

*Full length Research paper*

# Energy consumption and gross domestic product in the Philippines: an application of maximum entropy bootstrap framework

Kenneth Barroga\* Agustina Tan-Cruz<sup>2</sup>

Department of Science and Technology Bajada, Davao City, Philippines  
University of Southeastern Philippines Obrero, Davao City, Philippines

Accepted 28 July, 2017

**We utilize the most extreme entropy bootstrap (MEB) structure to give persuading proof on the vitality utilization (EC) and GDP nexus in the vicinity of 1975 and 2010 in the Philippines. We additionally play out a cointegration examination and Granger causality trial of the information to outline the upsides of MEB approach. This paper indicates more precise derivation in contrast with customary speculation tests in view of asymptotic hypothesis. Without utilizing MEB, the consequence of causality is exceptionally delicate to a little example size and day and age picked that made the outcomes conflicting. Consequently, MEB system is powerful to day and age picked and even in a little example estimate. The investigation demonstrates no proof of a causal connection amongst EC and GDP in the Philippines. The discoveries accentuate the way that the Philippines is a less created nation and overwhelmingly agrarian-based; in this way, vitality subordinate.**

**Keywords:** bootstrap, cointegration, energy consumption, GDP, Granger causality, highest density region, maximum entropy bootstrap.

## INTRODUCTION

The relationship between energy consumption (EC) and GDP of the Philippines is yet to be established in

the literature. That is, whether GDP growth leads to EC or that EC is the engine of GDP growth. Understanding the nature of a possible causal nexus between EC and GDP has important implications for energy policy in the Philippines. These arguments, leading to whether or not energy conservation policies affect economic activity, are of great interest in the international debate

---

Corresponding Author E-mail: [kennethbarroga@yahoo.com](mailto:kennethbarroga@yahoo.com)

on global warming and the reduction of greenhouse gas emissions (Belke, Dreger, and de Haan, 2011).

Over the recent years, the Philippines regularly achieved high growth rates while its energy consumption more than tripled during the recent period (APEC, 2013). The Philippines, through collaborative efforts with key economic development agencies, will continue to formulate plans and programs to maintain its positive growth for the coming years (Navarro and Yap, 2012). The Philippine government plans to reduce greenhouse gas (GHG) emissions starting 2012 (DOE, 2009). This will happen by improving energy efficiency in the electricity generation, transmission and distribution sub-sectors as well as intensifying the implementation of the Renewable Energy (RE) Law which would consequently reduce fossil fuels consumption. Consequently, if the so-called "*growth hypothesis*" that EC results in more output is true, energy conservation policies can be detrimental to future economic growth in the Philippines.

However, if there is a unidirectional causality running from economic growth to EC ("*conservation hypothesis*"), it may be possible to implement energy conservation policies and cut GHG emissions with little or no adverse effects on output (Yalta, 2011). In fact, a possible bi-directional causal relationship running from economic growth to EC can even result to significant implications for energy conservation and economic development, and implies that EC and GDP are jointly determined and affected at the same time (Kiran and Guris, 2009). On the other hand, neither energy conservation nor expansion policies will have any effect on economic growth if the "*neutrality hypothesis*" holds, which means that a causal relationship does not exist between EC and GDP.

The aforementioned hypotheses are still to be tested in the case of the Philippines. Thus, the EC-GDP connection is now of great interest to economists, econometricians, and policymakers because of its significant policy implications for the Philippines; not to mention, the advent of the power outages in some parts of the country. Empirical studies between EC and GDP

are limited in the Philippines. Despite the various articles on the EC-GDP connection, the Philippines has not been of interest using Maximum Entropy Bootstrap (MEB). Hence, as far as the author knows, no articles analyzing the EC-GDP connections of the Philippines using MEB were published in the recent years. The findings of the existing empirical studies do not show strong consensus evidence of the causal relationship between EC and GDP for region-specific studies (Karanfil, 2009). In addition, the inconsistency of the existing findings on the EC-GDP relationship and the absence of research on EC-GDP nexus specific for the Philippines currently make it impossible to suggest a reliable policy direction for the Philippines. Therefore, a gap still remains to provide a reasonable policy recommendation for energy and/or economic growth in the case of the Philippines.

All of the above justify why there is a need to research and bring into play the MEB technique. Simulation based hypothesis testing is long known to yield in small samples substantially more accurate results in comparison to conventional inferences based on asymptotic theory. In the energy economics literature, however, bootstrapping has been rarely employed, partly because of the absence of a bootstrap technique useful for time series data. The recently developed MEB data generation process (DGP) is specifically designed to fill this gap. It can be employed in all forms of structural breaks and non-stationarity without transforming the data, and allows hypothesis testing that is not only accurate, but also robust in the sense of avoiding specification errors (Yalta, 2011). The primary objective of the study was to employ Maximum Entropy Bootstrap (MEB) to provide conclusive evidence on the connection between EC and GDP in the Philippines. Specifically the study aimed: (1) to evaluate the relationship between EC and GDP for the Philippines using MEB method; (2) to employ, if possible, cointegration tests to validate and illustrate the advantages of MEB approach in the analysis of the causal relationship between macroeconomic variables; and (3) to apply the Granger

causality test to verify the direction of causality between EC and GDP for the case of the Philippines.

## METHODOLOGY

### Conceptual framework

This study analyzed the causal relationship between GDP and EC by using MEB approach, Cointegration and Granger causality tests. As shown in Figure 1, the directions that the causal relationship between EC and GDP could be categorized into four types each of which has important implications for energy policy (Yoo, 2006).

The uni-directional causality running from EC to GDP. It is also called "growth hypothesis". It implies that restrictions on the EC may adversely affect GDP while increases in EC may contribute to GDP. The growth hypothesis suggests that EC plays an important role in GDP both directly and indirectly in the production process as a complement to labor and capital. As noted by Jumbe (2004), among others, if causality runs from EC to GDP then it means that an economy is energy-dependent and hence energy is a stimulus to growth implying that a shortage of energy may negatively affect economic growth or may cause poor economic performance. In other words, energy is a factor in economic growth (Stern 2000).

The uni-directional causality running from GDP to EC. It is also called "conservation hypothesis". It suggests that the policy of conserving EC may be implemented with little or no adverse effect on GDP, such as in a less energy-dependent economy.

The conservation hypothesis is supported if an increase in GDP causes an increase in EC.

As noted by Masih and Masih (1996), amongst others, if causality only runs from GDP to EC then it means that an economy is not energy dependent hence, energy conservation policies may be implemented with no adverse effect on growth and employment.

Bi-directional causality between EC and GDP. It is also called "feedback hypothesis". It implies that EC and GDP are jointly determined and affected at the same time.

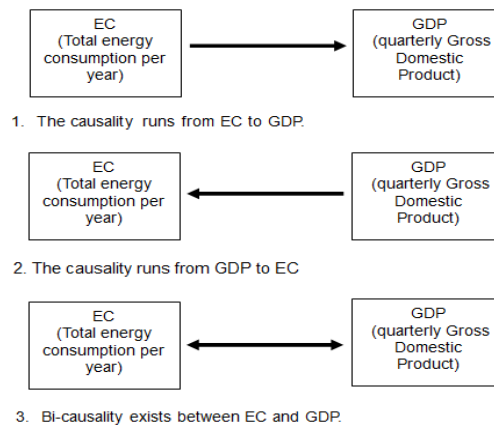
If causality in either direction does not exist, we have the so-called "neutrality hypothesis". It implies that neither conservative nor expansive policies in relation to EC have any effect on GDP. The neutrality hypothesis is supported by the absence of a causal relationship between EC and real GDP. Thus, energy conservation policies may be pursued without adversely affecting the economy (Jumbe, 2004). The issue on which among the possible causal relationships between GDP and EC is true, has been the subject of intense and often heated debate worldwide. As observed in Table 1, the results for the Philippines using different econometric models are inconsistent. Moreover, Turkey has similar results with that of the Philippines' as evidenced by Table 2. Similar to other country-specific studies on GDP-EC nexus, the results have been varied. However, this issue is almost resolved in Turkey after Yalta (2011) proposed a method to address the inconsistent results on GDP-EC nexus.

As per the case of the Philippines, the question of which among the possible causal relationships between GDP and EC will be used for policy recommendation, is still an unresolved issue; not to mention, the minimal number of empirical studies for the Philippines about this topic.

### Econometric Model

The modeling strategy adopted in the analysis of the subject is a bivariate approach. The Maximum Entropy Bootstrap (MEB) was primarily employed to investigate the bivariate causal relationship between EC and GDP. Because MEB makes it possible to work with multiple time series without first making them stationary, simpler model specifications are allowed. As a result, this study

**Figure 1** Possible relationships between EC and GDP.



**Table 1** Summary of empirical studies on EC-GDP interaction for the Philippines.

Authors	Period	Econometric Methodology	Causality Relationship
1. Yu and Choi (1985)	1950-1982	Sim's, Granger	GNP ← EC
2. Masih and Masih (1996)	1955-1991	Cointegration, ECM	No causality
3. Asafu-Adjaye (2000)	1971-1995	Cointegration, ECM	GDP ↔ EC
4. Wei et al. (2008)	1954-2006	Linear and nonlinear regression; Granger	GDP → EC

first investigated the bivariate causal relationship between EC and GDP by using the system:

$$y_t = c_1 + \sum_{i=1}^m \alpha_{1i} e_{t-i} + \sum_{j=1}^n \beta_{1j} y_{t-j} + u_{1t} \tag{1}$$

$$e_t = c_2 + \sum_{i=1}^m \alpha_{2i} e_{t-i} + \sum_{j=1}^n \beta_{2j} y_{t-j} + u_{2t} \tag{2}$$

where:

$c_k$  = constant term,  $k = 1, 2$

$y_t$  = log of GDP in year  $t$

$u_{kt}$  = residual term,  $k = 1, 2$

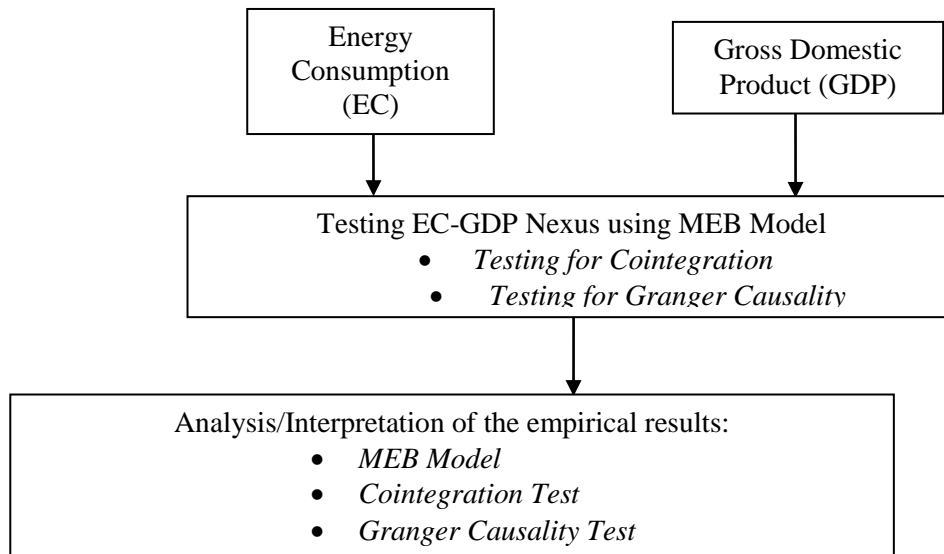
$e_t$  = log of energy consumption in year  $t$

$\alpha_{1i}, \beta_{1j}$  = coefficient estimates for  $y_t$ ,  $i = 1, 2, \dots, m$ ;  $j = 1, 2, \dots, n$

**Table 2** Summary of empirical studies on EC and GDP interaction for Turkey.

Authors	Period	Econometric Methodology	Conclusion
1. Soytaş <i>et al.</i> (2003)	1960-1995	Cointegration	GDP $\leftarrow$ EC
2. Altınay and Karagöl (2004)	1950-2000	Hsiao's version of Granger causality	No causality
3. Lise and Van Montfort (2007)	1970-2003	Error correction model (ECM) approach	GDP $\rightarrow$ EC
4. Karanfil (2008)	1970-2005	Granger causality, Cointegration	GDP $\rightarrow$ EC; No causality (when unrecorded economy is taken into account)
5. Erdal <i>et al.</i> (2008)	1970-2006	Pairwise causality	Granger GDP $\leftrightarrow$ EC

**Figure 2** Flowchart showing the estimation process.



**Table 3** Causality test results based on Maximum Entropy Bootstrap inference.

Model	Period	Conf. level	HDR interval (log GDP)	HDR interval (log EC)	Causality
1	1975-2010	99%	(-2.81, 2.76) <sup>ns</sup>	(-2.74, 2.72) <sup>ns</sup>	None
		95%	(-2.04, 2.03) <sup>ns</sup>	(-2.01, 2.07) <sup>ns</sup>	None
		50%	(-0.59, 0.80) <sup>ns</sup>	(-0.67, 0.67) <sup>ns</sup>	None
2	1975-1992	99%	(-2.58, 2.59) <sup>ns</sup>	(-2.54, 2.54) <sup>ns</sup>	None
		95%	(-2.01, 2.02) <sup>ns</sup>	(-1.95, 1.95) <sup>ns</sup>	None
		50%	(-0.70, 0.68) <sup>ns</sup>	(-0.67, 0.68) <sup>ns</sup>	None
3	1993-2010	99%	(-2.57, 2.55) <sup>ns</sup>	(-2.62, 2.75) <sup>ns</sup>	None
		95%	(-1.95, 1.89) <sup>ns</sup>	(-1.96, 1.99) <sup>ns</sup>	None
		50%	(-0.73, 0.62) <sup>ns</sup>	(-0.73, 0.67) <sup>ns</sup>	None

<sup>ns</sup> not significant at 1%, 5%, 50% significance level

(i.e., fail to reject the null hypothesis, Ho: There is no causality between GDP and EC)

$\alpha_{2i}, \beta_{2j}$  = coefficient estimates for  $e_t$ ,  $i = 1, 2, \dots, m$ ;  $j = 1, 2, \dots, n$

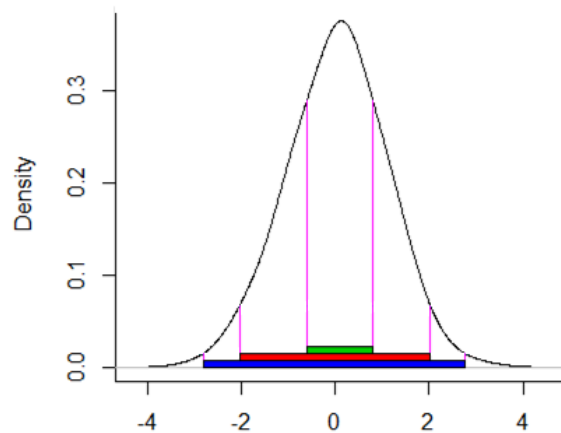
In the traditional theory on bootstrapping, an ensemble  $\Omega$  represents the population from which the observed time series is drawn (Lahiri, 2003). The MEB procedure proposed by Vinod and Lopez-de-Lacalle (2011) constructs a large number of replicates (say,  $J=1,000$ ) as elements of  $\Omega$  for inference using an algorithm designed to satisfy the ergodic theorem (the grand mean of all ensembles is close to the sample mean). The constructed  $\Omega$  retains the basic shape and time dependence structure of the autocorrelation function (ACF) and the partial autocorrelation function (PACF) of the original time series (Vinod and Lopez-de-Lacalle, 2011).

The MEB is similar to Efron's traditional bootstrap but avoids the three restrictions which make the traditional bootstrap unsuitable for economic and financial time series data. The MEB algorithm is based on the Maximum Entropy (ME) density and satisfies the ergodic theorem, Doob's theorem and almost sure convergence of sampling distributions of pivotal

statistics without assuming stationarity. Thus, the algorithm provides a reliable resampling for short non-stationary time series. It avoids all structural change and unit root type testing involving complicated asymptotics and all shape-destroying transformations like detrending or differencing to achieve stationarity. (Yalta, 2011)

In particular, the ME density  $f(x)$  is chosen so as to maximize  $H = E(-\log f(x))$  (Shannon's information), subject to certain mass-preserving and mean preserving constraints. Considering this, Vinod (2006) offers an intensive construction of a plausible ensemble created from a density satisfying the ME principle. The MEB algorithm uses quantiles  $x_{j,t}$  for  $j = 1, \dots, J$  ( $J = 1,000$ ), of the maximum entropy (ME) density as members of  $\Omega$  from the inverse of its 'empirical' cumulative distribution function (CDF). The algorithm guarantees the satisfaction of the ergodic theorem (grand mean of all  $x_{j,t}$  representing the ensemble average equals the time average of  $x_t$ ) and the central limit theorem.

**Figure 3** Highest density confidence region for estimates of log of GDP for Model 1 (model utilizing data on GDP from 1975 to 2010)



### Advantages of MEB

Although bootstrapping is quite widely used, it is not always well understood. In practice, bootstrapping is often not as easy to do, and does not work as well, as seems to be widely believed. Some bootstrap methods are very easy to implement, and some bootstrap methods work extraordinarily well in certain cases. But in other cases bootstrap methods do not always work well, and choosing among alternative ones is often not easy. It is problematic for highly dependent (evolving) time series data (Davison and Hinkley, 1997).

However, the recently-developed technique called the Maximum Entropy Bootstrap (MEB) is the answer to the problems of using bootstrapping. MEB is more general, since it does not assume stationarity and does not need possibly 'questionable' differencing operations. In addition to avoiding stationarity, Vinod

(2006) mentions the following advantages of MEB: This method does not use any simulated errors based on the assumed reliability of a parametric model. It does not need to assume that the conditional mean of the dependent variable given a realization of regressors in standard notation is linear. It is robust against heteroscedastic errors.

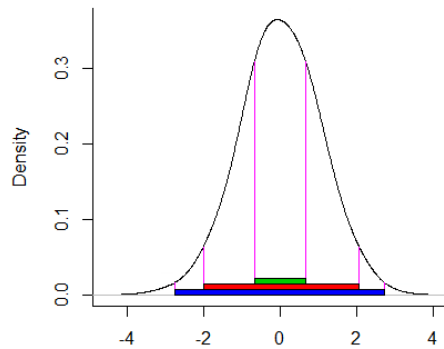
### The Estimation Process

#### RESULTS AND DISCUSSION

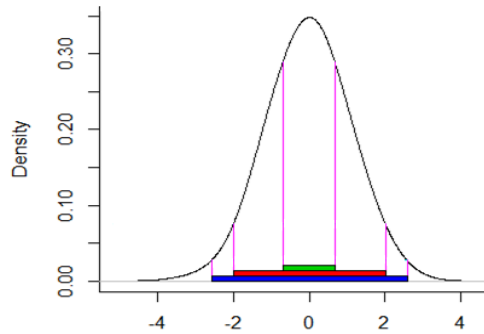
#### Empirical output using MEB inference and HDR approach for causality

For the causality testing on the EC-GDP relationship, the procedure employed the MEB algorithm to create a resample of  $J = 1,000$  series every dataset. For this

**Figure 4** Highest density confidence region for estimates of log of EC for Model 1 (model utilizing data on EC from 1975 to 2010).



**Figure 5** Highest density confidence region for estimates of log of GDP for Model 2 (model utilizing data on GDP from 1975 to 1992).



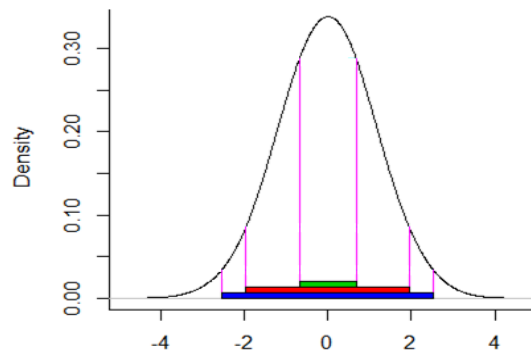
study, the MEB created 36,000 datapoints for GDP and another 36,000 datapoints for EC. These series represented the “population” of the original data and were referred to as “ensemble” in the statistical literature. After taking the replicates, this study ran J regressions for equations (1) and (2). The 1,000 coefficient estimates for each parameter were subsequently used to obtain the confidence intervals for the estimates. In order to compute these intervals, this study used the Highest Density Region (HDR) method discussed by Hyndman (1996). Moreover, this study

chose three different periods: 1975-2010, 1975-1992, and 1992-2010, to ascertain that the MEB method has consistent results despite different time periods. Therefore, this study generated three different models. For every time period chosen, a resample of J = 1,000 series for GDP and EC was done and then 1,000 regressions were run for equations (1) and (2).

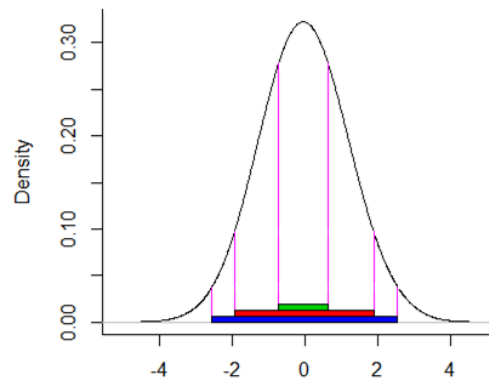
Table 3 shows the causality test results along with the respective HDR interval values for different models specified in equations (1) and (2). The HDR was used since it offers an advanced and reliable approach for



**Figure 6** Highest density confidence region for estimates of log of EC for Model 2 (model utilizing data on EC from 1975 to 1992).



**Figure 7** Highest density confidence region for estimates of log of GDP for Model 3 (model utilizing data on GDP from 1993 to 2010).



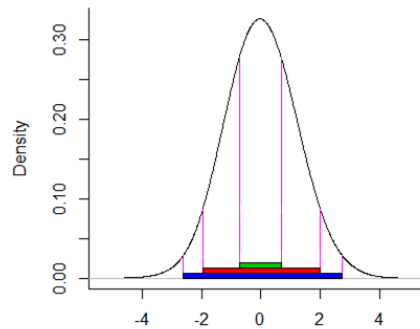
analyzing the estimates. This method also solved the major problem in computational difficulty of testing the causality hypothesis given a thousand of data points generated from MEB process.

Moreover, Table 3 clearly shows that zero is found inside the 50%, 95%, and 99% confidence intervals for the respective parameters of the estimates of each model. As a result, the null hypothesis of no causality

cannot be rejected at 0.50, 0.05, and 0.01 significance levels. This finding of no causality between GDP and EC in the Philippines confirms the analysis of Yalta (2011) where he applied the HDR approach and found the same result of no causal relationships between GDP and EC in Turkey.

To further illustrate the findings in Table 3, this study provided graphs of the density of the HDR intervals for

**Figure 8** Highest density confidence region for estimates of log of EC for Model 3 (model utilizing data on EC from 1993 to 2010).



**Table 4** Unit root test results based on Augmented Dickey Fuller and Phillips- Perron tests.

Variable	ADF		PP	
	Level	First Difference	Level	First Difference
<b>Model 1: 1975-2010 period</b>				
Log of EC	-1.1268	0.87718	-1.2485	0.99662
Log of GDP	-0.86274	1.2929	-1.1265	1.3942
5% Crit. Value	-3.41 <sup>ns</sup>	6.25 <sup>ns</sup>	-3.41 <sup>ns</sup>	6.25 <sup>ns</sup>
<b>Model 2: 1975-1992 period</b>				
Log of EC	-1.4113	1.1430	-2.6367	4.4565
Log of GDP	-1.4840	1.1338	-0.63700	1.0120
5% Crit. Value	-3.41 <sup>ns</sup>	6.25 <sup>ns</sup>	-3.41 <sup>ns</sup>	6.25 <sup>ns</sup>
<b>Model 3: 1993-2010 period</b>				
Log of EC	-2.6314	4.4292	-2.6367	4.4565
Log of GDP	-0.54418	1.0339	-0.63700	1.0120
5% Crit. Value	-3.41 <sup>ns</sup>	6.25 <sup>ns</sup>	-3.41 <sup>ns</sup>	6.25 <sup>ns</sup>

<sup>ns</sup> not significant at 5% significance level

the parameter estimates of log of EC and log of GDP for models 1 through 3. Model 1 utilizing the complete ensemble of 36,000 observations from the original data on GDP from 1975-2010 has a corresponding HDR plots of its 1,000 estimates shown in Figure 4.

As observed, Figure 3 clearly shows three horizontal bars which represent the probability coverage levels 50, 95, and 99, respectively. The said plot shows how the HDR, which is narrower than the naive percentile intervals, cover zero for all significance levels in model

**Table 5** Summary of results of Granger causality test.

Model	Granger Test (Null Hypothesis of no causality)	Causality	Joint-F	P-Value	Causality Results
Model 1: 1975-2010 period	EC does not cause GDP	Granger	3.72 <sup>ns</sup>	0.063	No causality
	GDP does not cause EC	Granger	0.141 <sup>ns</sup>	0.709	
Model 2: 1975-1992 period	EC does not cause GDP	Granger	0.0101 <sup>ns</sup>	0.921	No causality
	GDP does not cause EC	Granger	1.75 <sup>ns</sup>	0.207	
Model 3: 1993-2010 period	EC does not cause GDP	Granger	10.3*	0.006	GDP ↔ EC
	GDP does not cause EC	Granger	5.32*	0.037	

Note: For all tests, significance level = 0.05  
<sup>ns</sup> not significant \* significant

1. Thus, zero is found inside the 50%, 95%, and 99% confidence intervals for the parameter. For this reason, the null hypothesis of no causality cannot be rejected at 0.50, 0.05, and 0.01 significance levels. Similar output was observed when Model 1 used the complete ensemble composed of 36,000 observations from the original data on EC from 1975-2010 as shown in Figure 4. Figure 4 also shows that zero is found inside the three horizontal bars representing the probability coverage levels 50, 95, and 99, respectively. Therefore, the null hypothesis of no causality cannot be rejected at 0.50, 0.05, and 0.01 significance levels. Consequently, when the tests were repeated with Model 2 considering the data on GDP and EC from 1975-1992 (See Figure 5 and Figure 6) and Model 3 which accounts the data on GDP and EC from 1993-2010 (See Figure 7 and Figure 8) subperiods respectively, the findings of no causality did not change. Overall, accounting the subperiods in the analysis, this study obtained consistent results

supporting the *neutrality hypothesis* between EC and GDP.

The findings using HDR approach provide strong evidence supporting the hypothesis on no causality between EC and GDP for the Philippines. This also validates the diagnosis of the published research on EC-GDP relationship using MEB framework and HDR approach done by Yalta (2011) for Turkey.

However, the findings of this study contradict to Yu and Choi (1985), Asafu-Adjaye (2000), and Wei et al. (2008) findings which claim that there is a causal relationship between EC and GDP in the Philippines. Based on the robustness of the results, it is possible that the said contradicting findings can be caused by over-rejecting the null hypothesis of no causality due to the severe size distortions typical for small sample statistical inference based on asymptotic theory.

**Empirical output using cointegration test**

The original data on real GDP and EC was used to conduct unit root test and cointegration test. Without

**Table 6** Comparative results of the outputs using different methods.

Data	Method Used	Unit Root Test Result	Causality Test Result
Model 1: 1975-2010 period	MEB approach	Stationary	No Causality
	ADF and PP	Non-stationary	
	Granger causality in VAR framework		No Causality
Model 2: 1975-1993 period	MEB approach	Stationary	No Causality
	ADF and PP	Non-stationary	
	Granger causality in VAR framework		No Causality
Model 3: 1993-2010 period	MEB approach	Stationary	No Causality
	ADF and PP	Non-stationary	
	Granger causality in VAR framework		Bi-causality

using MEB-based simulation, Model 1 is composed of 36 observations utilizing the data from 1975 to 2010, while Models 2 and 3 each has only 18 observations using the data from 1975-1992 and 1993-2010, respectively. This investigation of the time series properties of the datasets was useful to illustrate the advantages of MEB approach in the analysis of the causal relationship between macroeconomic variables.

The classical unit root tests, namely the ADF and PP tests, were conducted. ADF and PP tests are based on the null hypothesis that a unit root exists in the time series. These unit-root tests were performed in level and first differences of variable. The model with and without trend was adopted in the empirical analysis. ADF and PP test results are presented in Table 4. Table 4 indicates all univariate test results cannot reject the null hypothesis of a unit root at the model with and without trend. Thus, this suggests that EC and GDP are accordingly non-stationary in both the level and first

differenced form. It can therefore be concluded that in most cases, GDP and EC are integrated of order one, that is,  $I(1)$ . This result can be due to the small sample size of the data which is sensitive to changes. Also, ADF and PP produce a t-statistic which needs to cross a critical value above which the series can be confirmed to be stationary. This test still needed to be run for different orders of integration, with trend and/or intercept and a number of lags.

The utilized data have to be incorporated with potential structural change in the level of the series from the boom-and-bust cycles triggered by the brutal assassination of former Senator Aquino in 1983, the power blackouts of 1991-1992, and the Asian financial crisis in 1998, as well as possible changes in growth rates. This changes the mean and variance over time. The non-stationarity of the datasets can also be caused by its inconsistency with past data. This means that some unobserved aspect of reality was correlated with

expected results, and varying values of that “*hidden context*” must force variation on learned models.

Rapach (2002) reveals that, with univariate methods, the unit root null can be rejected more frequently once structural breaks are allowed in deterministic trends for long-horizon. The reason of failure of rejecting the unit-root hypothesis given ADF and PP tests is that the power of a single equation is low (Levin et al., 2002).

The results of testing the order of integration are also reported in Table 4.5 as the summary of the Cointegration tests. Based on the residual test using Residual Dickey Fuller (RESDF) and Residual Phillips-Perron (RESP), the absolute values of the calculated test statistics for all the residuals are less than its critical value at 5 percent level of significance. Thus, neither of the residual series is cointegrated. In all cases, the null hypothesis of no cointegration cannot be rejected at 5% level of significance, implying that a long-run equilibrium relationship does not exist between EC and GDP in the Philippines. This underlines the fact that formal tests are helpful only to some extent in reducing the present uncertainty involved in the analysis of time series. Based on these findings, one can advocate the use of MEB framework as errors are inevitable in the standard practice of testing for unit roots and cointegration. MEB approach, on the other hand, avoids such preliminary analyses which can and do induce incorrect results into causality testing. Consequently, one main advantage of the MEB-based framework is in the department of reliability in the sense of avoiding specification errors. In many papers performing a cointegration analysis, one finds statements such as: if cointegration exists between two variables in the long run, then, there must be either unidirectional or bi-directional Granger-causality between these variables. Or, Cointegration implies that causality exists between the two series but it does not indicate the direction of the causal relationship.

### Granger causality test results

As provided by the joint Wald  $F$ -statistics of the lagged explanatory variables, it can be seen that EC (in the GDP equation) or GDP (in the EC equation) is significant in Model 3 at the 5% level. Hence, EC and GDP are only significant in Model 3 at 5% critical value. This implies that the null hypothesis that GDP does not granger-cause EC (or vice versa) can be rejected. This further implies that EC and GDP are jointly determined and affected at the same time or there is a bi-causality relationship between the two variables. It suggests that the policy of conserving EC may be implemented with little or no adverse effect on GDP, especially in the case of the Philippines which is an energy-dependent economy. At the same time, it suggests that restrictions on the EC may adversely affect GDP while increases in EC may contribute to GDP.

This finding of bidirectional Granger causality between EC and GDP, which is consistent with the findings of Asafu-Adjaye (2000), has a number of implications for policy analysts and forecasters of the Philippines. This implies that an energy-dependent economy like Philippines is relatively vulnerable to energy shocks. A high level of economic growth leads to high level of energy demand and vice versa. Efforts must also be made to encourage industry to adopt technology that minimizes pollution.

### Comparison of results

Applying the unit root test, cointegration test, and Granger causality test, the author observes contradicting results that can explain some of the variation in causality conclusions in the literature. Proposing MEB framework for causality analysis, this study supports the neutrality hypothesis for the Philippines. Table 6 shows the advantage of MEB over other methods for dealing with stationary issues of a time series data with a small sample size. The MEB approach avoids preliminary testing and shape destroying transformations such as differencing and detrending. Hence, it frees the researcher from always

having to use differencing when the available data have near unit roots or other forms of nonstationarity, sometimes forcing to transform all the series into stationary series.

## SUMMARY AND CONCLUSION

Due to the growing population and ongoing industrialization in the Philippines, energy investments remain of crucial importance to the country. The Philippines is directed to strategically intensify development and utilization of renewable and environment-friendly alternative energy resources/technologies, accelerate exploration and development of geothermal, oil, gas, and coal resources, enhance energy efficiency and conservation, maintain a competitive energy investment climate and attain nationwide electrification (DOE, 2009).

Furthermore, the Philippines is currently facing power shortages in some parts of the country, specifically in Mindanao. The country has recently passed the Renewable Energy Law in 2008, and the National Renewable Energy Plan which seek to triple the renewable energy (RE) capacity of the country in 2010 by 2030. In fact, President Aquino signed last 2011 the National Climate Change Action Plan which identified sustainable energy as a priority. These are the main reasons which make Philippines a source of interest in the energy economics literature and bring about a number of studies analyzing the causal relationship between its EC and GDP. However, after numerous articles published in the last decade, the findings are still indecisive, pointing out the need for investigating this issue using state of the art econometric techniques rather than employing the usual methods.

The maximum entropy bootstrap data generation process - the method used in this study provides a flexible and powerful tool for doing statistical inference using time series data. It has the main advantage of

yielding in small samples substantially more accurate results in comparison to conventional hypothesis tests based on asymptotic theory (Yalta, 2011). Moreover, the technique can be used without performing shape-destroying transformations under all types of nonstationarity including structural breaks, near unit roots, and fractional integration. This in turn improves reliability in the sense of avoiding specification errors caused by preliminary testing (Yalta, 2011).

Proposing a MEB based framework for causality analysis, this study tried to provide conclusive evidence regarding the relationship between EC and GDP in the Philippines. Our tests reveal that a statistically significant relationship does not exist. The findings in this study are robust to the time period chosen in model specification. Finally, applying various stationarity and cointegration tests reveals contradicting results that can explain some of the variation in causality conclusions observed in the literature.

Our findings provide strong evidence supporting the neutrality hypothesis for Philippines. Based on the robustness of the results, it is possible that some of the previous findings on this nexus can be caused by over-rejecting the null hypothesis of no causality due to the severe size distortions typical for small sample statistical inference based on asymptotic theory. Such size distortions can be orders of magnitude smaller when bootstrapping is used. The MEB approach is suitable for performing such analysis using time series data.

The results of no causality in either direction, the so-called 'neutrality hypothesis', indicate that EC is generally neutral with respect to its effect on GDP in the Philippines (or vice versa). This finding can be explained by the fact that less developed countries like the Philippines is energy dependent.

This finding further implies that the effect of energy conservation policies to help combat global warming would not have effect on the overall growth of GDP. Thus, energy conservation policies may be pursued without adversely affecting the economy. The goal of the DOE to establish an appropriate policy framework

on energy efficiency and conservation may continuously be implemented by the Administration. The existing laws and policies on energy efficiency and conservation may be strictly enforced at this time. However, the identification of possible energy resource within the country shall be a priority so that the Philippines will become energy-independent in the future.

This result suggests that the causality between GDP and EC in the Philippines appears to be very weak, possibly reflecting that Philippines has an economy based on agriculture and labor-intensive. Hence, given its stage of development, Philippines is energy dependent wherein energy use in the country is not generally affected by GDP.

## RECOMMENDATIONS

This study will become more promising if the following were thought of and considered: (1) extending the number of time periods considered, (2) utilizing the data lifted from the Philippine data bank, and not from international organizations, (3) extending the comparative analysis to country-level to provide better comparison for the robustness of MEB inference, and (4) employing robust causality tests such as Hsiao's granger causality test.

As a result, future research should focus on testing the validity of the diagnosis of this study by extending the analysis to other countries. It is also worth pursuing to carry out a sectoral analysis using disaggregated data. Exploiting other new and innovative econometric tools is encouraged as well.

## BIOGRAPHICAL:

Kenneth Barroga is the Provincial Science and Technology Director of the Department of Science and Technology Regional Office No. 11. He holds an MSc in Econometrics from University of Southeastern

Philippines, the only university in the Philippines that offer such degree, and a BSc in Applied Economics from the top university of the Philippines, the University of the Philippines Mindanao. He had also served as a Faculty member at University of the Philippines Mindanao. His fields of interest are: Maximum Entropy Bootstrap, Applied Econometric Modeling, Applied Mathematics, Mathematical Economics, Statistical Theory, Applied Regression Analysis, and Project Evaluation.

Agustina Tan-Cruz is the Dean of the School of Applied Economics of the University of the Southeastern Philippines, Obrero, Davao City. She holds a PhD in Econometrics and Master of Economics from University of New England, Australia, Master in Economics. She served as a Faculty member at Mindanao State University – Iligan Institute of Computing, Iligan City, Philippines and a Research Coordinator of the University of Southeastern Philippines – College of Development and Management. Her fields of interest are: Bayesian Econometrics, Applied Econometric Modeling, Mathematical Economics, Statistics, Mathematics, and Regression Analysis.

## REFERENCES

- Altınay G, Karagöl E (2004). 'Structural break, unit root, and the causality between energy consumption and GDP in Turkey', *Energy Economics* 26 (6) :985-994.
- APEC. (2013) *APEC Energy Demand and Supply Outlook, 5<sup>th</sup> Edition*. Energy Working Group. APEC#213-RE-01.5.
- Asafu-Adjaye J (2000). 'The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries', *Energy Economics* 22, 615–625.
- Belke A, Dreger C, de Haan F (2011) 'Energy Consumption and Economic Growth New Insights into the Cointegration Relationship', *RUHR Economics Papers* 190 : pp. 1-3.

- Davison AC, Hinkley DV (1997). 'Bootstrap Methods and Their Applications', Cambridge University Press, Cambridge.
- DOE (2009). The Philippine Energy Plan 2009-2030. PEP.
- Efron B (1979). 'Bootstrap methods: Another look at the jackknife', *Annals of Statistics* 7: 1–26.
- Efron B (1982). 'The Jackknife, the Bootstrap and Other Resampling Plans', Society for Industrial and Applied Mathematics, Philadelphia.
- Erdal GH Erdal K, Esengu (2008). 'The causality between energy consumption and economic growth in Turkey', *Energy Policy* 36 (10): 3838–3842.
- Hall P (1988). 'On symmetric bootstrap confidence intervals', *Journal of the Royal Statistical Society, Series B*, 50, 35–45.
- Horowitz JL (2001). 'The bootstrap', Chapter 52 in *Handbook of Econometrics* Vol. 5 ed. J. J. Heckman and E. E. Leamer, Amsterdam, North-Holland, pp:3159-3228.
- Hyndman RJ (1996). 'Computing and Graphing Highest Density Regions', *The American Statistician* 50: 120-126.
- Jumbe CBL. (2004). 'Cointegration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi', *Energy Economics* 26: 61-68.
- Karanfil F (2008). 'Energy consumption and economic growth revisited: does the size of unrecorded economy matter. *Energy Policy* 36 (8): 3029–3035.
- Karanfil F (2009) 'How many times again will we examine the energy-income nexus using a limited range of traditional econometric tools?', *Energy Policy* 37: 1191-1194.
- Kiran B, Guris B (2009). 'Relationship between electricity consumption and GDP in Turkey', *Problems and Perspectives in Management*: pp:166-171. Volume 7, Issue 1, 2009
- Lahiri SN (2003). 'Resampling Methods for Dependent Data'. Springer-Verlag, New York.
- Levin A., Lin CF, Chu CS (2002). 'Unit root tests in panel data: asymptotic and finite-sample properties', *Journal of Econometrics* pp :108: 1-24.
- Lise W, Van MK (2007). 'Energy consumption and GDP in Turkey: is there a co-integration relationship?', *Energy Economics* 29: 1166–1178.
- MacKinnon JG (2002). 'Bootstrap Inference in Econometrics', *Canadian Journal of Economics*, 35: 615–645.
- Masih A, Masih R (1996). 'Energy consumption, real income and temporal causality: Result from multi-country study, based on cointegration and error correction technique', *Energy Economics* 18: 165-183.
- Navarro AM, Yap JT (2012). 'The Philippine economy in 2011 and prospects for 2012', *Development Research News*, Vol. XXX No. 1, January–February 2012.
- Rapach DE (2002). 'Are real GDP levels nonstationary? Evidence from panel data tests', *Southern Economic Journal* 68(3): 473-495.
- Soytas U, Sari R (2001). 'Energy Consumption and GDP: Causality Relationship in G-7 Countries and Emerging Markets', *Energy Economics* 25: pp.33–37.
- Soytas U, Sari R, Ozdemir O (2003). 'Energy consumption and GDP relation in Turkey: a cointegration and vector error correction analysis', *Economics and Business in Transition: Facilitating Competitiveness and Change in the Global Environment Proceedings*, pp. 838-844.
- Stern DI (2000). 'A multivariate cointegration analysis of the role of energy in the US macroeconomy', *Energy Economics* 22: 267–283.
- Vinod HD (2006). 'Hands-On Intermediate Econometrics Using R', 1st edn., World Scientific Publishing Ltd., Singapore.
- Vinod HD de Lacalle JL (2011). 'Maximum Entropy Bootstrap for Time Series: The meboot R Package', *Journal of Statistical Software* 29: 1–19.
- Wei SZ, C Chen Z Xhu (2008). 'Economic growth and energy consumption revisited: Evidence from linear and nonlinear Granger causality', *Energy Economics* 30, 3063–3076.



Yalta AT (2011). 'Analyzing Energy Consumption and GDP Nexus Using Maximum Entropy Bootstrap: The Case of Turkey'. Working Paper No: 11-03 TOBB University of Economics and Technology Department of Economics.

Yoo S (2006). 'Causal relationship between coal consumption and economic growth in Korea', *Applying Energy* 83, 1181–9.

Yu ES, Choi J (1985). 'The causal Relationship between Energy and GDP: An International Comparison', *Journal of Energy and Development* (Spring): pp 249-271