Energy consumption and growth in South America: Evidence from a panel error correction model

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ABSTRACT

This study examines the relationship between energy consumption and economic growth for a panel of nine South American countries over the period 1980–2005 within a multivariate framework. Given the relatively short span of the time series data, a panel cointegration and error correction model is employed to infer the causal relationship. Pedroni’s heterogeneous panel cointegration test reveals a long-run equilibrium relationship between real GDP, energy consumption, the labor force, and real gross fixed capital formation with the respective coefficients positive and statistically significant. The Granger-causality results indicate both short-run and long-run causality from energy consumption to economic growth which supports the growth hypothesis.

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1. Introduction

The South American region is rich in natural resources with the agricultural, energy, and other commodity sectors providing much of the region’s export-driven growth. The continued expansion of this growth hinges on the ability to combine the region’s natural resources with value-added industry. Furthermore, the enhancement of the transportation infrastructure and trade routes to link the inland countries of the region will provide greater access to agricultural and energy products for global markets. Currently, South America is positioned among the world’s leaders in oil, natural gas, hydroelectricity, and ethanol production. For example, Venezuela is the seventh largest net oil exporter in the world along with having the second largest proven natural gas reserves in the Western Hemisphere behind the U.S. Ecuador and Argentina are also major oil exporters. Argentina is also the largest natural gas producer in South America. Brazil has the second largest proven oil reserves in South America behind Venezuela and in recent years oil production has increased and according to the Energy Information Administration will be a net oil exporter by 2009. In addition to its oil production, Brazil is one of the largest ethanol producers in the world and the largest ethanol exporter. With respect to hydroelectricity, Brazil and Paraguay maintain the world’s largest hydroelectric generation facility with much of the hydroelectricity exported to other countries in South America. However, the abundance of natural resources, namely oil and natural gas, has led to concerns of the economy’s dependency on these resources. For instance, Venezuela’s oil and natural gas industry is nationalized, known as Petroleos de Venezuela SA. As such resources needed to maintain desired production levels are strained by the fact that Venezuela’s oil and natural gas sector is responsible for roughly three-fourths of the country’s export revenues, half of the tax revenues, and comprises nearly half of the country’s GDP. Likewise, Ecuador’s economy is heavily dependent on the oil sector with over half of the country’s export revenues and a third of its tax revenues originate from this sector. Furthermore, given the lack of refining capacity, Ecuador does not reap the full benefits of high world oil prices as it must import more expensive refined petroleum products.

Table 1 displays the composition of energy production and consumption, the net generation and consumption of electricity by energy source, energy intensity, carbon dioxide emissions per capita, and real GDP per capita for nine South American countries. There is a great deal of variation in the composition and usage of energy sources across countries in this region. With respect to fossil fuels, petroleum and natural gas production and consumption dominant the production and consumption of coal. As shown by the 2005 data in Table 1,
Table 1
Overview of energy production and consumption, selected South American countries, 2005.

<table>
<thead>
<tr>
<th></th>
<th>Argentina</th>
<th>Bolivia</th>
<th>Brazil</th>
<th>Chile</th>
<th>Ecuador</th>
<th>Paraguay</th>
<th>Peru</th>
<th>Uruguay</th>
<th>Venezuela</th>
</tr>
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<tbody>
<tr>
<td>Petroleum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Production</td>
<td>798.05</td>
<td>62.66</td>
<td>2038.45</td>
<td>15.41</td>
<td>532.76</td>
<td>0.03</td>
<td>111.50</td>
<td>0.95</td>
<td>2866.93</td>
</tr>
<tr>
<td>Consumption</td>
<td>483.01</td>
<td>50.80</td>
<td>2206.22</td>
<td>259.86</td>
<td>159.41</td>
<td>25.81</td>
<td>157.73</td>
<td>40.14</td>
<td>582.15</td>
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<tr>
<td>Natural gas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>1611.4</td>
<td>436.1</td>
<td>345.0</td>
<td>72.0</td>
<td>9.2</td>
<td>0.00</td>
<td>55.8</td>
<td>0.00</td>
<td>1012.5</td>
</tr>
<tr>
<td>Consumption</td>
<td>1428.1</td>
<td>74.5</td>
<td>657.2</td>
<td>301.6</td>
<td>9.2</td>
<td>0.00</td>
<td>55.8</td>
<td>3.20</td>
<td>1013.5</td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>0.00</td>
<td>0.00</td>
<td>6.90</td>
<td>0.06</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>7.90</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.08</td>
<td>0.00</td>
<td>23.70</td>
<td>5.90</td>
<td>0.00</td>
<td>0.00</td>
<td>1.60</td>
<td>0.00</td>
<td>1.00</td>
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<tr>
<td>Electricity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Generation</td>
<td>100.3</td>
<td>4.9</td>
<td>395.7</td>
<td>50.2</td>
<td>12.9</td>
<td>50.7</td>
<td>23.0</td>
<td>7.6</td>
<td>99.2</td>
</tr>
<tr>
<td>% Oil</td>
<td>5.43</td>
<td>16.71</td>
<td>2.91</td>
<td>3.41</td>
<td>40.97</td>
<td>0.00</td>
<td>8.24</td>
<td>12.49</td>
<td>10.48</td>
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<tr>
<td>% natural gas</td>
<td>52.32</td>
<td>32.26</td>
<td>4.67</td>
<td>29.94</td>
<td>7.68</td>
<td>0.00</td>
<td>9.69</td>
<td>0.04</td>
<td>15.64</td>
</tr>
<tr>
<td>% coal</td>
<td>2.05</td>
<td>0.00</td>
<td>2.47</td>
<td>16.71</td>
<td>0.00</td>
<td>0.00</td>
<td>3.15</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>% hydroelectric</td>
<td>32.40</td>
<td>47.76</td>
<td>83.73</td>
<td>48.14</td>
<td>51.35</td>
<td>100.00</td>
<td>78.29</td>
<td>87.00</td>
<td>73.88</td>
</tr>
<tr>
<td>% nuclear</td>
<td>6.50</td>
<td>0.00</td>
<td>2.45</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Net consumption</td>
<td>88.2</td>
<td>4.2</td>
<td>367.9</td>
<td>45.8</td>
<td>11.3</td>
<td>4.5</td>
<td>20.6</td>
<td>6.5</td>
<td>71.3</td>
</tr>
<tr>
<td>Energy intensity</td>
<td>6.58</td>
<td>6.43</td>
<td>7.56</td>
<td>6.75</td>
<td>8.43</td>
<td>5.68</td>
<td>12.74</td>
<td>10.59</td>
<td>4.31</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions per capita</td>
<td>3.69</td>
<td>0.77</td>
<td>1.80</td>
<td>3.87</td>
<td>2.26</td>
<td>0.72</td>
<td>1.17</td>
<td>1.66</td>
<td>6.60</td>
</tr>
<tr>
<td>Real GDP</td>
<td>$10,815</td>
<td>$3,715</td>
<td>$8,474</td>
<td>$12,248</td>
<td>$6,737</td>
<td>$3,824</td>
<td>$6,452</td>
<td>$9,266</td>
<td>$9,877</td>
</tr>
</tbody>
</table>

Notes: Petroleum production and consumption measured in thousands of barrels per day. Natural gas production and consumption measured in billion cubic feet. Coal production and consumption measured in million short tons. Electricity net generation and consumption measured in billion kilowatt hours. Data on petroleum, natural gas, coal, and electricity net generation and consumption were obtained from the Energy Information Administration-International Energy Data and Analysis (www.eia.doe.gov). Data on energy intensity measured in GDP per unit of energy use (constant 2005 PPP international dollars per kilogram of oil equivalent). Carbon dioxide emissions measured in metric tons per capita in 2004. Real GDP per capita measured in constant 2005 PPP international dollars. Data on percentage of electricity produced by source, energy intensity, carbon dioxide emissions, and real GDP per capita were obtained from World Bank Economic Indicators CD-ROM.

The production levels of oil for Argentina, Bolivia, Ecuador, and Venezuela exceeded their consumption levels whereas Brazil, Chile, Paraguay, Peru, and Uruguay relied on oil imports to meet their oil consumption needs. In terms of natural gas, the production levels in Argentina and Bolivia exceeded their consumption whereas Brazil, Chile, and Uruguay imported natural gas. The energy sources used in net electricity generation varies across countries as well. The percentage of net electricity generation from oil ranges from 40.97% in Ecuador to 0.00% in Paraguay; the percentage from natural gas ranges from 52.32% in Argentina to 0.00% in Paraguay; the percentage from coal ranges from 16.71% in Chile to 0.00% in Bolivia, Ecuador, Paraguay, Uruguay, and Venezuela; the percentage from hydroelectric ranges from 100.0% in Paraguay to 32.40% in Argentina; and the percentage from nuclear energy ranges from 6.50% to 0.00% in all the remaining countries with the exception of Brazil at 2.45%. Besides the variation in energy production and consumption, there is also variation in the efficiency of energy usage which ranges from 12.74 in Peru to 4.31 in Venezuela. With respect to environmental concerns, with the exception of Venezuela, carbon dioxide emissions in metric tons per capita are relatively close across countries ranging from 6.60 in Venezuela to 0.72 in Paraguay. Finally, real GDP per capita, as a proxy for the level of economic development ranges from $12,248 in Chile to $3,715 in Bolivia.

The objective of this study is to examine the causal relationship between energy consumption and economic growth for a panel of nine South American countries within a multivariate framework in order to determine the degree to which energy consumption influences the growth prospects of this region. Unlike previous studies which have relied upon limited time series data, usually 30 to 35 observations, which reduces the power and size properties of conventional unit root and cointegration tests, this study employs the panel unit root and cointegration testing approach set forth by Pedroni (1999, 2004). The use of panel unit root and cointegration tests will provide additional power by combining the cross-section and time series data while allowing for heterogeneity across countries. Section 2 discusses the various hypotheses associated with the energy consumption and economic growth literature along with the previous empirical studies on South American countries. Section 3 presents the data, methodology, and results. Concluding remarks are given in Section 4.

2. The energy consumption-growth literature for South America

The causal relationship between energy consumption and economic growth has been extensively examined in the literature with varying results across countries. Of significance is the policy implications associated with the causal inferences drawn with respect to the energy consumption-growth relationship. The presence of unidirectional causality from energy consumption to economic growth (growth hypothesis) signals the economy is energy dependent in which case energy conservation policies may have an adverse impact on economic growth. On the other hand, unidirectional causality from economic growth to energy consumption (conservation hypothesis) suggests that energy conservation policies may have little or no impact on economic growth. It is also possible there is bidirectional causality between energy consumption and economic growth (feedback hypothesis) reflecting...
the interdependence and possible complementarities associated with energy consumption and economic growth. Finally, the absence of causality between energy consumption and economic growth (neutral-ity hypothesis) implies that energy conservation policies will have an insignificant impact on economic growth.

Previous studies with respect to South American countries yield a range of results. In a 16 country study, Nachane et al. (1988) find unidirectional causality from commercial energy consumption per capita to real GDP per capita for Argentina and Chile while bidirectional causality in the cases of Brazil, Colombia, and Venezuela. In another multi-country study, Murray and Nan (1996) show unidirectional causality from real GDP to electricity consumption for Colombia. In a 12 country study of G7 and emerging markets, Soyatas and Sari (2003) find bidirectional causality between energy consumption and GDP per capita in the case of Argentina. Cheng (1997) provides evidence of unidirectional causality from energy consumption to real GDP for Brazil and the absence of causality between energy consumption and real GDP for Venezuela. Within a panel of 18 developing countries which includes Argentina, Chile, Colombia, Peru, and Venezuela, Lee (2005) finds unidirectional causality from energy consumption to real GDP. Chontanawat et al. (2006, 2008) reveal unidirectional causality from energy consumption per capita to real GDP per capita for Chile, Colombia, and Uruguay; unidirectional causality from real GDP per capita to energy consumption per capita for Bolivia, Paraguay, Peru, and Venezuela; bidirectional causality for Argentina and Brazil; and the absence of causality for Ecuador. In a study of net energy exporting developing countries, Mahadevan and Asafu-Adjaye (2007) provide support for bidirectional causality between energy consumption per capita and real GDP per capita for Argentina and Venezuela. Within a panel of 11 oil exporting countries which include Ecuador and Venezuela, Mehrara (2007) finds unidirectional causality from real GDP per capita to commercial energy consumption per capita. In a study of OPEC countries, Squalli (2007) provides evidence of unidirectional causality from electricity consumption per capital to real GDP per capita in Venezuela. Finally, in an 82 country panel which includes Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela, Huang et al. (2008) find for the low income panel the absence of causality between energy consumption and real GDP per capita whereas unidirectional causality from real GDP per capita to energy consumption for the middle and high income panels.

With the exception of the studies by Lee (2005), Cheng (1997), Mahadevan and Asafu-Adjaye (2007), and Huang et al. (2008), the previous studies pertaining to South American countries evaluated the relationship between energy consumption and economic growth within a bivariate framework. However, a common problem of bivariate analysis is the possibility of omitted variable bias (Lütkepohl, 1982). To circumvent the omitted variable issue, this study examines the relationship between energy consumption and economic growth within a multivariate framework by including measures of capital and labor.

Tests of dynamic heterogeneity (i.e. variation of the intercept over countries and time) across a cross-section of the relevant variables indicate that the relationships are characterized by heterogeneity in both dynamics and error variances across groups.۱۰ In light of the parameter heterogeneity, the Im et al. (IPS, 2003) panel unit root test is utilized which allows for heterogeneous autoregressive coefficients.۱۱ Given the following autoregressive specification:

\[ y_{it} = \rho y_{i,t-1} + \delta X_{it} + \varepsilon_{it} \]  

where \( i = 1, ..., N \) for each country in the panel; \( t = 1, ..., T \) refers to the time period; \( X_{it} \) represents the exogenous variables in the model including fixed effects or individual time trend; \( \rho_i \) are the autoregressive coefficients; and \( \varepsilon_{it} \) are the stationary error terms.

Specifically, Im et al. (2003) averages the augmented Dickey-Fuller (ADF) unit root tests while allowing for different orders of serial correlation:

\[ e_{it} = \sum_{j=1}^{p_i} \phi_{ij} e_{i,t-j} + u_{it} \]  

Substitution of Eq. (2) into Eq. (1) yields

\[ y_{it} = \rho y_{i,t-1} + \sum_{j=1}^{p_i} \phi_{ij} e_{i,t-j} + \delta X_{it} + u_{it} \]  

where \( p_i \) represents the number of lags in the ADF regression. The null hypothesis is that each series in the panel contains a unit root \( (H_0: \rho_i = 1 \forall i) \). The alternative hypothesis is that at least one of the individual series in the panel is stationary \( (H_0: \rho_i < 1) \). Im et al. (2003) specify a \( t-bar \) statistic as the average of the individual ADF statistics as follows:

\[ t-bar = \frac{1}{N} \sum_{i=1}^{N} T_{1, i} \]  

where \( T_{1, i} \) is the individual \( t \)-statistic for testing \( H_0: \rho_i = 1 \forall i \) from Eq. (3). The \( t-bar \) statistic is normally distributed under the null hypothesis.۱۲ Table 2 reports the results of the IPS panel unit root tests which include an intercept and trend term. The panel unit root tests indicate all the variables are integrated of order one.

With the respective variables integrated of order one, the heterogeneous panel cointegration test advanced by Pedroni (1999, 2004), which allows for cross-section interdependence with different individual effects, is performed as follows:

\[ Y_{it} = \alpha_i + \delta_i t + \gamma_1 E_{it} + \gamma_2 L_{it} + \gamma_3 K_{it} + \varepsilon_{it} \]  

where \( i = 1, ..., N \) for each country in the panel and \( t = 1, ..., T \) refers to the time period. The parameters \( \alpha_i \) and \( \delta_i \) allow for the possibility of country-specific fixed effects and deterministic trends, respectively. \( \varepsilon_{it} \) denote the estimated residuals which represent deviations from the long-run relationship.

۱۰ Following Holtz-Eakin et al. (1985) and Holtz-Eakin (1986) several tests of dynamic heterogeneity were performed. First, the ADF(3) test examines the null hypothesis that the regression parameters are equal across equations using an F-test. The ADF(3) test statistic for parameter equality, 17.89, rejects the null hypothesis at the 1% significance level. Second, a Chow-type F-test on a 3rd order autoregressive model, AR(3), for each of the relationships is estimated to test the null hypothesis of parameter equality. The AR(3) test statistic, 25.62, rejects the null hypothesis which indicates heterogeneity in the cross-sectional parameters at the 1% significance level. Third, the White test for group-wise heteroskedasticity is used to test the null hypothesis of homogeneity error variance across countries. White's chi-square test statistic, 33.44, rejects the null hypothesis of homogeneity error variance across countries at the 1% significance level.

۱۱ The Hadri (2000), Choi (2001), Levin et al. (2002), and Carrion-i-Silvestre et al. (2005) tests were also performed. All the tests indicated that the respective variables contain a unit root. Results are available upon request from the authors.

۱۲ Critical values provided by Im et al. (2003).
To test the null hypothesis of no cointegration, $\rho_i = 1$, the following unit root test is conducted on the residuals as follows:

$$e_{it} = \rho_i e_{i,t-1} + w_t$$ (6)

Pedroni (1999, 2004) proposes two types of cointegration tests. First, the panel tests are based on the within dimension approach which includes four statistics: panel $v$, panel $\rho$, panel PP, and panel ADF-statistics. These statistics essentially pool the autoregressive coefficients across different countries for the unit root tests on the estimated residuals. These statistics take into account common time factors and heterogeneity across countries. Second, the group tests are based on the between dimension approach which includes three statistics: group $\rho$, group PP, and group ADF-statistics. These statistics are based on averages of the individual autoregressive coefficients associated with the unit root tests of the residuals for each country in the panel. All seven tests are distributed asymptotically as standard normal.

Table 3 reports both the within and between dimension panel cointegration test statistics. All seven test statistics reject the null hypothesis of no cointegration at the 1% significance level.

Next, the fully modified OLS (FMOLS) technique for heterogeneous cointegrated panels is estimated (Pedroni, 2000).\(^\text{13}\) Table 4 displays the FMOLS results. All the coefficients are positive and statistically significant at the 1% significance level and given the variables are expressed in natural logarithms, the coefficients can be interpreted as elasticity estimates. The results indicate that a 1% increase in real GDP by 0.42%; a 1% increase in real gross capital formation increases real GDP by 0.12%; and a 1% increase in the labor force increases real GDP by 0.50%. Compared to the results of other FMOLS estimates using panel data, the elasticity of energy usage is slightly smaller than the 0.50% reported by Lee et al. (2008) for 22 OECD countries, and the 0.12% reported by Narayan and Smyth (2008) for G7 countries, and the 0.28% reported by Apergis and Payne (2009a) for a panel of CIS countries excluding Russia and the same value for the CIS panel that includes Russia.

Given the variables are cointegrated, a panel vector error correction model (Pesaran et al., 1999) is estimated to perform Granger-causality tests. The Engle and Granger (1987) two-step procedure is undertaken by first estimating the long-run model specified in Eq. (5) in order to obtain the estimated residuals. Next, defining the lagged residuals from Eq. (5) as the error correction term, the following dynamic error correction model is estimated:

$$\Delta Y_{it} = \alpha_{ij} + \sum_{k=1}^{q} \theta_{ij} \Delta Y_{it-k} + \sum_{k=1}^{q} \theta_{ijk} \Delta E_{it-k}$$

$$+ \sum_{k=1}^{q} \theta_{ijk} \Delta K_{it-k} + \sum_{k=1}^{q} \theta_{ijk} \Delta L_{it-k} + \lambda_{1i} e_{it-1} + u_{it}$$ (7a)

Notes: Critical value at the 1% significance level denoted by “a”: Im et al. (2003) – 2.61. Panel unit root test includes intercept and trend.


<table>
<thead>
<tr>
<th>Test statistics</th>
<th>Within dimension</th>
<th>Between dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel $v$-statistic</td>
<td>40.03750(^{a})</td>
<td>Group $\rho$-statistic</td>
</tr>
<tr>
<td>Panel $\rho$-statistic</td>
<td>41.28008(^{a})</td>
<td>Group PP-statistic</td>
</tr>
<tr>
<td>Panel PP-statistic</td>
<td>40.04769(^{a})</td>
<td>Group ADF-statistic</td>
</tr>
<tr>
<td>Panel ADF-statistic</td>
<td>4.52255(^{a})</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Of the seven tests, the panel $v$-statistic is a one-sided test where large positive values reject the null hypothesis of no cointegration whereas large negative values for the remaining test statistics reject the null hypothesis of no cointegration. Critical values at the 1% significance level denoted by “a”: panel $v$ (24.56), panel $\rho$ (17.60), panel PP and group PP (25.59), panel ADF (2.97), group $\rho$ (21.12), and group ADF (3.18).

| Notes: | T-statistics are reported in parentheses and probability values in brackets. LM is the LaGrange multiplier test for serial correlation. RESET is the misspecification test. HE is White’s heteroskedasticity test. Significance at the 1% level denoted by “a”. |

**Table 4**


<table>
<thead>
<tr>
<th>FMOLS estimates</th>
<th>$Y = 0.397 + 0.42 E + 0.12 K + 0.50 L$ (5.67)$^{+}$ (9.62)$^{+}$ (12.74)$^{+}$ (13.71)$^{+}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostics</td>
<td>Adj. $R^2 = 0.86$</td>
</tr>
<tr>
<td></td>
<td>[0.46]</td>
</tr>
</tbody>
</table>

Notes: See Pedroni (1999) for details on the heterogeneous panel and heterogeneous group mean cointegration statistics.

\(^{13}\) See Pedroni (1999) for details on the heterogeneous panel and heterogeneous group mean cointegration statistics.

\(^{14}\) According to Banerjee (1999), the estimates from either the FMOLS or DOLS are asymptotically equivalent for more than 60 observations. This study has 144 observations.
While the error correction term is statistically significant the speed of adjustment toward long-run equilibrium appears much faster than in the case of the economic growth or labor force equations, but still with a relatively slow adjustment. In regards to Eq. (7d), economic growth, energy consumption, and real gross fixed capital formation have a positive and statistically significant impact on the labor force in the short-run. The error correction term is statistically significant with a relatively slow speed of adjustment towards equilibrium.

In summary, the short-run and long-run Granger-causality tests reveal several interesting results. First, there is unidirectional causality from energy consumption to economic growth in both the short-run and long-run without feedback. Second, energy consumption also indirectly affects economic growth through its positive impact on real gross fixed capital formation and not through its impact on the labor force. Third, the panel vector error correction model also shows that energy consumption is exogenous to the other variables in the model. These findings lend support for the growth hypothesis with respect to the energy consumption-growth nexus. The growth hypothesis asserts that energy conservation policies which reduce energy consumption may have an adverse impact on economic growth.

4. Concluding remarks

The abundance of natural resources has served South America’s export driven growth. With respect to energy sources, South America is among the world’s leaders in oil, natural gas, hydroelectricity and ethanol production. However, the economic fortunes of many South American countries rest with the sustainability of their respective energy sectors. This study has attempted to examine the contribution of energy consumption to economic growth. Specifically, the study employs a panel data set for nine South American countries (Argentina, Bolivia, Brazil, Chile, Ecuador, Paraguay, Peru, Uruguay, and Venezuela) over the period 1980–2005 to infer the causal relationship between energy consumption and economic growth taking into account the labor force and real gross fixed capital formation.

Pedroni’s heterogeneous panel cointegration test reveals there is a long-run equilibrium relationship between real GDP, energy consumption, real gross fixed capital formation, and the labor force. This long-run relationship suggests that a 1% increase in energy consumption increases real GDP by 0.42%; a 1% increase in capital increases real GDP by 0.12%; and a 1% increase in the labor force increases real GDP by 0.50%. Furthermore, the estimation of a panel vector error correction model indicates the presence of both short-run and long-run unidirectional causality from energy consumption to economic growth. This result provides support for the growth hypothesis which confirms the importance of energy consumption in the growth process of South America.

Though many countries in South America are energy dependent, it is vital to continue to diversify their economic base in order to insulate themselves from the possible depletion of these natural resources along with their susceptibility to volatile oil and natural gas prices in international markets. Furthermore, while energy conservation policies that reduce energy consumption may have an adverse impact on growth, policy makers need to also recognize the environmental consequences of fossil fuel usage in the design and implementation of a sustainable energy consumption mix that ensures future economic growth. Policy makers need to balance the needs for sustained economic growth with the environmental costs associated with excessive energy consumption. As such policy makers should continue to enhance energy efficiency usage and reduce the long-run environmental consequences associated with dependence on fossil fuels production and consumption.

References


