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

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Abstract: We employ the maximum entropy bootstrap (MEB) framework to provide convincing evidence on the energy consumption (EC) and gross domestic product (GDP) nexus between 1975 and 2010 in the Philippines. We also perform a cointegration analysis and Granger causality test of the data to illustrate the advantages of MEB approach. This paper shows more accurate inference in comparison to conventional hypothesis tests based on asymptotic theory. Without employing MEB, the result of causality is very sensitive to a very small sample size and time period chosen that made the results inconsistent. Therefore, MEB framework is robust to time period chosen and even in a very small sample size. The analysis shows no evidence of a causal relationship between EC and GDP in the Philippines. The findings emphasise the fact that the Philippines is a less developed country and predominantly agrarian-based; thus, energy dependent.

Keywords: bootstrap; cointegration; EC; energy consumption; GDP; granger causality; HDR; highest density region; MEB; maximum entropy bootstrap.


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1 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 on global warming and the reduction of greenhouse gas (GHG) emissions (Belke et al., 2011).

Over the recent years, the Philippines regularly achieved high growth rates while its EC 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 GHG emissions starting 2012 (DOE, 2009). This will happen by improving energy efficiency in the electricity generation, transmission and distribution subsectors as well as intensifying the implementation of the renewable energy (RE) Law which would consequently reduce fossil fuels consumption. Accordingly, if the ‘growth hypothesis’ that EC results in more output is true, energy conservation policies can be unfavourable to the future economic growth of the Philippines. However, if the ‘conservation hypothesis’ that there is a unidirectional causality from economic growth to EC is correct, 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, if the ‘neutrality hypothesis’ holds, neither energy conservation nor expansion policies will have any effect on economic growth. This 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 have not been of interest using maximum entropy bootstrap (MEB). Hence, as far as the author knows, no articles analysing 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. According to Yalta (2011), 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. It clearly shows that in the energy economics literature, 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 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 MEB to provide conclusive evidence on the connection between EC and GDP in the Philippines. Specifically the study aimed:

- to evaluate the relationship between EC and GDP for the Philippines using MEB method
- 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
- to apply the Granger causality test to verify the direction of causality between EC and GDP for the case of the Philippines.

2 Methodology

2.1 Conceptual framework

This study analysed 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 categorised into three types each of which has important implications for energy policy (Yoo, 2006).
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- 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 labour 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, then 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.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Period</th>
<th>Econometric methodology</th>
<th>Causality relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yu and Choi (1985)</td>
<td>1950–1982</td>
<td>Sim’s, Granger</td>
<td>GNP ← EC</td>
</tr>
<tr>
<td>Wei et al. (2008)</td>
<td>1954–2006</td>
<td>Linear and nonlinear regression; Granger</td>
<td>GDP → EC</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Authors</th>
<th>Period</th>
<th>Econometric methodology</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>4  Karanfil (2008)</td>
<td>1970–2005</td>
<td>Granger causality, Cointegration</td>
<td>GDP → EC; No causality (when unrecorded economy is taken into account)</td>
</tr>
</tbody>
</table>

Figure 1  Possible relationships between EC and GDP

2.2  Econometric model

The modelling strategy adopted in the analysis of the subject is a bivariate approach. As shown in Figure 2, the 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 first investigated the bivariate causal relationship between EC and GDP by using the system:

\[
y_t = c_1 + \sum_{j=1}^{\infty} \alpha_{ij} e_{t-j} + \sum_{j=1}^{\infty} \beta_{ij} y_{t-j} + u_t \tag{1}
\]

\[
e_t = c_2 + \sum_{j=0}^{\infty} \alpha_{2j} e_{t-j} + \sum_{j=0}^{\infty} \beta_{2j} y_{t-j} + u_{2t} \tag{2}
\]
where
\[ c_i : \text{constant term, } k = 1, 2 \]
\[ y_t : \log \text{ of GDP in year } t \]
\[ u_{kt} : \text{residual term, } k = 1, 2 \]
\[ e_t : \log \text{ of EC in year } t \]
\[ \alpha_{jk}^{1}, \beta_{jk}^{1} : \text{coefficient estimates for } y_t, i = 1, 2, ..., m; j = 1, 2, ..., n \]
\[ \alpha_{jk}^{2}, \beta_{jk}^{2} : \text{coefficient estimates for } e_t, i = 1, 2, ..., m; j = 1, 2, ..., n. \]

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, \( J = 1000 \)) 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).

**Figure 2** Flowchart showing the estimation process

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 such as detrending or differencing to achieve stationarity (Yalta, 2011).

In particular, the ME density \( f(x) \) is chosen so as to maximise \( H = E (\log f (x)) \) (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 $j = 1, \ldots, J$ ($J = 1000$), of the 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.

2.3 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 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 realisation of regressors in standard notation is linear
- it is robust against heteroscedastic errors
- the estimation process.

3 Results and discussion

3.1 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 $J = 1000$ series every dataset. For this 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 1000 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 $J = 1000$ series for GDP and EC was done and then 1000 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 analysing 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.

Table 3  Causality test results based on maximum entropy bootstrap inference

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

ns 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).

Moreover, Table 3 clearly shows that zero are 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 the parameter estimates of log of EC and log of GDP for Models 1–3. Model 1 utilising the complete ensemble of 36,000 observations from the original data on GDP from 1975 to 2010 has a corresponding HDR plots of its 1000 estimates shown in Figure 3.

As observed, Figure 4 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 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 to 2010 as shown in Figure 3. Figure 3 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 to 1992 (see Figures 5 and 6) and Model 3 which accounts the data on GDP and EC from 1993 to 2010 (see Figures 7 and 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.

**Figure 3** Highest density confidence region for estimates of log of EC for Model 1 (model utilising data on EC from 1975 to 2010) (see online version for colours)

![Density distribution of log EC for Model 1](image)

**Figure 4** Highest density confidence region for estimates of log of GDP for Model 1 (model utilising data on GDP from 1975 to 2010) (see online version for colours)

![Density distribution of log GDP for Model 1](image)

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.
Figure 5  Highest density confidence region for estimates of log of GDP for Model 2
(model utilising data on GDP from 1975 to 1992) (see online version for colours)

Figure 6  Highest density confidence region for estimates of log of EC for Model 2
(model utilising data on EC from 1975 to 1992) (see online version for colours)

Figure 7  Highest density confidence region for estimates of log of GDP for Model 3
(model utilising data on GDP from 1993 to 2010) (see online version for colours)
3.2 Empirical output using cointegration test

The original data on real GDP and EC was used to conduct unit root test and cointegration test. Without using MEB-based simulation, Model 1 is composed of 36 observations utilising the data from 1975 to 2010, while Models 2 and 3 each has only 18 observations using the data from 1975 to 1992 and 1993 to 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 utilised 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.
Table 4  Unit root test results based on Augmented Dickey Fuller and Phillips–Perron tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>First difference</td>
</tr>
<tr>
<td>Model 1: 1975–2010 period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log of EC</td>
<td>–1.1268</td>
<td>0.87718</td>
</tr>
<tr>
<td>Log of GDP</td>
<td>–0.86274</td>
<td>1.2929</td>
</tr>
<tr>
<td>5% crit. value</td>
<td>–3.41**</td>
<td>6.25**</td>
</tr>
<tr>
<td>Model 2: 1975–1992 period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log of EC</td>
<td>–1.4113</td>
<td>1.1430</td>
</tr>
<tr>
<td>Log of GDP</td>
<td>–1.4840</td>
<td>1.1338</td>
</tr>
<tr>
<td>5% crit. value</td>
<td>–3.41**</td>
<td>6.25**</td>
</tr>
<tr>
<td>Model 3: 1993–2010 period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log of EC</td>
<td>–2.6314</td>
<td>4.4292</td>
</tr>
<tr>
<td>Log of GDP</td>
<td>–0.54418</td>
<td>1.0339</td>
</tr>
<tr>
<td>5% crit. value</td>
<td>–3.41**</td>
<td>6.25**</td>
</tr>
</tbody>
</table>

** not significant at 5% significance level.

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 as the summary of the Cointegration tests. Based on the residual test using Residual Dickey Fuller (RESD) 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% 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.
3.3 Granger causality test results

As provided by the joint Wald $F$-statistics at the third column in Table 5 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 minimises pollution.

Table 5 Summary of results of Granger causality test

<table>
<thead>
<tr>
<th>Model</th>
<th>Granger causality test (null hypothesis of no causality)</th>
<th>Joint-$F$</th>
<th>$P$-Value</th>
<th>Causality results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1: 1975–2010 period</td>
<td>EC does not Granger cause GDP</td>
<td>3.72**</td>
<td>0.063</td>
<td>No causality</td>
</tr>
<tr>
<td></td>
<td>GDP does not Granger cause EC</td>
<td>0.141ns</td>
<td>0.709</td>
<td></td>
</tr>
<tr>
<td>Model 2: 1975–1992 period</td>
<td>EC does not Granger cause GDP</td>
<td>0.0101ns</td>
<td>0.921</td>
<td>No causality</td>
</tr>
<tr>
<td></td>
<td>GDP does not Granger cause EC</td>
<td>1.75ns</td>
<td>0.207</td>
<td></td>
</tr>
<tr>
<td>Model 3: 1993–2010 period</td>
<td>EC does not Granger cause GDP</td>
<td>10.3*</td>
<td>0.006</td>
<td>GDP ↔ EC</td>
</tr>
<tr>
<td></td>
<td>GDP does not Granger cause EC</td>
<td>5.32*</td>
<td>0.037</td>
<td></td>
</tr>
</tbody>
</table>

For all tests, significance level = 0.05.
**ns not significant; *significant.

3.4 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 non-stationarity, sometimes forcing to transform all the series into stationary series.

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

<table>
<thead>
<tr>
<th>Data</th>
<th>Method used</th>
<th>Unit root test result</th>
<th>Causality test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1: 1975–2010 period</td>
<td>MEB approach</td>
<td>Stationary</td>
<td>No Causality</td>
</tr>
<tr>
<td></td>
<td>ADF and PP</td>
<td></td>
<td>Non-stationary</td>
</tr>
<tr>
<td></td>
<td>Granger causality in VAR framework</td>
<td></td>
<td>No Causality</td>
</tr>
<tr>
<td>Model 2: 1975–1993 period</td>
<td>MEB approach</td>
<td>Stationary</td>
<td>No Causality</td>
</tr>
<tr>
<td></td>
<td>ADF and PP</td>
<td></td>
<td>Non-stationary</td>
</tr>
<tr>
<td></td>
<td>Granger causality in VAR framework</td>
<td></td>
<td>No Causality</td>
</tr>
<tr>
<td>Model 3: 1993–2010 period</td>
<td>MEB approach</td>
<td>Stationary</td>
<td>No Causality</td>
</tr>
<tr>
<td></td>
<td>ADF and PP</td>
<td></td>
<td>Non-stationary</td>
</tr>
<tr>
<td></td>
<td>Granger causality in VAR framework</td>
<td></td>
<td>Bi-causality</td>
</tr>
</tbody>
</table>

4 **Summary and conclusion**

Due to the growing population and ongoing industrialisation in the Philippines, energy investments remain of crucial importance to the country. The Philippines is directed to strategically intensify development and utilisation 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 are currently facing power shortages in some parts of the country, specifically in Mindanao. The country has recently passed the RE Law in 2008, and the National RE Plan which seek to triple the 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 analysing 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 MEB 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 non-stationarity 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 have an economy based on agriculture and labour-intensive. Hence, given its stage of development, Philippines is energy dependent wherein energy use in the country is not generally affected by GDP.

5 Recommendations

This study will become more promising if the following were thought of and considered:

- extending the number of time periods considered
- utilising the data lifted from the Philippine data bank, and not from international organisations
- extending the comparative analysis to country-level to provide better comparison for the robustness of MEB inference
- 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.

References


Energy consumption and gross domestic product in the Philippines


Bibliography


