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Econometric Prediction on the Effects of Financial Development and Trade Openness on the German Energy Consumption: A Startling Revelation from the Data Set

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ABSTRACT: This study aims to predict the effects of financial development and Trade openness on the German energy consumption. To ensure this, the study used time series data from 1970-2013. Following to this, the Zivot-Andrew structural break unit root test, the Bayer-Hank combined cointegration test, the ARDL bounds test and the VECM Granger causality test were applied. The findings of the study confirmed the existence of cointegration among the variables. As a result, the study discovered that economic growth adds to energy demand in Germany. Surprisingly, financial development, capital use and Trade openness were found to decline energy demand. It was discovered that a 1% increase in economic growth influence energy consumption by 2.1053%., while a 1% increase in financial development, capital use and Trade openness decrease energy consumption by 0.1863%, 0.9269%, 0.2091% respectively. The causality analysis reveals the existence of feedback effect between financial development and energy consumption and same inference was found to exist between trade openness and energy consumption. The results of the Granger causality analysis reveal that economic growth Granger-cause energy consumption, financial development, capital use and trade openness in Germany. In the light of this, the study advocates for a continued investment effort in renewable energy and the adoption of those policies and strategies that will promote the use of 'green' technologies at the industrial level. While at the household level, investment should be encouraged in the appropriate energy infrastructure that could assist with the simultaneous satisfaction of efficient energy usage.

Keywords: Economic Growth; Financial Development; Trade; Energy; Germany
JEL Classifications: C61; D24; Q42

1. Introduction

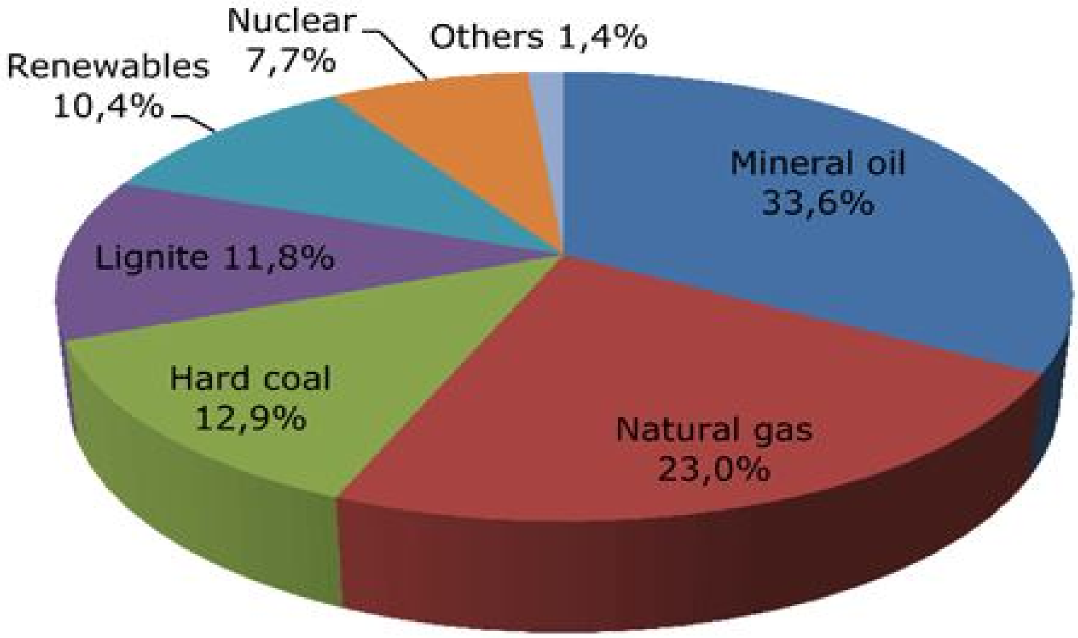
Energy is the life wire and the most crucial element that facilitates production and production activities to take place in such a coherent, efficient and effective manner, this fact is irrespective of whether a country is developed or a developing nation. In essence, energy is a key production component comparable to non except land, labour and capital. In addition to that, energy consumption is among the fundamental indicator that signifies an existing rise in economic growth and development or otherwise (Ucan *et al.*, 2014). Supporting this claim, Halicioglu (2009) in his theoretical wisdom emphasised that economic advancement and productivity may be mutually established and that economic growth is directly associated with efficient energy utilization. Additionally, higher economic growth necessitates additional utilisation of energy, similarly "more efficient energy use" requires an advanced or advancing economic growth prospects or in other cases a significant rise in the welfare position of individuals within a nation. Therefore, the direction of causality may not be a determined priori. Underscoring the direction of this argument, multiplicities of studies have established that Germany was the largest energy consumer in Europe and the eighth-largest energy consumer in the world in 2012. Electricity generation in Germany stood at 567.3 billion KWh between the periods of 1991 to 2011 while in 2013, electricity generation in Germany was estimated to stand at 575.95 billion KWh. The consumption of electricity on the other hand was put at 544.26 billion KWh in periods of 1991 and 2011 while in 2013 electricity consumption declined to 537.87 billion KWh (EIA, 2013). This vast energy generation, consumption and efficiency was among other crucial factors that propelled the country to be the largest and highly developed economy throughout Europe, thus giving it the 4th global ranking in terms of GDP after the United States, China, and Japan in 2012 (EIA, 2013).

In another related development, the EIA (2013) pointed out that Germany is the world's largest operator of non-hydro renewable energy capacity and the world's second largest generator of wind energy. Nuclear power accounted for only 17.7% of the national electricity supply in 2011, compared to 22.4% in 2010 (BDEW, 2011). The cause for the reduced nuclear electricity energy generation in Germany was due to the lesson drawn from the Fukushima energy disaster in Japan. This incident resulted in making Germany to shut down eight of its seventeen operating reactors and also establishing the strategic plan towards the phasing out of some key nuclear energy generating plants that were previously scheduled to go offline as late as 2036. Following to that, the proportion of electricity generated from renewable energy rose from 6.3% in 2000 to more than 25% in the initial half of 2012 (BDEW, 2013). On the recent economic scene and despite the country's efficient and effective energy generation and consumption, yet, the German economy was reported to be in economic contraction by about 0.1%. This situation was then saved by the rising forces of household consumption and exports which again saw the rebounding of the economy to the same figure of 0.1% in the same year of 2014. This development was a better position when compared to the 2009 German economic contraction of -3.70% (Trading Economics, 2014). The massive consumption scenario recorded in the 2014 German economic contraction saga ultimately led to the fall of national investment which in turn affected the financial development prospects of the country. Could this situation transcend to affect the economic growth prospects in Germany? An answer to this will be among the search of this study.

In a related theoretical and conceptual development, Payne (2010) and Ozturk (2010) offered four opposing theories regarding the manner in which energy comprises the core of economic development, they emphasize that: (i) in a situation where energy consumption Granger causes economic growth (i.e. the growth hypothesis) the authors posit that energy decreasing policies have to be prevented, and novel origins of sustainable and renewable energy have to be investigated, to ensure that existing demands are met with efficient supply (ii) Another potential factor identified by the authors is that when causality was found to shift from financial development to energy consumption, this means that energy decreasing regulations would not imply negative consequences for economic development as economic development of the nation does not appear to be reliant on energy, (iii) if feedback hypothesis was found, then this infers the inter-reliance of energy consumption and economic growth. Following to this an increase in economic growth will result in the rise of energy requirement, which in response encourages economic growth, and as a result of this and unlike the first case, energy conservation policies will inhibit the direction of economic growth (iv) in a situation where no causality connecting energy consumption and economic growth was found then this implies neutrality hypothesis, signifying that energy and development are not co-reliant. In addition to this and with regard to the fourth point, the authors continued to argue that the implementation of energy conservation measures as well as exploration of energy policies may not have a constructive impact on economic growth.

Having regard to the foregoing and considering the mixed result yielded by other past studies this study aims to predict the effects of financial development and Trade Openness on the German energy consumption. Specifically the study aims to investigate the contribution of financial development, Trade openness, capital and the potential rise in economic growth on energy demand to the country. The remainder of the paper is organised as follows: Section 2 provides an overview of the recent empirical literature linking energy consumption to financial development, trade openness and economic growth. Section 3 is the methodology which introduces the data, the model, and the model estimation procedure; section 4 contains the results and discussion. Finally, section 5 presents the conclusion and recommendations for policy. Table 1 indicates the position of energy in Germany between the periods of 2004 to 2012. While, figure: 1 show the Primary level of energy consumption in Germany, between the periods of 2013.

Figure 1. show the Primary level of energy consumption in Germany, 2013



Source: European Nuclear Society, 2013.

Table 1. indicating the position of Energy in Germany

	Capita	Prim. Energy	Production	Import	Electricity	CO_2-emission
	Million	TWh	TWh	TWh	TWh	Mt
2004	82.5	4,048	1,582	2,509	580	849
2007	82.3	3,853	1,594	2,344	591	798
2008	82.1	3,899	1,560	2,453	587	804
2009	81.9	3,705	1,478	2,360	555	750
2010	81.8	3,807	1,528	2,362	590	762
2012	81.8	3,626	1,444	2,315	579	748
Change 2004-2010	-0.9 %	-5.9 %	-3.4 %	-5.9 %	1.7 %	-10.3 %
Mtoe = 11.63 TWh, Prim. energy includes energy losses that are 2/3 for nuclear power						

Sources: Key World Energy Statistics IEA.

2. Empirical Review

The revolutionary work by Kraft and Kraft (1978) on the nexus linking economic development and energy is still considered to be the main influence in the area of energy economics. The writers were the first to establish a unidirectional causal association linking GNP development and energy consumption for the United States during the time frame 1947-1974. Subsequent to this splendid discovery, a number of noted researchers the likes of Akarca and Long (1980) made a subsequent exploration with regard to the discovery of Kraft and Kraft (1978). While employing an alternative data set and various research time frames, the writers rejected the discovery of a unidirectional association between energy and economic development. This response resulted in the encouragement of early writers to carry on the investigation within the sphere of energy economics by means of employing a varied study background. For example, Erol and Yu (1988) tactically carried out their research from 1952-1982 through dichotomising the divisions of their case study into six internationally leading industrial countries generally renowned to have considerable energy consumption prospects. The outcomes from their research disclosed considerable bi-directional causality in the instance of Japan. Nonetheless, a different outcome was acquired in the instance of their results from Canada, which displayed some inclinations of unidirectional causality from energy to financial development. Comparably, non-uniform study results were additionally established with regards to Italy and Germany, which within that time frame displayed that it is financial development that encourages energy consumption, and unexpectedly none in the instance of England and France.

Another pioneering study linking financial development and energy consumption was that of Sadorsky (2010 and 2011) in which the author argued that the sophistication and modernity of the financial system will elevate the extent of energy consumption and this has a significant role in the considerable increase and inflow of FDI, enhancement in the banking operations which stimulates the growth of the stock market which is an alternative economic infrastructure that ensure vital energy consumption as well as a significant and vibrant element of economic growth, arguably through the blossoming and thriving of entrepreneurial activities among other things. In another alternative development, Tamazian *et al.* (2009) stated that financial development assists in encouraging local requirement which in response increases energy consumption. To confirm the logic behind this finding, Karanfil (2009) conducted a research on the impacts of financial development on energy consumption within Guangdong, China. The finding of the author was stated in a kind of unidirectional causal relation, which is from financial development to energy consumption. A comparable endeavour was noted in the instance of Sadorsky (2010) in his research on 22 developing economies between 1990 and 2006. The conclusion of the author underscored the trend that energy consumption was vital in those continents under survey particularly in increasing the spate of financial development. This result urged Shahbaz and Lean (2012) to explore the precision of the impact of how financial development can enhance energy consumption in Pakistan. In their own approach, the writers established that this can be attributed mainly to the capability of financial development to encourage requirement of consumables in facilities as well as non-facilities founded operations, and that there is bidirectional Granger causality on one another; nonetheless, they additionally discovered that the former overshadows the latter within Pakistan.

According to the previous research suppositions, it is evident at this juncture to know that an increase ineffectual and competent entrepreneurial operations in a country will result in a likely growth in export, thus rendering necessary the requirement for additional machineries as well as export directed apparatus for utilisation in delivery and shipping of goods to the airports and harbours, where such exports are subsequently packed and re-packed to international destinations. The chain of operations in this undertaking needs energy to function. In addition to this, an increase in commercial output, exportations and alternative value added economic operations will result in a rise in the consumption of energy and the opposite will be true. Similarly, the export-directed energy concept asserts that a decrease in exports affects consumption of energy. However, the energy directed hypothesis on its part determined that any considerable reduction in consumption of energy affects the movement of exports. In another perspective, it has been established by leading researchers such as Shahbaz and lean (2012) that the availability of a causal relationship linking exports and energy is quite considerable, taking into account that energy is an important aspect in establishing the direction of exports although exports are significant aspects in accounting for consumption of energy. These associations linking consumption of energy and inputs additionally has a comparable dynamic inclination similar to export; in the two different instances, energy consumption may not be prevented. Hypothetically any reduction in imports will impact consumption of energy by means of a considerable hindrance in directing the imported produce to the correct location and individual networks thereby stopping delivery, and encroaching on the structure of the supply network. Overall, in addition to the failure of the welfare structure, it is apparent that a considerable disruption of output will be forthcoming. Table 2 presents a summary of the literature linking Trade openness and energy consumption

Table 2. Summary of studies linking Trade openness and energy consumption

No	Author(s)	Time Period	Methodology	Countries	Direction of causality
1	Haliciouglu (2009)	1960-2005	VECM Granger Causality	Turkey	TR ≠ E
2	Erkan *et al.* (2010)	1970-2006	Granger Causality	Turkey	X←E
3	Narayan and Smyth (2009)	1974-2002	Panel VECM Granger Causality	Iran, Israel, Kuwait. Oman, Saudi Arabia, Syria	X → E
4	Lean and Smyth (2010)	1970-2008	ARDL, TYDL Granger Causality	Malaysia	X ≠ E
5	Sami (2011)	1960-2007	ARDL, VECM Granger Causality	Japan	X → E
6	Sadosky (2011)	1980-2007	Panel VECM Granger Causality	Bahrain, Iran, Jordan, Oman, Qatar, Saudi Arabia, Syria, UAE	X → E, I ↔ E
7	Sadosky (2012)	1990-2007	Panel FMOLS, Panel VECM Granger Causality	Argentina, Brazil, Chile, Ecuador, Paraguay Peru, Uruguay	X ↔E, I → E
8	Hossain (2012)	1976-2009	Panel VECM Granger Causality	SAARC countries	TR ≠ E
9	Sultan (2011)	1970-2009	ARDL, VECM Granger Causality	Mauritius	X←E
10	Dedeoğlu and Kaya (2013)	1980-2010	Cunning and Pedroni (2008) Causality	OECD Countries	X ↔ E, I ↔ E
11	Bouoiyour et al. (2014)	1996-2013	meta-analysis	Panel of 43 countries, US, EU, Asia and MENA	Mixed results
12	Rafindadi and Yusof (2014)	1970-2011	Clement-Montanes-Reyes' Detrended Structural Break, Bayer and Hanck, (2013); ARDL, IAA and VECM Granger Causality	South Africa	TR → E
13	Altıntas and Kum (2013)	1970-2010	ARDL	Turkey	TR ↔ E
14	Rafindadi, (2015)	1970-2011	Clement-Montanes-Reyes' Detrended Structural Break, Bayer and Hanck, (2013); ARDL, IAA and VECM Granger Causality	Nigeria	TR → E
15	Adom, P.K (2011)	1971-208	The Toda and Yamamoto Granger Causality test	Ghana	G → E
16	Farhani et al. (2014)	1980-2010	ARDL, Toda-Yamamoto Causality	Tunisia	TR → E
17	Rafindadi (2015)	1970 – 2013	Zivot-Andrew, Bayer and Hanck, (2013); ARDL, IAA and VECM Granger Causality	United Kingdom	TR ↔ E

Note →, ↔ and ≠ indicate unidirectional, bidirectional and no causality respectively, while X, I, TR, G and E indicates exports, import, trade openness, Growth, energy consumption.

2.1 From the above review, the contributions of this study are:

Having regard to the above empirical appraisal, and in contrast to other empirical research, the present study is an endeavour to contribute to the energy literature by predicting the effects of financial development and Trade Openness on the German energy consumption. Specifically the study aims to investigate the contribution of financial development, Trade openness, capital and the potential rise of the German economic growth on energy demand. From this empirical finding, the study will seek to determine what policy guide could be derived in achieving a continued sustainable economic growth prospects amidst environmental and energy challenges of the country.

Apart from that, the majority of previous studies surveyed mainly used ADF, PP, DF-GLS, KPSS, and Ng-Perron tests, however, these unit root test are less parsimonious and susceptible to loss of vital information. In addition to that, these test cannot provide the mechanism of dealing with structural breaks information stemming in the series, following to this, after checking the stationarity of the data using Ng Perron unit root test, the study proceed to apply the Zivot and Andrew, (1992) structural break test to identify possible structural breaks in the series. From that analysis, the Bayer and Hanck, (2013) combined cointegration methodology was then applied.

From these methodological application, the study then proceeds to apply the ARDL bounds testing approach to cointegration in the presence of structural break. This methodology was applied due its serial advantages which include: (i) flexibility and is robustly applicable within the range of I (0) and I (1) cointegrating properties of the data set. In addition to that, simulation results have widely shown that this methodology is parsimonious and effective in providing consistent results particularly for small sample data set (Pesaran and Shin, 1999). (ii) Allowing for the possibilities of using OLS for the determination of short-run and long-run relationship (iii) the possibility of using the VECM Granger causality technique in determining the causal relationship between the variables.

3. The Data, model and estimation procedure

The German annual data over the period of 1970-2013 has been used in this study. The data was obtained from the CD ROM of the world development indicators (2013) from this source, the study collect the data on real GDP, electricity consumption (kg of oil equivalent) per capita, real domestic credit to private sector per capita, real capital stock per capita, real exports per capita, real imports per capita and finally real trade openness per capita of the German economy. This is with the main objective of investigating the dynamic linkages between economic growth, financial development, trade openness and energy consumption for the German economy with the main thrust of predicting the effects of financial development, trade openness and the rising economic growth of the country on energy consumption. The existing literature indicates that financial development affects energy demand via consumer, wealth and business effect. Similarly, trade openness impacts energy consumption via income, composition and technique effect. Economic growth leads energy demand via industrialization effect. This leads us to construct functional form of energy demand function as following:

$$EC_t = f(Y_t, F_t, K_t, TO_t) \tag{1}$$

All the variables have been transformed into logarithm. We use log-linear transformation for attaining reliable empirical results. The empirical equation of model is constructed as following:

$$\ln EC_t = \beta_1 + \beta_2 \ln Y_t + \beta_3 \ln F_t + \beta_4 \ln K_t + \beta_5 \ln TO_t + \mu_t \tag{2}$$

where, $\ln EC_t$ is natural log of energy consumption per capita, $\ln Y_t$ is natural log real GDP per capita (proxy for economic growth), $\ln F_t$ is natural log of real domestic credit to private sector proxy for financial development, $\ln K_t$ is natural log of real capital per capita, trade openness is indicated by natural log of trade (exports + imports) i.e. $\ln TO_t$ and μ_t is residual term with assumption of normal distribution.

Notwithstanding the plethora of econometric methodologies that deals with the estimation and determination of the cointegrating properties of research variables such as the Engle-Granger, (1987) residual-based cointegration test, the Johansen, (1995) system based cointegration test and, the Boswijik, (1994) and Banerjee *et al.* (1998) that suggested the lagged error correction based approaches to cointegration. In all these methodologies, Pesavento, (2004) established that the potency of these tools to provide robust outcome is limited due to their insensitivities to filter the infiltrating level of nuisance inherent in most time series data. The author further establishes that the possibility of obtaining uniform outcome among the mentioned cointegration tools is virtually difficult. According to him, while one cointegration test rejects the null hypothesis another may be bound to accept it. It is following to this shortcoming, that this research established a measure of avoiding the likely repercussion of most of these estimators by using the most up to date methodology developed by Bayer and Hanck, (2013). The authors in their infinite research wisdom developed a parsimonious method that helps in eliminating the likely bias of the old existing estimators with respect to determining the cointegrating properties of time series data. The methodology of the Bayer and Hanck, (2013) cointegration test as applied in this study aim at providing efficient estimates by eliminating the undue multiple testing procedures that is the common problem with other cointegration methodologies. To ensure its robustness, the Bayer and Hanck, (2013) when formulating their cointegrating model followed Fisher, (1932) formula, and this is given below:

$$EG-JOH=-2[\ln(P_{EG})+\ln(P_{JOH})] \tag{3}$$

$$EG-JOH-BO-BDM=-2[\ln(P_{EG})+\ln(P_{JOH})+\ln(P_{BO})+\ln(P_{BDM})] \tag{4}$$

To determine the likelihood for the occurrence of cointegration relation between variables such as in the case of using Engle-Granger, (1987); Johansen, (1995); Boswijik, (1994) and, Banerjee, Dolado and Mestre, (1998) the following notations are observed: P_{EG}, P_{JOH}, P_{BO} and P_{BDM} respectively. However, in the case of the Bayer and Hanck cointegration test, the decision of whether cointegration exists or not between the variables the Fisher statistic is followed. In this respect, it can be concluded in favor of cointegration when the null hypothesis of no cointegration is rejected. Following to this, once the critical values generated by Bayer and Hanck analysis are found to be less than the estimated Fisher statistics and vice versa. To determine the existence of a long-run relation between the variables requires the careful detection of the direction of causality between the variables and this can be undertaken by applying the VECM (vector error correction method) Granger causality framework. The vector error correction method (VECM) is as follows:

$$\begin{bmatrix}\Delta\ln EC_t\\ \Delta\ln Y_t\\ \Delta\ln F_t\\ \Delta\ln K_t\\ \Delta\ln TO\end{bmatrix}=\begin{bmatrix}b_1\\ b_2\\ b_3\\ b_4\\ b_5\end{bmatrix}+\begin{bmatrix}B_{11,1}\ B_{12,1}\ B_{13,1}\ B_{14,1}\ B_{15,1}\\ B_{21,1}\ B_{22,1}\ B_{23,1}\ B_{24,1}\ B_{25,1}\\ B_{31,1}\ B_{32,1}\ B_{33,1}\ B_{34,1}\ B_{35,1}\\ B_{41,1}\ B_{42,1}\ B_{43,1}\ B_{44,1}\ B_{45,1}\\ B_{51,1}\ B_{52,1}\ B_{53,1}\ B_{54,1}\ B_{55,1}\end{bmatrix}\times\begin{bmatrix}\Delta\ln EC_{t-1}\\ \Delta\ln Y_{t-1}\\ \Delta\ln F_{t-1}\\ \Delta\ln K_{t-1}\\ \Delta\ln TO_{t-1}\end{bmatrix}+\ldots+\begin{bmatrix}B_{11,m}\ B_{12,m}\ B_{13,m}\ B_{14,m}\ B_{15,m}\\ B_{21,m}\ B_{22,m}\ B_{23,m}\ B_{24,m}\ B_{25,m}\\ B_{31,m}\ B_{32,m}\ B_{33,m}\ B_{34,m}\ B_{35,m}\\ B_{41,m}\ B_{42,m}\ B_{43,m}\ B_{44,m}\ B_{45,m}\\ B_{51,m}\ B_{52,m}\ B_{53,m}\ B_{54,m}\ B_{55,m}\end{bmatrix} \tag{5}$$

$$\times\begin{bmatrix}\Delta\ln EC_{t-1}\\ \Delta\ln Y_{t-1}\\ \Delta\ln F_{t-1}\\ \Delta\ln K_{t-1}\\ \Delta\ln TO_{t-1}\end{bmatrix}+\begin{bmatrix}\zeta_1\\ \zeta_3\\ \zeta_3\\ \zeta_4\\ \zeta_5\end{bmatrix}\times(ECM_{t-1})+\begin{bmatrix}\mu_{1t}\\ \mu_{2t}\\ \mu_{3t}\\ \mu_{4t}\\ \mu_{5t}\end{bmatrix}$$

Where TO_t is for exports, imports and Trade, the difference operator is $(1-L)$ and the ECM_{t-1} is obtained from the estimation of the long-run relationship. The long-run causal relationship is usually indicated by the attainment of significant position with respect to the coefficient of the ECM_{t-1} and following the t-test statistic. The F statistic for the first-differenced lagged independent variables, on the other hand, is used to test the direction of short-run causal relationship between the variables.

4. Results and Discussions

Examining the stationarity of the series is preliminary condition for cointegration analysis. Following to this, the study applied the Ng-Perron unit root test. The results of this test are shown in Table 3. The findings indicate that none of the variable is stationary at level, intercept and trend. However, at first difference, energy consumption, economic growth, financial development, capital use and trade openness were found to be stationary at 5 percent level of significance.

Table 3. Ng-Perron Unit Root Test

Variables	MZa	MZt	MSB	MPT
$\ln EC_t$	-0.8399 (2)	-0.4382	0.5217	57.3046
$\ln Y_t$	-3.8507 (3)	-1.2634	0.3281	22.0413
$\ln FD_t$	-4.6787 (1)	-1.1855	0.2534	17.3585
$\ln K_t$	-8.2175 (2)	-1.9710	0.2398	11.2569
$\ln TO_t$	-3.8507 (1)	-1.2634	0.3281	22.041
$\Delta \ln EC_t$	-20.6158 (2) **	-3.2101	0.1557	4.4228
$\Delta \ln Y_t$	-20.9015 (2) **	-3.2204	0.1540	4.4345
$\Delta \ln FD_t$	-18.5903 (1) **	-3.0322	0.1631	5.0022
$\Delta \ln K_t$	-19.2648 (2) **	-3.0971	0.1607	4.7695
$\Delta \ln TO_t$	-20.9015 (3) **	-3.2204	0.1540	4.4345
The dual asterisk ** refers to 5% level of significance. While the lag length of variables is denoted by using small parentheses.				

The presence of structural break makes the results of Ng-Perron ambiguous; in addition to that there are every likely possibilities of rendering the regression result to be spurious. To overcome this issue the Zivot and Andrews (1992) unit root test which has the power of taking care for a single unknown structural break stemming from the series is applied in this study. The effective application of the Zivot and Andrews (1992) is followed strictly on the basis of selecting of the break date which is based on T-statistic. Following to this, the break date will be selected where the evidences are favorable for the null hypothesis. The Zivot-Andrew (1992) test with structural breaks as used in this study can be tested using the following econometric models:

$$ax_{t-1} + bt + cDU_t + \sum_{j=1}^{k} d_j \Delta x_{t-j} + \mu_t \text{......................................}(6)$$

$$\Delta x_t = b + bx_{t-1} + ct + bDT_t + \sum_{j=1}^{k} d_j \Delta x_{t-j} + \mu_t \text{........................}(7)$$

$$\Delta x_t = c + cx_{t-1} + ct + dDU_t + dDT_t + \sum_{j=1}^{k} d_j \Delta x_{t-j} + \mu_t \text{............}(8)$$

Where DU_t denotes the dummy variable, and it provides the shifting possibilities of the mean in each point while DT_t is a shift in the trending variable.

$$DU_t = \begin{cases} 1...if - t \geq TB \\ 0...if - t \leq TB \end{cases} and DU_t = \begin{cases} t - TB...if.t \geq TB \\ 0...if.t \leq TB \end{cases} \text{....}(9)$$

The null hypothesis of unit root break date is $c = 0$ which indicates that the series is not stationary with a drift particularly when not having information about structural break stemming in the series while $c < 0$ hypothesis implies that the variable is found to be trend-stationary with one unknown time break. Zivot-Andrews unit root test takes control of fixing all points as potential for possible time break and does estimation through regression for all possible structural breaks successively. One of the major properties of this test is that it selects the time break on the basis of that series with a reducing effects on the one-sided t-statistic which is in order to test for $\hat{c}(= c - 1) = 1$. Similar to the earlier mentioned point on the properties of this structural break unit root test is that in any position where an end point exist the asymptotic distribution of the statistics is diverged to infinity point, this them makes it is possible to select a region particularly where the end points of the sample period are excluded. To the avoidance of spurious result the Zivot-Andrews established that the defined position of the trimming regions i.e. (0.15T, 0.85T) should be strictly adhered to in addition to that all the characteristic features of the estimation process should also be carefully accommodated. The findings of this test as applied in this study are presented in Table 4 and we find the structural breaks in the series to be in 1990, 1990, 2000, 1989 and 1992 and these are for the series of energy consumption, economic growth, financial development, capital use and trade openness at level. The variables are found to be stationary at first difference with intercept and trend. This shows that that energy consumption, economic growth, financial development, capital use and trade openness are stationary at first difference in the presence of structural breaks. Having found this, we may concluded that the integrating order of the variable is I(1).

Table 4. Zivot-Andrews Unit Root Test

Variable	At Level		At 1st Difference	
	T-statistic	Time Break	T-statistic	Time Break
$\ln EC_t$	-3.438 (1)	1990	-7.338 (2)*	1995
$\ln Y_t$	-4.870 (2)	1990	-6.387 (1)**	2009
$\ln FD_t$	-4.635 (1)	2000	-5.544 (2)*	1990
$\ln K_t$	-5.031 (3)	1989	-5.772 (1)*	1993
$\ln TO_t$	-4.152 (1)	1992	-6.833 (2)*	1995

The asterisk: * and ** denote 1%, and 5% level of significance respectively. While the lag order is denoted by the parenthesis.

Table 5. The Lag Order Selection

VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	225.4982	NA	1.47e-11	-10.7560	-10.54704	-10.6799
1	503.1571	474.0518	6.58e-17	-23.0808	-21.8270*	-22.6242*
2	529.5023	38.5538*	6.52e-17*	-23.1465	-20.8477	-22.3093
3	554.8737	30.9407	7.45e-17	-23.1645*	-19.8210	-21.9470

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 5 shows the results of lag selection criterion, and we find that lag 3 is suitable for empirical analysis. Following to this, the AIC criterion of the lag order selection of the variable was adopted due to its superior explanatory properties. Following the selection of lag length 3, we proceed to apply the Bayer-Hanck combined cointegration tests such as EG-JOH and EG-JOH-BO-BDM tests. Table 6 shows the results of Bayer-Hanck combined cointegration analysis. We note that the computed Fisher F-statistics (EG-JOH, EG-JOH-BO-BDM) are great than critical values as we use energy consumption, financial development, capital use and trade openness as dependent variables. This leads to reject the hypothesis of no cointegration but as we used economic growth as dependent variable, the hypothesis of no cointegration was accepted. This concludes that we have four cointegrating vectors which confirm the presence of cointegration among the variables. This finding entails that there is a long-run relationship among energy consumption, economic growth, financial development, capital use and trade openness in case of Germany over the period of 1970-2013. In the presence of structural breaks, the Bayer-Hank combined cointegration will fail to provide efficient and consistent empirical results. To avoid this, the study applied the ARDL bounds testing approach to cointegration in order to assess the cointegrating relationship among the variables. The findings of the ARDL analysis are reported in Table 7. In that analysis the study discovered that the estimated F-statistics are found to be greater than the upper critical bounds at 1%, 5% and 10% respectively when energy consumption, financial development, capital use and trade openness were treated as dependent variables. This finding validates the presence of cointegration thus enabling the possibilities of proceeding to the next step of testing the empirical robustness of the cointegration analysis on table 7 using the Johansen cointegration test.

Table 6. The Bayer and Hanck Cointegration Analysis

Estimated Models	EG-JOH	EG-JOH-BO-BDM	Cointegration
$F_{EC}(EC/Y,FD,K,TO)$	16.535**	77.862*	✓
$F_{Y}(Y/EC,FD,K,TO)$	9.907	13.733	X
$F_{FD}(FD/EC,Y,K,TO)$	16.266**	29.267**	✓
$F_{K}(K/Y,EC,FD,TO)$	18.604**	44.387*	✓
$F_{TO}(TO/Y,EC,FD,K)$	19.437**	29.467**	✓
The sign: * refers to significant level at 1%. While the critical values at 1% level are 15.845 (EG-JOH) and 30.774 (EG-JOH-BO-BDM) respectively.			

Table 7. The Results of ARDL Cointegration Test

Bounds Testing to Cointegration				Diagnostic tests			
Estimated Models	Optimal lag length	Structural Break	F-statistics	χ^2_{NORMAL}	χ^2_{ARCH}	χ^2_{RESET}	χ^2_{SERIAL}
$F_{EC}(EC/Y,FD,K,TO)$	2, 1, 2, 2, 2	1990	6.230***	0.0959	[1]: 2.3638	[1]: 0.4121	[1]: 0.1050
$F_{Y}(Y/EC,FD,K,TO)$	2, 2, 2, 2, 1	1990	1.182	0.5300	[1]: 2.1326	[2]: 1.6334	[2]: 2.3150
$F_{FD}(FD/EC,Y,K,TO)$	2, 2, 2, 2, 2	2000	10.335*	1.3950	[1]: 5.0574	[2]: 1.7394	[1]: 3.1159
$F_{K}(K/Y,EC,FD,TO)$	2, 1, 1, 2, 2	1989	6.171***	0.3877	[1]: 0.1031	[2]: 1.6639	[2]: 2.2917
$F_{TO}(TO/Y,EC,FD,K)$	2, 1, 1, 1, 2	1992	6.642**	0.9975	[1]: 0.0771	[2]: 0.2882	[1]: 2.0789
Significant level	Critical values (T= 44)						
	Lower bounds $I(0)$	Upper bounds $I(1)$					
1 percent level	7.317	8.720					
5 percent level	5.360	6.373					
10 percent level	4.437	5.377					
Note: The asterisks *, ** and *** denote the significant at 1%, 5% and 10% levels, respectively. The optimal lag length is determined by AIC. [ ] is the order of diagnostic tests. Critical values were obtained from Narayan (2005).							

The empirical robustness of cointegration results is tested by applying Johansen cointegration approach, and results are shown in Table 8. We find three cointegrating vectors by trace statistics, and maximum eigenvalue test reports one cointegrating vector. This favors the rejection of the hypothesis that signifies no cointegration and confirms the presence of cointegration among the variables. This finding enables us to ascertain the existence of cointegration among the variables for long-run relationship to be robust and consistent.

Table 8. Results of Johansen Cointegration Test

Hypothesis	Trace Statistic	Maximum Eigen Value
$R = 0$	100.0955*	38.8813**
$R \leq 1$	61.2142**	25.5967
$R \leq 2$	35.6174**	21.3639
$R \leq 3$	14.2535	13.9964
$R \leq 4$	0.2570	0.2570
Note: * and ** show significant at 1% and 5% levels of significance respectively.		

Next step is to investigate the long-run and short-run impact of economic growth, financial development, capital use and trade openness on energy demand. The results are reported in Table 9. In contrast to the panel study of Apergis and Tang (2013) our results show that economic growth has positive and significant influence on energy consumption in Germany. In addition to that, we note in our finding that a 1% increase in economic growth increases energy consumption by 2.1053 percent, and it is statistically significant at 1 percent level. Financial development was found to have no significant link with energy consumption in Germany. This result contradicts the novel study of Erol and Yu (1988). Following to this startling revelation we discovered that a 1% increase in financial development decreased energy consumption by 0.1863, all else is same. In addition to that finding, the study also discovered the existence of negative and significant relationship between capital use and energy consumption. This shows that, a 1% increase in capital use declines energy demand by 0.9269, and it is statistically significant at 1% level. Trade openness, on the other hand, was discovered to have a negative and significant impact on energy consumption. In that relationship, it was also discovered that, a 1% increase in trade openness decreases energy consumption by 0.2091 in Germany.

The results of the short-run analysis are presented in the lower segment of Table 9. In that analysis, the study discovered that economic growth has positive and significant effect on energy consumption. While financial development was found to add to energy demand insignificantly. Capital use declines energy demand significantly. Trade openness increases energy consumption insignificantly. The ECM is found to be negative and significant which shows the convergence from short-run towards long-run equilibrium path. The estimate of ECM term was found to be -0.1620 which confirms that short-run deviations are corrected by 16.20% every year. This shows that the convergence from short-run towards long-run will take 6 years and 1 month. The results of diagnostic test from this study show the absence of serial correlation, autoregressive conditional heteroskedasticity and white heteroskedasticity. The results of Ramsay reset test confirm the specification of short-run model.

Table 9. Long and Short-runs Results

Dependent variable = $\ln EC_t$				
Long-run Analysis				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.7765	1.3518	-0.5744	0.5692
$\ln Y_t$	2.1053*	0.3048	6.9068	0.0000
$\ln F_t$	-0.1863***	0.1063	-1.7522	0.0880
$\ln K_t$	-0.9269*	0.1385	-6.6929	0.0000
$\ln TO_t$	-0.2091*	0.0589	-3.5470	0.0011
Short-run Analysis				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.0122**	0.0054	-2.2406	0.0313
$\Delta \ln Y_t$	1.4470*	0.3439	4.2075	0.0002
$\Delta \ln F_t$	0.0418	0.1051	0.3981	0.6929
$\Delta \ln K_t$	-0.3660*	0.1180	-3.1002	0.0037
$\Delta \ln TO_t$	0.0077	0.0617	0.1261	0.9003
ECM_{t-1}	-0.1620**	0.0759	-2.1328	0.0398
R^2	0.5498			
F-statistic	8.7960*			
D. W	1.4891			
Short-run Diagnostic Tests				
Test	F-statistic	Prob. Value		
$\chi^2 SERIAL$	1.1175	0.4000		
$\chi^2 ARCH$	2.0230	0.1629		
$\chi^2 WHITE$	2.6662	0.2912		
$\chi^2 REMSAY$	0.3437	0.5614		
Note: *, ** and *** show significant at 1%, 5% and 10% level of significance respectively.				

The VECM Granger Causality Analysis

The VECM Granger causality test is used for determining the direction of causality between the variables. This will be helpful in enabling us to determine a comprehensive economic, financial, trade and energy policies that will be very vital in controlling energy demand towards sustainable economic growth prospects in the case of Germany. The results of this analysis are reported in Table 10. The findings in that table reveal that economic growth Granger causes energy demand, financial development, capital use and trade openness in the long-run. In addition to that, we found the existence of the feedback effect between financial development and energy consumption. Capital use was also found to Granger-cause energy consumption and in resulting circumstances, energy consumption Granger causes capita use. This means that there is a bi-directional causal relationship to exist between trade openness and energy consumption in the long-run in Germany.

In the short-run, the study discovered the existence of the same bi-directional causality between per capita income and energy consumption, between energy consumption and physical capital, between per capita income and physical capital, between per capita income and trade openness. Following to this the study further discovered the existence of short-run unidirectional causality running from energy consumption to trade openness and on the other hand there is unidirectional causality that was found to be running from financial development to energy consumption. In addition to that, the existence of a long-run bidirectional causality running between energy consumption and per capita income was also discovered, following to this, the feedback effect was found between financial development and energy consumption in Germany.

Table 10. The VECM Granger Causality Analysis

Dependent Variable	Direction of Causality					
	Short-run					Long-run
	$\Delta \ln EC_{t-1}$	$\Delta \ln Y_{t-1}$	$\Delta \ln FD_{t-1}$	$\Delta \ln K_{t-1}$	$\Delta \ln TO_{t-1}$	ECT_{t-1}
$\Delta \ln EC_t$	....	7.0646* [0.0030]	0.3114 [0.7204]	3.1028*** [0.0591]	4.4771** [0.0196]	-0.0750* [-2.9310]
$\Delta \ln Y_t$	7.4067* [0.0023]	....	0.2953 [0.7463]	25.2264* [0.0000]	5.7283* [0.0075]	....
$\Delta \ln FD_t$	0.4135* [0.6651]	0.7168 [0.4782]	....	0.6565 [0.5262]	0.1605 [0.8524]	-0.1679*** [-1.6881]
$\Delta \ln K_t$	5.9609* [0.0068]	32.9384* [0.0000]	0.0394 [0.9613]	1.0482 [0.3634]	....	-0.4308* [-3.1996]
$\Delta \ln TO_t$	1.7219 [0.1954]	9.9209* [0.0005]	0.80009 [0.4581]	2.2980 [0.1173]	....	-0.1605*** [-1.7041]
Note: * and ** show significance at 1 and 5 percent levels respectively.						

In short-run, the bidirectional causality is found between energy consumption and economic growth and same is true for capital use and energy consumption. Energy consumption was also found to Granger causes financial development. The relationship between economic growth and capital use is bidirectional and same is true for trade openness and capital use. Trade openness causes energy demand and economic growth in the Granger sense.

5. Concluding Remarks and Policy Implications

This study conducted an econometric prediction on the effects of financial development and Trade Openness on the German energy consumption. Specifically the study delved into the determination of the linkages between economic growth, financial development, capital use, trade openness and energy consumption using energy demand function for the case of Germany. The study used time series data over the period of 1970-2013. In doing so, the unit root properties of the data was examined using the Ng-Perron unit root tests in addition to this, the traditional structural break unit root test by Zivot-Andrew was applied. The cointegration properties of the data was observed using the Bayer-Hanck combined cointegration test and the ARDL bounds test approach to cointegration while the VECM Granger causality analysis is applied to examine the causal relationship between the series. The results confirmed the existence of cointegration among the variables. As a result of this development, the study discovered that, economic growth adds to energy demand in the case of

Germany, in respect to this, the econometric prediction exercise showed that a 1% rise in economic growth in Germany will lead to 2.1053% increase in energy consumption and this is found to be significant at 1% level. In contrast to this finding, the study discovered that financial development does not have any effect on the German energy consumption meaning that the contribution of the developed financial sector in Germany cannot influence the existing energy consumption of the country. This may possibly be due to the recent economic contraction faced by the country which stands to about -3.70% in 2009 and 0.1% in 2014. Capital use, on the other hand, was found to be inversely related with energy consumption. Similar to that development, Trade openness was also found to decline energy consumption in the long-run. In the short-run, the study discovered that it is only economic growth that has the same positive and significant effect on energy consumption while all others were found to be insignificant**.** The causality analysis established the existence of the feedback effect between financial development and energy consumption and same case was found about trade openness and energy consumption. The causality result with respect to capital use was found to Granger-cause energy consumption, and energy consumption Granger causes capital. Economic growth was also found to Granger-cause energy consumption; same inferences were also found with respect to financial development and trade openness.

Our concluding remark in this study rests on the fact that energy is a crucial part of production factors in the contemporal era, and a cardinal means of achieving sustainable economic growth not only in Germany but the world over; following to this, Ferguson *et al.* (2000) argued that for the global economy as a whole, there is a strong interrelation between energy consumption and the creation of wealth (economic growth) than that connecting total use of energy and wealth (economic growth). The author continue to insist that, in the same rich nations like Germany, the rise in economic growth with time will correlate with the rise in the amount of energy that is used and this will modestly make energy consumption a root cause to economic growth. By this development, it means that the higher the degree of economic growth in Germany the greater will be the energy consumption. In this respect, and going by the arguments raised by Ferguson (2000) and following the discoveries observed in this study, we are of the view that the likely policy implication that could arise in the long-run, may relate to the persistent rise in energy demand which could then lead to the rise of more pollutants. This may be due to the un-relented need for a significant rise in economic growth for the case of Germany, with this situation in focus; the energy requirement to sustain the degree of economic growth attained will follow the hypothesis raised by Ferguson (2000) while failure to comply with that development could lead to an ailing energy system due to insufficient supply.

Following to this, it is pertinent to argue that an ailing energy system is synonymous with an ailment in the planning process, and an ailing planning process is tantamount to precarious economic growth. As a result of this electricity conservation policies in Germany will significantly affect the rate of economic growth and also that energy conservation policies cannot be implemented to combat global warming without restraining the process of economic growth particularly since energy consumption does not Granger cause economic growth. This twin reason will lead to more energy consumption as argued earlier. This development will in turn lead to more environmental pollutants thereby leading to the encroachment of the EU vision 20/20/20. To avoid this and ensure a balance between energy consumption and environmental quality the study propose for the German energy policy makers to continue with their effort in investing heavily in new renewable energy source. In addition to this, new 'green' technologies that are less dependent on fossil fuels should be encouraged for industrial usage. Although the existence of *a priori* developed financial infrastructure and energy efficient technologies have favoured efficient energy use in Germany, notwithstanding this, a continued and careful attention should consistently be given at both the industrial and household level, by encouraging more investment in the appropriate energy infrastructure that could assist with the simultaneous satisfaction of efficient energy usage. In doing so, both the economic performance and the quality of the environment can be sustained and balanced. This study also noted that Germany is the frontrunner in the EU particularly in the point of renewable energy usage and the ambition to decrease greenhouse gas emissions and mitigate the climate change. The ultimate solution proposed in this study, will in our view assist in keeping track with the EU-wide energy strategy of 20/20/20 target i.e. (i) savings of 20% in energy use compared to projections, (ii) achieving 20% portion of the renewable energy combination from the reserves of renewable power, (iii) a 20% decrease in greenhouse gas emissions by 2020.

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