Does Short and Long Run Equilibrium Exists Between Electricity Consumption and Foreign Aid

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Abstract: Because of its limited and unmanaged internal resources to promote socio-economic development, Nepal has become an aid-dependent country. Past trends show that the majority of extant hydropower projects in Nepal were built through aid. In this light, using a single equation model, this study attempts to investigate short and long run equilibrium between two variables constructed from data collected between 1974-2011: 1) electricity consumption as the dependent variable, and 2) foreign aid as explanatory variable. There are two co-integrating equations that indicate a long run equilibrium between the variables. The long run elasticity coefficient reveals that a 1% change in foreign aid will change the electricity consumption by 0.48%. The results of ECM indicate that there is both short and long run equilibrium in the system. The coefficient of one period lag residual is negative and significant which represents the long run equilibrium. The coefficient is -0.336, which means that the system corrects its previous period disequilibrium at a speed of 33.6% annually.

Key words: Electricity consumption, foreign aid, co-integration, short run, long run, error correction

Introduction

Because of its limited and unmanaged internal resources to promote socio-economic development, Nepal has become an aid-dependent country. Infrastructure projects require huge investments that the government is incapable of producing. As the noted development economist Jeffrey Sachs has written, "Successful development requires public investments, but governments in impoverished countries are often too cash strapped and too indebted to finance the requisite investments. When the government is unable to build the roads, a power grid and other basic infrastructure the private sector languishes and result in a fiscal policy trap in which poverty leads to low public investments and low public investments reinforce poverty. This kind of fiscal collapse is one of the most important causes of economic development failures in the poorest countries" (2008:223). In Nepal, the private sector is reluctant to invest in infrastructure because of the long gestation period bound by the risk of political instability. In spite of this, the private sector has been eager to increase its stake in generating hydroelectricity from Nepal's considerable water resources. But the rate of investment in this sector is not encouraging. Most existing hydropower projects have been built using either foreign loans or grants. So aid has played a vital role in the development of hydropower projects. Thirty years ago, aid occupied a key role in jump starting Nepal's hydropower industry. But the terms of foreign assistance and the amounts available have changed over time. Grants are being replaced by loans and bilateral donors are more often multilateral. For this reason, it is important that we understand how the influx of aid - either grant or loan - has influenced electricity consumption in Nepal.

Relevant Studies

A number of studies have been conducted to investigate the casual relationships between energy consumption and economic growth but few studies have analyzed the effects of foreign aid in this scenario. Aqueel and Butt (2001) studied the causal relationship between energy consumption and economic growth. Using integration and Granger tests, they found unidirectional causality running from economic growth to petroleum consumption and causality running from economic growth to gas consumption. Dhungel (2013) used Vector Error Correction Models (VECM) to investigate the short and long run causality between gross domestic product and foreign aid. He found that foreign aid does not cause GDP in the long run but it caused in the short run. The opposite is true in the case of GDP. GDP cause foreign aid in the long run but not in the short run. Mozumdar and Marathe have applied VECM to explore the dynamic Granger causality. They found that per capita gross domestic product Granger causes per capita energy consumption. Dhungel (2008) has found a unidirectional relationship running from coal, oil and commercial energy to per capita real GDP and a unidirectional causality from per capita real GDP to per capita electricity consumption in Nepal. Mashih and Mashih (1996) use VECM to analyze six Asian economies to examine the temporal causality between energy consumption and income. They find that energy consumption is causing income in India, income causes energy consumption in Indonesia, and bi-directional causality exists in Pakistan. However, they use an ordinary vector autoregressive (VAR) model for the other three countries (Malaysia, Singapore and the Philippines), so the comparison among the six is not robust. Mashih and Mashih also failed to find any causality between energy consumption and income. Dhungel (2009) has investigated the causal relationship between per capita electricity consumption and GDP during the period 1980-2006 in Nepal using co-integration and the vector error correction model. He found unidirectional causality from per capita real GDP to per capita electricity consumption, but not otherwise. Zaman et al.(2012) have found that determinants of electricity consumption functions are co-integrated and influx of foreign direct investment, income and population growth is positively related to electricity consumption in Pakistan. However, the intensity of these determinants was different on electricity consumption. If there is 1% increase in income, foreign direct investment and population growth; electricity consumption increases by 0.973%; 0.056% and 1.605% respectively. Dhungel (2012) has estimated elasticity coefficient of earning from export, tourism and remittance by using Granger causality test. He found that a 1% change in remittance and export changes GDP by 0.02% and 0.09% respectively.

Variables and Data Sources

Electricity consumption (EC) in million KWh over the period 1974-2011 is the dependent variable. Foreign aid (FA) in millions of rupees (from grants and loans) over the same period of time is the explanatory variable. These data were collected from a variety of sources, including the Ministry of Finance, the Ministry of Energy, the Central Bureau of Statistics, the Nepal Rasta Bank, and other published sources.

Estimation Method

To begin, the collected data of the variables under consideration have been converted into per capita terms to capture the effect of population growth, and converted into a natural logarithm. Generally, time series data are non-stationary if used to run regression and, in some cases, may produce spurious regression which is not desirable. In other words, the regression of a non-stationary time series on another non-stationary time series may cause a spurious regression. In such cases, Durbin-Watson statistics may be less than the value of R-squared. If the R-squared value is found to be greater than Durbin-Watson statistic, we may conclude the possibility of a spurious regression. But if the residual of the model is found to be stationary, the model under consideration would no longer be considered spurious. Therefore, OLS estimation of the given non-stationary time series data is a necessary condition for the estimation of R-squared, the Durbin-Watson statistic and residuals (error term) which are used to detect spurious regression. If the model is non-spurious, then the variables in the model are co-integrated or they may be concluded to have a long run relationship or equilibrium between them. Accordingly, the estimated coefficients may be taken as long run coefficients. The model is given by:

$EC = b_o + b_1FA + U$

Where, EC = Electricity consumption in million KWh,

FA = Foreign aid in million rupees

U = Error term (residual-difference between observed and estimated values)

b_o (intercept), b_1 (slope coefficient) are parameters to be estimated and they represent long run coefficients.

Generally, time series data contains unit root, which means that these series are not stationary. The augmented Dickey Fuller (ADF) test, a generally popular method, has been applied to test the unit root. Akaike criterion has been followed to lag selection. To test the long run relationship between these variables, aJohansen co-integration test has been conducted. Finally, short and long run equilibrium has been investigated with the help of the error correction model (ECM), which is appropriate for single equation model.

Empirical findings

Graphical representation of data

Each variable under consideration are non-stationary. The first set of graphs represent the non-stationary series. The second set of graphs represents the stationary series.

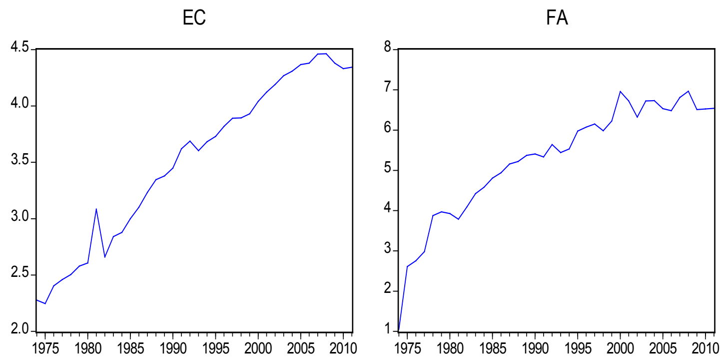

Figure 1: Graph of EC and FA at their level

Graphs of non-stationary series

A graphical view of the non-stationary series is given in Figure 1. The graph of all the three variables indicated by EC and FA are non-stationary.

Graphs of stationary series

Figure 2 is a graphical view of the stationary series. Presented graphs of all the series indicated by DEC (first difference of electricity consumption) and DFA (first difference of foreign aid) are being drawn after the corresponding data has been converted into first difference.

Spurious regression

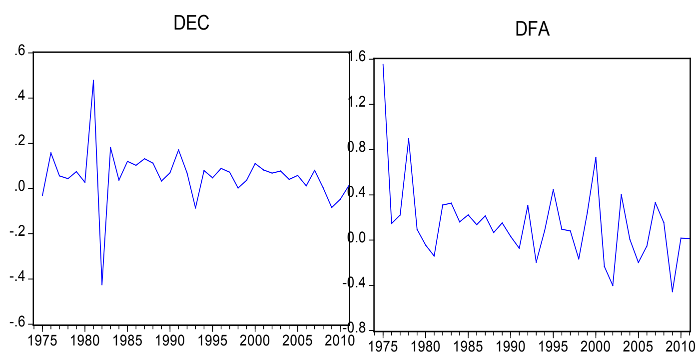

Figure 2: Each series becomes stationary at first difference

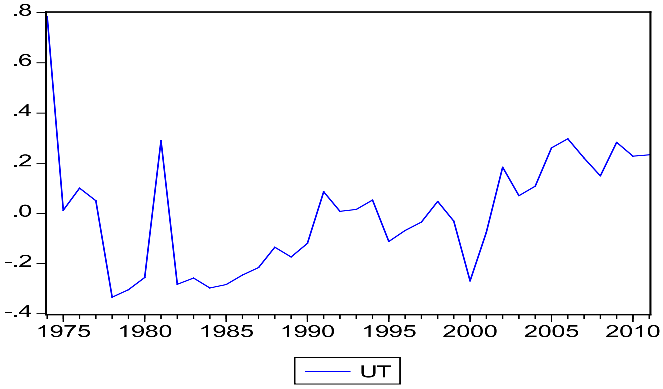

Figure 3: Stationary of residual at level

Unit root test

Observed variable

The finding of the ADF test exhibits that all the series under consideration are non-stationary in their level. However, stationarity is found after first deference. The appropriate lag order is 3, selected by using Akaike criteria. The ADF test results are given in table 1.

Variable	Level		First difference	
	Value	Prob	Value	Prob
EC	-1.3621	0.5901	-9.84636	0
FA	-2.04802	0.266	-5.5766	0

**significant at 1% level*

Table 1: ADF test (unit root test)

Residual

Results show that the R-squared value is greater than Durbin-Watson statistic, thus displaying a symptom of spurious regression (table 4). However, residual of this regression is stationary at level. It can be considered alternative criteria for accepting the model if spurious as proved by R-squared and the Durbin-Watson statistic. Table 2 shows the stationarity of residual at level as shown by ADF test.

Variable	Statistic	Probability
Residual	-4.6892	0.0005

Table 2: Residual unit root test

Co-integration test

Table 2 represents the Johansen co-integration test results. This table shows whether there is any long run co-movement between the series under consideration. Test results shows that there are two co-integrating equations indicating a long run relationship between variables (EC and FA).

Ho	H1	Statistic					
		Tracc	CV(0.05)	Prob	Max eigene value	CV(0.05)	Prob
r=0	r=1	20.56656*	15.49471	0.0079	12.46476	14.26460	0.0944
r=1	r=2	8.101803*	3.841466	0.0044	8.101803	3.841466	0.0044

(*) Indicates rejection of hypothesis at 5% level. Trace statistics indicates 2 co-integrating eqn(s) at the 0.05 level but not the Max-eigenvalue statistics.Series: EC and FA

Table 3: Results of co-integration test

OLS estimation results at level

The co-integration test suggests that a regression equation can be set up between electricity consumption and explanatory variables in levels. The OLS estimation is more important to detect the spurious regression. The results of this estimation are given in table 4.

Table 4 represents results from the ordinary least square estimation of the relationship between EC and FA. F-statistic (297.1 with probability 0) shows that overall estimation is significant at 1% level and has a strong explanatory power (R-squared is 0.89). Individual coefficients are also significant at 1% level as indicated by the t-statistic. It appears from these results that electricity consumption and foreign aid are positively correlated over the time period of 1974-2011.

Dependent variable EC				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	0.986898*	0.151686	6.506195	0
FA	0.47757*	0.027709	17.23522	0
R-squared				0.891909
Adjusted R-squared				0.970055
F-statistic		297.0529	Probability	0
Durbin-Watson stat				0.844436

(*) Significance at 1% level.

Table 4: Results of OLS parameter estimation at level

The growth elasticity of foreign aid in that time period is 0.48. It indicates that a 1% change in foreign aid and GDP will change the electricity consumption by 0.48%. The elasticity coefficient of FA is less than 1 indicating a less proportional change in electricity demand associated with the change in FA.

Another main purpose of the OLS estimation in level is to detect the spurious regression. The estimated result shows evidence for this. Durbin-Watson statistics areless than R-squared. This is the fundamental criteria for having spurious regression. But it is found that residual of this model is stationary at level (Table 2). It is the second criteria to accept the model for further analysis even at a situation in which R-squared is greater than Durbin-Watson statistics.

Error correction model (ECM)

Co-integration and non-spurious regression are the fundamental requirements of ECM. Results of co-integration test (Table 2) and OLS estimation (Table 3) at level have fulfilled these two conditions. EC and FA are co-integrated and non-spurious regression. They provide a basis to run the ECM on the proposed variables. Short and long run equilibrium between the variables EC and FA in the system have been investigated with the help of ECM as given below.

$d(EC) = b_3 d(FA) + b_4 U_{t-1} + V$

d (EC) = first difference of electricity consumption

d (FA) = first difference of foreign aid

U_{t-1} = One period lag of residual obtained from the OLS estimation at level

b_3 and b_4 are parameters to be estimated

V = Error term

Parameter b_3 irrespective of its sign but should be individually significant represent short run equilibrium between EC and FA. However, parameter b_4 represents long run equilibrium between the same variables. The sign of b_4 should be negative and significant as well for holding long run equilibrium. Table 5 represents the results of ECM.

Dependent variable d(EC)				
Variable	Coefficient	Std. Error	t-statistic	Prob.
D(FA)	0.113696*	0.053786	2.11199	0.0419
U_{t-1}	-0.33596*	0.088846	-3.78139	0.0006
R-squared				0.146277
Adjusted R-squared				0.121885
Durbin-Watson stat				2.435028

* indicate significant at 5% level.

Table 5: Results of OLS parameter estimation in first difference

The ECM is no spurious regression model as indicated by the R-squared and Durbin-Watson statistics. The coefficient b_3 is positive indicating that there is a positive relationship between d (EC) and d (FA). b_3 is significant at the 5% level. It is known as the short run equilibrium coefficient. The coefficient b_4 is the long run equilibrium coefficient, which also is known as the error correction coefficient. It is negative and significant as desired. The values of these parameters are given in Table 6 to show the short and long run equilibrium of the variables under consideration, which is the main theme of this investigation.

Equilibrium	d(FA)	U_{t-1}
	b_3	B_4
Short run	0.114	
Long run	-0.336	

Table 6: short and long run equilibrium

The Short run equilibrium

The value of b_3 is 0.114 (Table 6) and it is individually significant at 5% level (Table 5). This coefficient represents the short run coefficient and the short run equilibrium. It tells about the rate at which the previous period disequilibrium of the system is being corrected. The value of b_3 is 0.114, which indicates that the system corrects its previous period disequilibrium at a speed of 11.4% between variables EC and FA.

The Long run equilibrium

U_{t-1} is a one period lag error correction term or residual. It guides the variables (EC and FA) of the system back to equilibrium or corrects disequilibrium. For this relationship to be present, the sign of this should be negative and significant. Parameter b_4 represents its coefficient. b_4 describes the rate at which it corrects the previous period disequilibrium of the system, if it is negative and significant. The coefficient of b4 is negative (-0.336, table 6) and significant at 1% level (Table 5) meaning that system corrects its previous period disequilibrium at a speed of 33.6% annually.

Conclusion

A strong relationship exists between electricity consumption and foreign aid over the period of 1974-2011. The regression model is not spurious as tested. The time series data of these variables contain unit roots and they become stationary after conducting the ADF test. The variables have a long run relationship as indicated by the Johansen co-integration test. The statistically significant elasticity coefficient of the OLS estimation at level indicates that a 1% change in foreign aid will change the electricity consumption by 0.48%. The results of ECM indicate that there is both short and long run equilibrium in the system. The coefficient of one period lag residual coefficient is negative and significant which represent the long run equilibrium. The coefficient is -0.336 meaning that system corrects its previous period disequilibrium at a speed of 33.6% annually.

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10-11 September, 2014: Irrigation Efficiency Course. Location: Challenger Institute of Technology Murdoch, WA. Email: tracy.martin@irrigation.org.au URL: http://irrigationaustralia.com.au/

15-18 September, 2014: Irrigation Hydraulics Workshop. Location: Bunbury, WA. Email: tracy.martin@irrigation.org.au URL: URL: http://irrigationaustralia.com.au/

16-17 September, 2014: Irrigation Efficiency Course. Location: UWS Hawkesbury Campus, NSW. Email: tracy.martin@irrigation.org.au URL: http://irrigationaustralia.com.au/

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31 August - 05 September, 2014: World Water Week 2014. Location: Stockholm, Sweden. URL: http://www.unesco-ihe.org/world-water-week-2014

08-12 September, 2014: UNESCO-IHE co-organizes IMETE Summer school 'Resource Recovery form Wastewater'. Location: Coupure Links 653, 9000 Ghent, Belgium.

URL: http://www.unesco-ihe.org/imete-summerschool-resource-recovery-wastewater

29 September - 03 October, 2014: PhD week, Theme; 'Urban Sustainability'. Location: Westvest 7, Delft, the Netherlands. URL: http://www.unesco-ihe.org/phd-week-2014

02 October, 2014: Soil Plant Water Relationships/ Understanding Plant Water Use Location: Challenger institute of Technology, Murdoch, WA. Email: tracy.martin@irrigation.org.au URL: http://irrigationaustralia.com.au/

03 October, 2014: Water Budgeting. Location: Challenger institute of Technology, Murdoch, WA. Email: tracy.martin@irrigation.org.au URL: http://irrigationaustralia.com.au/

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