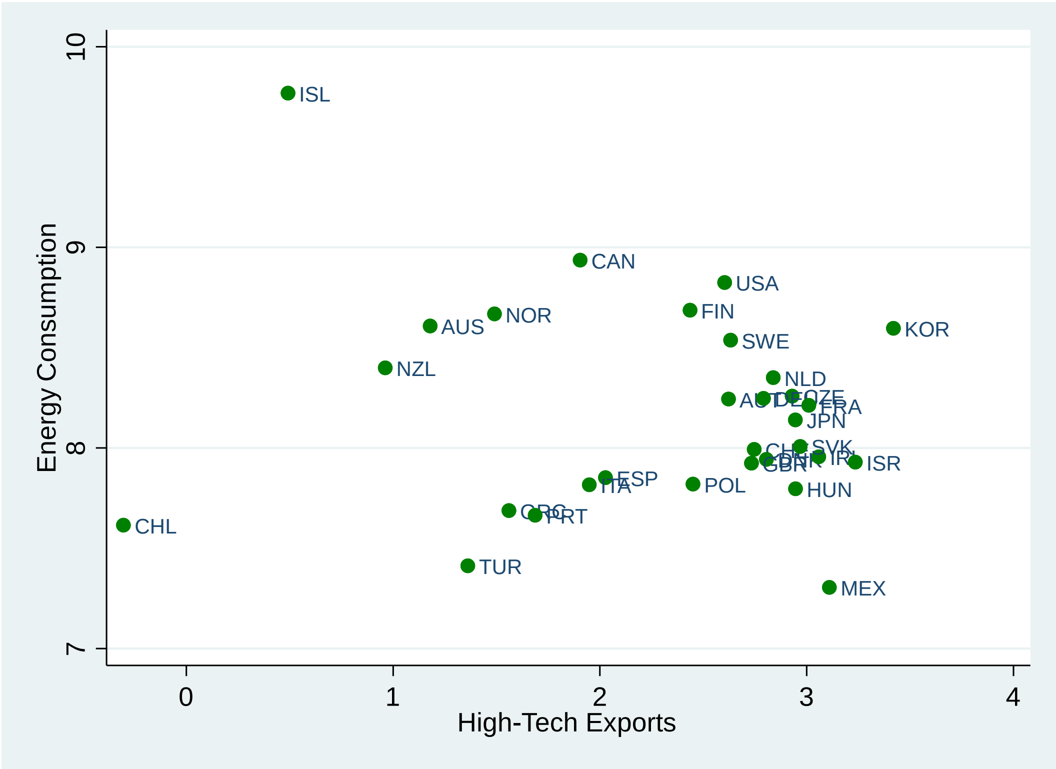

Figure 1: Share of the High-Tech Export and Energy Consumption.

OECD countries account for about 42% of global total energy consumption by 2016, followed by China and USA 23% and 17%, respectively. The majority of the increasing global energy demand comes from Asian countries. Approximately two-thirds of growth arises from China, India and other non-OECD Asian countries. Energy demand in OECD countries is stable. The growth in OECD fossil fuels consumption is decreasing due to environmental policies. Moreover, renewable energy sources are expanding its share in the energy sector. The increasing competitiveness of wind and solar energy is the dynamics of strong growth in renewable energy (BP, 2018). Similar to other sectors, the competitiveness and cost advantage in energy sector is determined by the technology.

Many researchers have identified the main channels of technology diffusion as foreign direct investments, foreign trade and human capital (Nelson and Phelps, 1966; Findlay, 1978; Bhagwati, 1978; Walz, 1997; Benhabib and Spiegel, 2005; Kohpaiboon, 2006). Trade openness provides emerging economies to import high technologies from developed economies. The export-led growth strategy for many developing countries plays an important role in quickly catching up with advanced economies. To this end, countries want to maximize the income they derive from foreign trade by increasing both the quantity and quality of export goods. Therefore, the export strategy of developing countries is focused on increasing the share of high technology in export goods. Furthermore, considering that energy is one of the primary inputs in the manufacturing process it is necessary to determine the relationship between export sophistication and energy consumption.

Theoretically, it can be explained around four basic hypotheses how export effects the energy consumption (Sadorsky, 2011). Significant reduction in energy consumption due to energy saving policies or negative energy supply shocks will decrease export. The energy led export hypothesis is supported when there is a one-way causality from energy consumption to exports. In the case of the existence of one-way causality from export to energy consumption is confirmed the export led energy hypothesis. The relationship between energy and exports may be neutral. In this case, the correlation between energy consumption and exports is statistically quite small. Energy consumption has little or no effect on export, and there is no causal relationship between the two variables, the neutrality hypothesis is valid. Finally, there is also the possibility of feedback between energy and exports. Feedback hypothesis implies that there is a bidirectional causal relationship between energy consumption and exports.

To date, there is no previous study that has examined the association between energy consumption and export sophistication. The contribution of this paper to the literature is a pioneering study investigates the relationship between energy consumption and export by classifying the export at the level of technology. It is clearly important to understand the extent to energy consumption how effect technology level of export.

Consequently, the subsequent stages of the study were organized as follows. In the following section, a brief literature review is given. In the third chapter, the empirical method used and the data set are introduced. While the fourth chapter, empirical results are discussed. The last part is the conclusion and policy recommendations.

1. A Brief Literature Review

This section has attempted to provide a brief summary of the literature addressed to the relationship between energy and export. Although there have been several investigations into energy consumption and real GDP as a time series (see Yang, 2000; Ho and Siu, 2007; Lise and Van Montfort, 2007; Zhang and Cheng, 2009; Lach, 2015; Dogan, 2015) and panel data analysis (see Lee and Chang, 2008; Payne, 2010; Apergis and Payne, 2012; Aslan, 2013; Ozturk, 2017), there are few studies addressing the relationship between energy consumption and trade.

Cole (2006) examined the association between trade liberalization and national electricity use for a panel of developed and developing countries over the period 1975-1995. Results point out that trade will increase energy consumption for the countries in the sample.

Kahrl and Roland-Holst (2008) estimated that 15-22% of total energy consumption and total CO2 emissions based on fossil fuel sources are due to net exports of China. According to the findings, the share of net exports in total domestic energy consumption increased by 9 percentage points over the period 1995-2005 in China. The study is conducted with a linear input-output method. Another study using the environmental input-output approach for the Chinese economy investigated by Xu et al. (2011). The result shows that although the emission intensity cuts down CO2 emissions, the change in export composition in favor of metal products from 2002 to 2007 has led to an increase in emissions.

Narayan and Smyth (2009) analysed the data from six Middle East countries and concluded that short-run Granger causality running from electricity consumption to real GDP and from income to exports. In the long run, Granger causality running from exports and electricity consumption to real income. They also found out evidence in favor of Granger causality relationship running from exports and real income to electricity consumption.

The study of the Malaysian economy Lean and Smyth (2010a) showed that there is a causality relationship between electricity generation and export, but in another paper Lean and Smyth (2010b) found no causality relation between electricity consumption and exports. Erkan et.al. (2010) analyzed for the Turkish economy using cointegration test, Granger causality test, and impulse response functions and they found a positive and statistically significant effect of energy consumption on export.

Panel study for the Middle East countries Sadorsky (2011) demonstrated that in the short run there is a unidirectional relationship between exports and energy consumption, a bi-directional relationship between investment and energy consumption. Sadorsky (2012) found some evidence of indirect causality between energy consumption and output via exports for South American countries. According to this paper, in the long run, there is a causal relationship between energy consumption and foreign trade. In a study conducted by Hossain (2012) for SAARC economies, it was shown that the causality relationship between export and electricity consumption.

Dedeoglu and Kaya (2013) showed that there existed a bi-directional causality relationship between energy consumption and export-import in the case of OECD using the panel cointegration and the Granger methods for the period 1980–2010. Findings of the study support the existence of the feedback hypothesis between energy consumption and export-import.

Nasreen and Anwar (2014) explore the causal relationship between the trade opennes and energy consumption using data from 15 Asian countries in the period 1980-2011. Pedroni and Johansen cointegration and panel Granger causality approaches are applied to examine the long-term and causal relationship between variables. The empirical results confirm the existence of cointegration between variables. In the study, the effect of trade openness on energy consumption is found to be positive and existing bi-directional causality between variables.

Shahbaz et al. (2014) investigated the causal relationship between openness and energy consumption for 91 countries (high, middle, and low-income countries), during the 1980-2010 period. The empirical findings have supported the feedback hypothesis between variables in middle and low-income countries. However, the non-homogeneous causality approach for high-income countries has indicated one-way causality running from openness to energy consumption. Export led energy hypothesis is valid for high income country group.

Aissa et al. (2014) show that there is no causal relationship between renewable energy consumption and both exports and imports in the short run for 11 African countries. In spite of that, long-term causality relationship from renewable energy consumption to export and import has determined.

Topçu and Payne (2018) investigated the relationship between energy consumption and trade with linear and nonlinear models. In the nonlinear model, the effect of trade on energy consumption reflects an inverted U shape. The coefficients of export on energy consumption are between 0.085-0.099, and the coefficients for imports are ranging between 0.113 and 0.134 in the linear model. The study covers the period 1990-2015 for OECD countries.

2. Data Set And Methodology

The dataset of the research is conducted as balanced panel of OECD countires over the years 1990-2016. Belgium, Estonia, Latvia, Lithuania, Luxembourg and Slovenia are excluded due to non availability and quality of the data. All the data are gathered from the World Development Indicators.

Theoretically, two fundamental variables that determine the export demand are the real Exchange rate and the real income of the other countries, $EX_i = f(RER_i, GDP_o)$. The model has been extended by real investment which is a proxy variable of capital stock and energy consumption. All variables were used in a logarithmic form in order to obtain elasticities. To determine the relationship between energy consumption and export sophistication, three separate models were formed as follows.

$$lnhtech = f(lnenegy, lni, lnreer, lnwgdp) \quad (1)$$

$$lnmtech = f(lnenegy, lni, lnreer, lnwgdp) \quad (2)$$

$$lnlowtech = f(lnenegy, lni, lnreer, lnwgdp) \quad (3)$$

The demand for high-tech export in log-linear form is expressed as equation 4:

$$lnhtech_{it} = \beta_{i0} + \beta_{i1} lnenegy_{it} + \beta_{i2} lni_{it} + \beta_{i3} lnreer_{it} + \beta_{i4} lnwgdp_{it} + \varepsilon_{it} \quad (4)$$

Where lnhtech, lnmtech, lnlowtech, lnenergy, lni, lnreer, lnwgdp are share of high tech export of total export, medium tech export of total export, low tech export of total export, energy consumption (kg of oil equivalent per capita), investment share (% of GDP), real effective exchange rate index (2010 = 100), other countries GDP per capita (constant 2010

US$), respectively. Consistent with theory, we expect $\beta_{i3} < 0$. β_{i3} is the exchange rate elasticity of high-tech export.

Pesaran (2004) CD procedure was applied to both variables and residuals in order to investigate cross-section dependency. Under the null hypothesis of cross-section independence, the CD test has a standard normal distribution and the test statistic is calculated as equation 5.

$$CD_{Pesaran} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} r_{ij}\right) \rightarrow N(0,1) \tag{5}$$

Pesaran (2003) cross-sectionally augmented ADF and cross-sectionally augmented IPS (2007) tests were employed for stationarity analysis. CADF and CIPS test statistics are shown in the following equations.

$$\Delta y_{it} = a_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + e_{it} \tag{6}$$

$$CADF_i(N,T) = \frac{\Delta y_i' \bar{M}_W y_{i,-1}}{\hat{\sigma}_i (y_i' \bar{M}_W y_{i,-1})^{1/2}} \tag{7}$$

The estimable equation of CIPS test is modeled as follows:

$$CIPS = N^{-1}\sum_{i=1}^{N} CADF_i \sim N(0,1) \tag{8}$$

The cointegration analysis was performed with Kao (1999), Pedroni (1999, 2004) and Westerlund (2005) panel data cointegration tests. Cointegration equation expressed in the following form:

$$y_{it} = d_t' \hat{\delta}_i + x_{it}' \hat{\beta}_i + \hat{e}_{it} \tag{9}$$

in this least squares regression, d_t denote a vector of deterministic components. $\hat{e}_{it}$ is stationary when y_{it} and x_{it} series are cointegrated (Westerlund, 2005).

$$\hat{e}_{it} = \rho_i \hat{e}_{it-1} + u_{it} \tag{10}$$

where ρ_i is an autoregressive parameter. Testing stationarity of residuals using autoregression is equivalent to testing the null hypothesis of no cointegration.

Tested for Granger causality in heterogeneous panels using the procedure proposed by Dumitrescu and Hurlin (2012). Panel regression model has the following form:

$$y_{it} = \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} y_{i,t-k} + \varepsilon_{i,t} \quad (11)$$

where K stands for the lag length, $\gamma_i^{(k)}$ is a autoregressive parameter and $\beta_i^{(k)}$ is the regression coefficient. Dumitrescu and Hurlin (2012) propose an average Wald statistic that tests the null of no causal relationship for any of the cross-section units and generated as below:

$$W_{N,T}^{Hnc} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \quad (12)$$

where $W_{i,T}$ indicates the individual Wald statistic for cross-section units.

The cointegration coefficients were estimated using Pedroni (2001) fully modified ordinary least squares and dynamic ordinary least squares methods. FMOLS and DOLS estimators correct potential endogeneity and serial correlation problems. The signs and the magnitudes of the long-run relationship are estimated with the following equations:

$$\hat{\beta}_{i,FMOLS}^{*} = \frac{1}{\sqrt{N}} \sum_{i}^{N} \hat{L}_{11i}^{-1} \left(\sum_{i}^{T} (x_{it} - \bar{x}_i)^2 \right)^{-1/2} \left(\sum_{i}^{T} (x_{it} - \bar{x}_i) y_{it}^{*} - T\hat{\gamma}_i \right) \rightarrow N(0,1) \quad (13)$$

$$y_{it}^{*} = (y_{it} - \bar{y}_i) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta x_{it} \; and \; \hat{\gamma}_i \equiv \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^{0} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \left(\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^{0} \right) \quad (14)$$

where $\hat{\Omega}$ and $\hat{\Gamma}$ are covariances and weighted sums of autocovariances obtained from the long-run covariance matrix.

3. Empirical Findings

Table 1 and table 2 contains *p*–values obtained while testing for cross-section dependency using the Pesaran CD, Breusch-Pagan LM and Pesaran scaled LM procedure.

Table 1. Testing Variables for Cross-Section Dependency

Variables	CD-test	p-value	corr	abs(corr)
lnhtech	20.13	0.000***	0.193	0.431
lnlowtech	63.35	0.000***	0.613	0.646
lnmtech	4.90	0.000***	0.045	0.384
lni	19.06	0.000***	0.184	0.386
lnenergy	28.29	0.000***	0.269	0.491
lnreer	9.31	0.000***	0.091	0.408
lnwgdp	103.68	0.000***	1.000	1.000

Notes: Under the null hypothesis of cross-section independence CD ~ N(0,1) (***) indicate rejection of the null hypothesis at the 1%, levels of significance.

Table 2. Testing Residuals for Cross-Section Dependency

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	2595.969	435	0.0000***
Pesaran scaled LM	72.24663		0.0000***
Pesaran CD	25.74871		0.0000***

Notes: Null hypothesis of No cross-section dependence (correlation) in residuals
(***) indicate rejection of the null hypothesis at the 1%, levels of significance
Periods included: 26. Cross-sections included: 30

According to the test results, the cross-sectional dependence of both variables and residuals are determined. Therefore, the stationarity check was performed with second generation unit root tests, which take into account the cross-sectional dependence and heterogeneity. It is possible that non-stationary series may give spurious results in empirical studies. Therefore, it is necessary to verify all variables are stationary and in the same order before the procedure to panel cointegration analysis. Table 3 provides the second generation Pesaran CADF (2003) and CIPS (2007) panel unit root test results. Intercept and time trend are allowed for each test.

Table 3. Panel Unit Root Tests

Variables	CADF Test				CIPS Test			
	Intercept		Intercept+Trend		Intercept		Intercept+Trend	
	Z [t-bar]	Prob.	Z [t-bar]	Prob.	Z [t-bar]	Prob.	Z [t-bar]	Prob.
lnhtec	0.023	0.509	2.135	0.984	-0.641	0.261	-2.180	0.015
lnlowtech	0.062	0.525	4.275	1.000	-0.101	0.460	2.077	0.981
lnmtech	-0.640	0.261	0.514	0.696	0.228	0.590	-0.356	0.361
lni	1.418	0.922	2.199	0.986	0.012	0.505	-1.652	0.049
lnenergy	1.697	0.955	2.128	0.983	-0.054	0.478	1.526	0.937
lnreer	-0.806	0.210	1.321	0.907	-0.678	0.249	0.238	0.594
lnwgdp	3.280	0.999	22.582	1.000	4.854	1.000	4.482	1.000
First Difference								
Δlnhtech	-3.257	0.001***	-1.436	0.076*	-2.736	0.003***	-4.551	0.000***
Δlnlowtech	-1.644	0.050**	-8.331	0.000***	-9.981	0.000***	-8.331	0.000***
Δlnmtech	-3.665	0.000***	-8.070	0.000***	-3.665	0.000***	-8.070	0.000***
Δlni	-3.036	0.001***	-3.579	0.000***	-6.254	0.000***	-3.549	0.000***
Δlnenergy	-2.554	0.005***	-1.636	0.051*	-2.851	0.002***	-8.423	0.000***
Δlnreer	-3.294	0.000***	-2.888	0.002***	-4.305	0.000***	-1.686	0.046**
Δlnwgdp	-3.724	0.000***	-3.618	0.000***	-2.470	0.007***	-0.904	0.183

Notes: ***p <0.01, **p <0.05, *p <0.1. (*) indicate rejection of the null hypothesis of unit root at the 1%, 5% and 10% levels of significance.

Test results show that all variables are nonstationary around at 1% significance level but stationary in their first differences. As a result of the stationary analysis, variables are determined I(1) which means they are integrated of the same order.

Presence of the variables integration same order enabled the implementation of panel cointegration approaches to examine the long-run relationship between the variables. Panel cointegration analysis is investigated with Pedroni (2004), Kao (1999) and Westerlund (2005) tests. The results of the cointegration analysis are reported in the following tables below.

Table 4. Pedroni residual cointegration test

	Model 1			Model 2			Model 3		
	Panel Statistic	Weighted Statistic	Group Statistic	Panel Statistic	Weighted Statistic	Group Statistic	Statistic	Weighted Statistic	Group Statistic
v	1.685** (0.046)	-1.108 (0.866)		-0.018 (0.507)	-0.108 (0.543)		1.705** (0.044)	0.460 (0.322)	
rho	-0.813 (0.208)	1.999 (0.977)	4.217 (1.000)	1.004 (0.842)	1.214 (0.887)	3.222 (0.999)	0.175 (0.566)	0.486 (0.686)	2.332 (0.990)
PP	-4.991*** (0.000)	-2.289** (0.011)	-2.549*** (0.005)	-2.759*** (0.003)	-2.799*** (0.002)	-2.745*** (0.003)	-4.142*** (0.000)	-4.177*** (0.000)	-5.742*** (0.000)
ADF	-4.320*** (0.000)	-3.881*** (0.000)	-4.345*** (0.000)	-2.835*** (0.002)	-3.6087** (0.000)	-3.545*** (0.000)	-4.114*** (0.000)	-4.062*** (0.000)	-5.125*** (0.000)

Notes: Null Hypothesis is no cointegration. Prob. values are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.
(*) indicate rejection of the null hypothesis at the 1%, 5% and 10% levels of significance.

Table 5. Kao Residual Cointegration Test

	Model 1			Model 2			Model 3		
	t-Statistic	Residual Variance	HAC Variance	t-Statistic	Residual Variance	HAC Variance	t-Statistic	Residual Variance	HAC Variance
ADF	-4.587*** (0.000)	0.048	0.050	-2.098** (0.018)	0.007	0.006	-5.877*** (0.000)	0.005	0.004

Notes: Null Hypothesis is no cointegration. Prob. values are in parentheses. ***p <0.01, **p <0.05, *p <0.1.
(*) indicate rejection of the null hypothesis at the 1%, 5% and 10% levels of significance

Table 6. Westerlund Cointegration Test

	Model 1		Model 2		Model 3	
	Statistic	P-Value	Statistic	P-Value	Statistic	P-Value
Variance ratio	2.4232	0.0077***	-2.7398	0.0031***	-2.8428	0.0022***

Notes: Null Hypothesis is no cointegration. Number of panels = 30.
Avg. number of periods = 25.333

The results from performed procedure reject the null hypothesis and indicate cointegration around at the 1% significance level. Statistics indicate that a long-run relationship exists between the variables.Cointegration is verified for all three models and in different cointegration approaches.

Granger causality analysis is investigated by Dumitrescu & Hurlin (2012) method which is robust to cross-sectional dependence and heterogeneity. Panel causality test results are given in Table 7. Results from the DH model show bidirectional causality between energy consumption and low, middle and high technology export. Moreover, there is also a bi-directional causality between energy consumption and real investment, real effective exchange rate. These findings support the feedback hypothesis for the OECD countries. Feedback hypothesis suggests that fluctuations in two variables have a significant impact on each other. For sample countries, existing bidirectional Granger causality between energy consumption and the technology level of exports, any energy reduction arises from energy conservation policies will not only reduce GDP by trade but also limit the technology diffusion among countries. In addition, the one-way causality relationship from the income of other countries to exports is determined. Medium-low technology exports and investment rates affect each other in a bi-directional manner. High-tech exports are the Granger cause of the investment rate. High-tech exports are expected to have a positive impact on investments as its content the high added value.

Table 7. Dumitrescu Hurlin Panel Causality Test

Null Hypothesis	Obs	W-Stat.	Zbar-Stat.	Prob.	Direction
lnenergy - lnhtec lnhtec - lnenergy	709	3.206 4.706	2.086 5.334	0.037 0.000	lnenergy ↔ lnhtec
lnenergy - lnmtech lnmtech - lnenergy	709	4.674 3.166	5.263 2.000	0.000 0.046	lnenergy ↔ lnmtech
lnenergy - lnlowtech lnlowtech - lnenergy	709	4.962 4.489	5.888 4.864	0.000 0.000	lnenergy ↔ lnlowtech
lnmtech - lnhtec lnhtec - lnmtech	739	2.229 3.292	0.004 2.334	0.997 0.020	lnhtec → lnmtech
lnlowtech - lnhtec lnhtec - lnlowtech	739	3.678 6.659	3.179 9.717	0.002 0.000	lnhtec ↔ lnlowtech
lnmtech - lnlowtech lnlowtech - lnmtech	739	4.646 3.694	5.303 3.215	0.000 0.001	lnmtech ↔ lnlowtech
lni - lnhtec lnhtec - lni	739	2.090 4.921	-0.301 5.906	0.763 0.000	lnhtec → lni
lni - lnmtech lnmtech - lni	739	3.674 3.121	3.172 1.958	0.002 0.050	lnmtech ↔ lni
lni - lnlowtech lnlowtech - lni	739	3.640 6.066	3.096 8.417	0.002 0.000	lnlowtech ↔ lni
lni - lnenergy lnenergy - lni	719	3.342 3.518	2.407 2.790	0.016 0.005	lnenergy ↔ lni
lni - lnreer lnreer - lni	739	2.734 4.026	1.109 3.940	0.268 0.000	lnreer → lni
lni - lnwgdp lnwgdp - lni	747	3.521 5.491	2.857 7.194	0.004 0.000	lni ↔ lnwgdp
lnreer - lnenergy lnenergy - lnreer	709	3.129 4.090	1.919 3.996	0.055 0.000	lnreer ↔ lnenergy
lnreer - lnhtec lnhtec - lnreer	730	3.487 2.791	2.736 1.217	0.006 0.224	lnreer → lnhtec

lnreer - lnlowtech lnlowtech - lnreer	730	3.851 3.442	3.530 2.638	0.000 0.008	lnlowtech ↔ lnreer
lnreer - lnmtech lnmtech - lnreer	730	3.509 3.015	2.784 1.706	0.005 0.088	lnmtech ↔ lnreer
lnwgdp - lnhtec lnhtec - lnwgdp	739	4.441 2.257	4.853 0.064	0.000 0.949	lnwgdp → lnhtec
lnwgdp - lnmtech lnmtech - lnwgdp	739	3.310 1.753	2.373 -1.041	0.018 0.298	lnwgdp → lnmtech
lnwgdp - lnlowtech lnlowtech - lnwgdp	739	4.922 2.696	5.907 1.026	0.000 0.305	lnwgdp → lnlowtech
lnwgdp - lnenergy lnenergy - lnwgdp	717	4.952 1.210	5.903 -2.232	0.000 0.026	lnwgdp ↔ lnenergy
lnwgdp - lnreer lnreer - lnwgdp	737	3.457 2.420	2.688 0.418	0.007 0.676	lnwgdp → lnreer

Notes: Null Hypothesis: x does not homogeneously cause y.

Table 8 provides the long-run parameters based on FMOLS and DOLS estimation. In fmols models, the coefficients are positive and statistically significant at the 1% level for energy consumption and real invesment. Exchange rate and world GDP are negative and statistically significant at the 1% level. Model 1 results indicate that one percent increase in energy consumption increases high-tech export share by 0.811%; a one percent increase in real gross fixed capital formation increases high-tech export share by 0.374%; one percent increase in real effective exchange rate decreases high-tech export share by -0.687%; one percent increase in the world GDP decreases high-tech export share by -1.742%; and %; and one percent increase in the real investment rises high-tech export share by range between 0.374%-0.786%. As world GDP increases, countries significantly reduce technology-intensive product imports from OECD countries. An increase in the real effective exchange rate represents an appreciation of the local currency in real terms, denoting a rise in the value of local commodities in terms of foreign commodities. Real effective exchange rate elasticity of technology-intensive exports is consistent with economic theory and statistically significant. Note there is a wide difference in elasticity estimates between export sophistication. The fact that FMOLS and DOLS residuals are stationary and no correlation between cross sections supports the existence of a long run relationship between variables and eliminates the possibility of spurious regression. Taken together, these results suggest that there is a causal relationship between energy consumption and export technology level.

Table 8. Results of FMOLS and DOLS regression

	Model 1 (Htech)		Model 2 (Mtech)		Model 3 (Lowtech)	
Variable	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**
lnenergy	0.811***	0.862***	0.162***	0.316***	-0.238***	-0.239***
	(-0.213)	(0.140)	(0.069)	(0.071)	(0.063)	(0.061)
lni	0.374***	0.786***	0.350***	0.049	0.094***	0.128***
	(0.102)	(0.097)	(0.045)	(0.073)	(0.039	(0.044)
lnreer	-0.687***	-0.119	-0.216***	0.133**	-0.139***	-0.190***
	(0.109)	(0.112)	(0.054)	(0.070)	(0.043)	(0.056)
lnwgdp	-1.742***	-3.806***	-0.849***	-0.222***	-0.542***	-0.471**
	(0.734)	(0.469)	(0.223)	(0.051)	(0.183)	(0.237)
Residual	-2.030**	-5.593***	-1.743**	-4.127 ***	-1.658**	-7.564***
Cips Test	[0.021]	[0.000]	[0.041]	[0.000]	[0.049]	[0.000]
Residual	1.35***	7.96	1.46 ***	1.50***	1.04***	0.92***
CD Test	[0.176]	[0.000]	[0.146]	[0.135]	[0.300]	[0.358]
Obs	734	667	734	686	734	663

Notes: Automatic leads and lags specification based on AIC criterion.

4. Concluding Remarks And Policy Implications

The most obvious finding to emerge from this study is that the feedback hypothesis is supported between two variables and there is a bidirectional Granger causality relationship between total energy consumption and export sophistication. The feedback hypothesis between two variables is supported. The long-run cointegration coefficients clearly show that as the energy consumption rising, the technology level of the exported goods increases and vice versa. The second major finding was that while the effect of long-run energy consumption on high-tech and medium-tech exports is positive, its impact on low-tech exports is negative. The energy consumption elasticities of high technology exports are comparatively high than middle and low-tech export. It shows that high-technology exports consume more energy than medium and low-technology exports. Results are important in that increased energy consumption affects export sophistication in the OECD and in both the short and long-run. In addition, the exchange rate elasticity of technology-intensive exports goods is consistent with economic theory and statistically significant. Another significant result to emerge from this study is that energy consumption supports the export-led growth hypothesis through high and medium-tech exports indirectly. This evidence indicates that as the technology and knowledge of countries accumulate, energy demands have increased. Moreover, any boost in a share of real investment is expected to have a powerful impact on high and medium tech export growth. The research has also shown that an energy reduction stem from energy saving policies will reduce GDP by export channel and limit technology diffusion. The fact that the intensity of technology in exports depends on energy consumption requires countries to provide energy supply security, extend resource diversity and green renewable energy sources. Energy consumption forecasts, which do not take into account the impact of the technology level in exports, will probably underestimate the energy demand. Future research should investigate the interaction between the sources of energy and export sophistication.

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