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Causality Linkages among Energy Poverty, Income Inequality, Income Poverty and Growth: A System Dynamic Modelling Approach

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1. INTRODUCTION

The energy services stipulation of a country discloses its importance as a decency of course of action necessary for economic prosperity, lessening the poverty and depolarising the social asymmetry [Barnes, *et al*. (2011)]. The accomplishment of basic needs of energy services that include excess to electricity, commercial use of energy for production process as well as usage of electricity in the residential areas and modern use of energy sources for cooking purposes portraits an image of high-quality living standard of individuals and offers a way forward to economic development.[1] The notion of pro-poor growth is well documented in the recent literature for assurance of thinning the poverty that is congregated through translation of growth into the lives of poor by reshaping the income distribution[2] for marginalised group of people. Ekouevi and Tuntivate (2012) and studies of international agencies [AGECC (2010); WHO (2006); UNDP and WHO (2009)] have preliminary acknowledged the need of improving the access to reliable and affordable modern energy services in the developing economies for economic prosperity and social welfare of individuals.

As for as social inequality is concern, energy poverty is of enormous worth to address it as deficiency in supplying commercial energy especially electricity, tends to emphasise the social asymmetry in the society [Pereira (2010)]. While the energy

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[1]International Energy Agency report (2010) declares that 1.3 billion people living without excess to electricity and about 2.6 million people who are not provided clean cooking facilities globally. This indicates a serious impediment to social and economic development and must be addressed uncompromisingly for the achievement of UN Millennium Development Goals [Dagoumas and Kitsios (2014)].

[2]According to Scheikman (2002), the prudent government policies formulated with the aim of reducing poverty and income inequality account education and health substances a lot and these issues cannot be accomplished without required energy services.

development mitigates the poverty as it provides the sustainability and enhances the opportunities for growth that leads to better quality of life [Pereira (2010)]. The significance of energy services in the mechanism of structural transformation for development and trading off the old modes of living for new ones has made the concept of energy poverty a leading concern now a days. In the developing countries like Pakistan, energy services supplies are not met perfectly that create social injustice by depriving people form clear cooking facility that badly effect their health conditions; as well as from education as new modes of training and guidance demand electricity essentially. Comfort and ease of life purely rely on the use of modern home appliance and on vehicles which run from electricity and fuel accordingly. Thus unswervingly availability of energy components (i.e., oil, gas, electricity and coal) at affordable prices diminishes social asymmetry; eliminates poverty; boosts up economic performance and ultimately up lifts the living standard of people.

The above deliberation urges to find out the causality linkages among energy poverty, income inequality, income poverty and growth for Pakistan. Moreover, secondly, study intends to examine the energy services conditions through construction of an Energy development index (EDI) that measures the energy poverty in Pakistan at macro level. Thirdly, study creates distinction on methodological grounds from rest of the studies. Study follows multivariate TY- procedure for the estimation of VAR system through seemingly unrelated regression (SUR) using modified Wald test for the causality analysis.

After a brief introduction in the first section, trends and size of energy services in Pakistan and its comparison with the rest of the economies and regions is drafted under Section 2. Section 3 is about the energy development index (EDI) and its construction. Review of Literature is presented in Section 4. Data and methodology is provided in Section 5 while the empirical results and discussion are presented in Section 6. At the end, Section 7 is consisting on conclusions and policy recommendations.

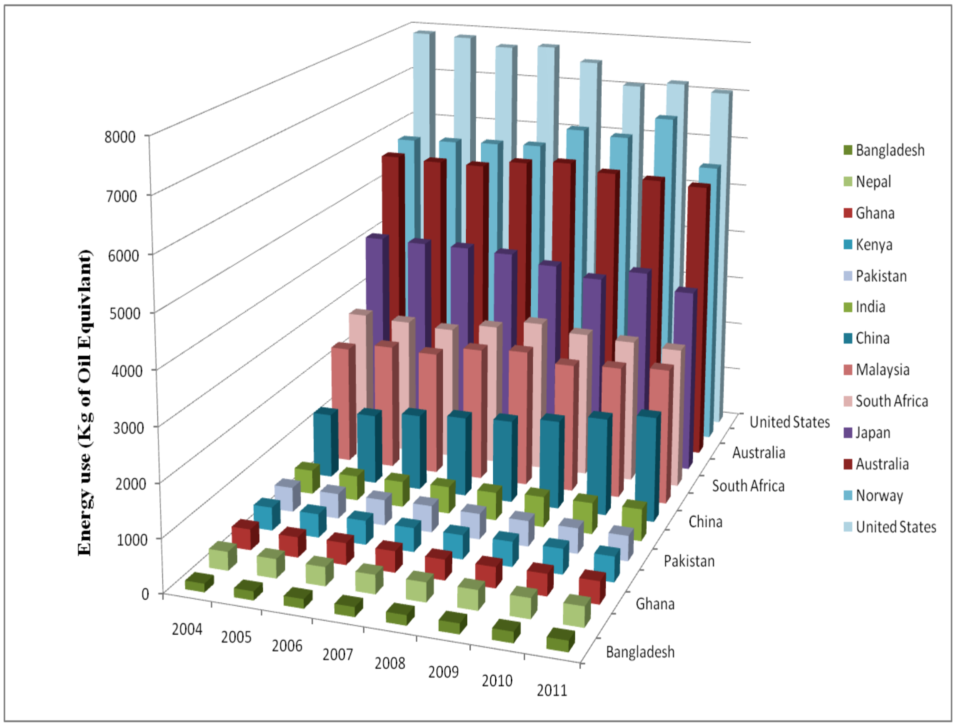
2. ENERGY POVERTY SCENARIO IN PAKISTAN

Per capita commercial energy consumption is thought-out well gauge for energy development which gears up economic growth and eliminates poverty. The present per capita energy use for Pakistan is near to the ground. The per capita energy use is 481.61 Kg tons of oil equivalent (Kg of Toe) for Pakistan while the average per capita energy use of South Asia is 555 kg Toe; OECD members countries has a average of 4176 kg Toe; Sub-Saharan Africa region has 681 Kg Toe; and, World average per capita energy consumption is 1890 kg Toe, the estimates of [WDI (2011)] reveal. This picture depicts the situation of energy poverty in Pakistan regarding use of energy as within the region, Pakistan energy consumption is about 15 percent below than average energy consumption of South Asia; 21 percent less than that of India; and, even less than Sri Lanka equals to 5 percent nearly. With respect to world energy consumption, Pakistan uses 75 percent less energy and in comparison to OECD countries its value is 88 percent. The Figure 2.1 demonstrates the situation of energy use for Pakistan as compared to different countries of the world.

People access to electricity is considered first-rated indicator for excess to modern energy services. The world development indicators show 1.2 percent increase, from 67.4

percent to 68.6 percent, in population accessed with the electricity in Pakistan for the year 2010 to 2011. Figure 2.2 displays an inclusive comparison of Pakistan with different regions and countries to make energy poverty incidence clear for Pakistan. Within the region of South Asia, Pakistan is providing electricity less than India, Sri Lanka and Nepal. In contrast to Malaysia and Unites Arab Emiratis who are providing electricity to whole population almost, Pakistan has succeeded just 68.6 percent in providing electricity to its population. Similarly, Pakistan is also 18 percent below than middle income countries and almost 10 percent below than the world average in percentage of providing excess to electricity.

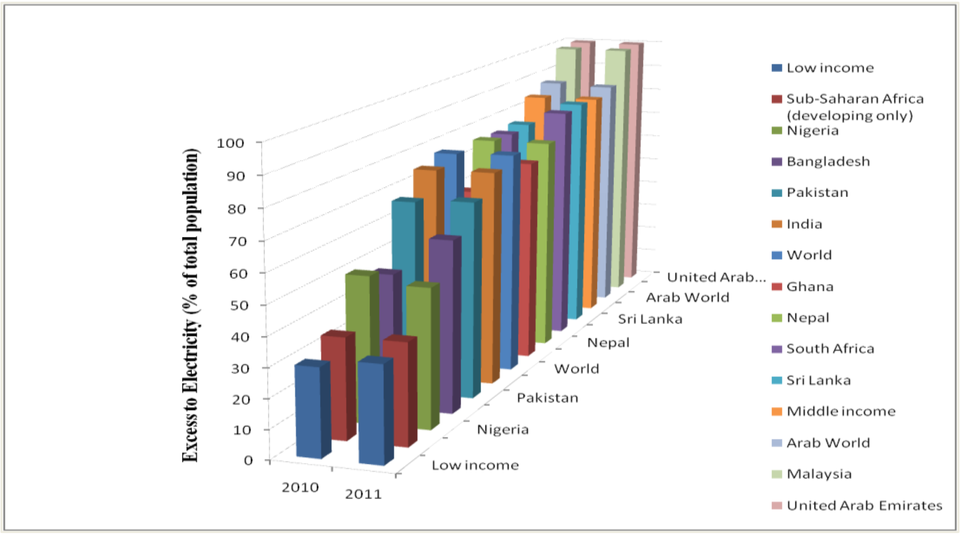
Fig. 2.1. Per Capita Energy Use in Pakistan Compared to World



Authors' assemblage. Source: WDI (World Bank Data CD-Rom).

Figure 2.3 presents substantial dependence of developing countries on biomass for cooking purposes. The statistics of World Energy Outlook, 2012 (IEA) and WHO database (2010) indicate that 2588 million people (38 percent of world population); over 1.8 billion people (equals to half of developing Asia population); and, about 700 million people (80 percent of the sub-Saharan Africa), who are using traditional biomass sources for cooking purposes and deprived from clean cooking facilities. 64 percent of population (111 million people) of Pakistan is using traditional biomass for cooking purposes. While in China, India, Indonesia, Philippines, Vietnam and rest of developing Asia, 29 percent, 66 percent, 55 percent, 50 percent, 56 percent and 54 percent of population is not availing clean cooking facilities respectively.

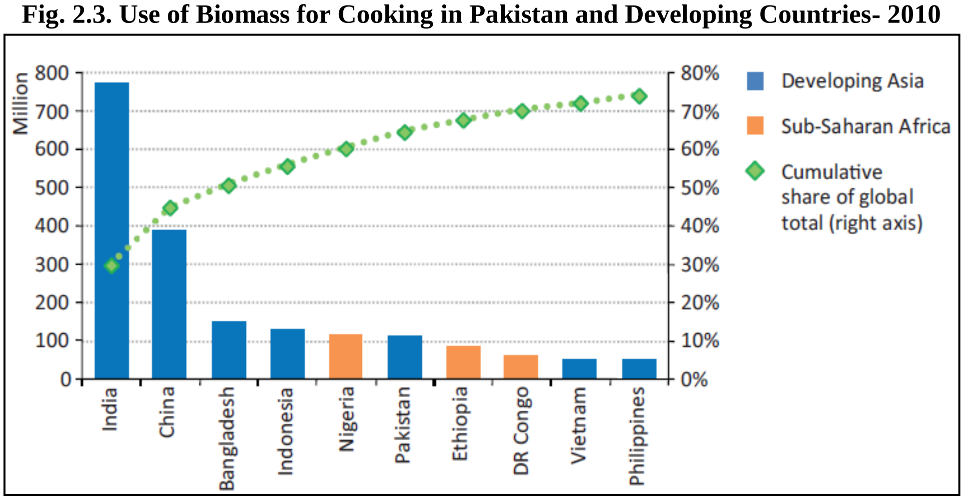
Fig. 2.2. Excess to Electricity in Pakistan Compared to World



Authors' assemblage. Source: WDI (World Bank Data CD-Rom).

Comparative exploration of modern fuel sources available for cooking purposes show the incidence of energy poverty in Pakistan. Biomass dependence, in Pakistan, is almost double than that of china and world average, almost equal to India and Africa region, 10 percent more than Vietnam and developing Asia average, 60 percent more than Middle East, 15 percent more than Philippines and developing countries. So, large dependence on biomass consumption for cooking purposes designates Pakistan a poor country who is failing in providing health and safe cooking facilities. Yet, Pakistan has shown an improvement in that indicator of energy poverty as in the list of developing Asian countries Pakistan is keeping pace with China, Thailand and Vietnam where a notable improvement in lessening biomass dependence is observed.

Fig. 2.3. Use of Biomass for Cooking in Pakistan and Developing Countries- 2010



Source: World Energy Outlook 2012, IEA and WHO database (2010).

3. LITERATURE REVIEW

The leading intention of the paper is to present a comprehensive review of prior work to confer a deep insight about the issue of energy poverty and its integrating factors. The empirical studies on the issue of energy poverty for the developing countries are not in surfeit. However, study makes a healthy endeavour to present literature on prior work done until now in the following.

The significance of the role of energy especially electricity as a mean of economic development is dated back at least to 1950s. Supply of electricity causes to stimulate human productivity and welfare that ultimately improve economic status of population. It is considered that poverty elimination, efficiency of productivity, pollution reduction, and health improvement is the fruit comes from provision of modern energy [United Nations (1954)].

After gaining the importance from a number of overseas development agencies [World Bank (1985); WIN (2005); UNDP (2007, 2012); ADB (2010a, b)], the energy related issues have, now, become the central focus for economic development and social wellbeing of individuals. The UN General Assembly has announced the years 2014-2024, to be "the decade of sustainable energy for all" [United Nations (2014)].

Recent literature and UNDP reports have re-conceptualised the poverty across-the-board that withdraw it from traditional perception in which poor were jammed with the notion of earning less than 2 dollar a day [Sovacool (2012)]. A number of factors have, now, encompassed in the definition of poverty that include life expectancy, literacy, caloric intake, housing quality and excess to energy [UNDP (2010)]. This inaugurated the intuition of non-income dimensions of poverty such as lack of excess to electricity and reliance on the traditional biomass fuel for cooking [Joneset, *et al*. (2010); International Energy Agency (2010)].

The health impacts of biomass combustion form cooking are observed in a number of studies. The pragmatic studies of [Pokhreletal (2005, 2013); Shrestha and Shrestha (2005); WIN (2005); Joshi, *et al*. (2009); Dhimal, *et al*. (2010); Mallaetal (2011)] come to a conclusion that emissions from burning of biomass are harmful for individuals health significantly, especially, for women and children health which reduce life expectancy, productivity and efficiency. Besides this, searching for biomass fuel is a time taking activity that restricts women and children from any other productive activity [Saghir (2005); Barnes and Toman (2006)].

Causality linkages of income inequality and energy poverty are well examined in the studies of [Hussain (2011); Sovacool (2012); Larson and Kartha (2000); Masud, *et al*. (2007)]. Studies narrated that income poor pay eight times more than the other group of income for the same unit of energy they use. It is estimated that on average 20-30 percent income is spent on the energy services by the poor households directly while additional 20-40 percent income is paid out indirectly in term of time and health injury related with collection and use of raw energy material respectively. On the other hand, in contrast, making use of modern energy services in running heavy machinery, illumination of shops and factories, refrigeration of products for preservation and development of the mechanisation process has lifted up employment opportunity and provided incentive to poor by decreasing inequality and increasing their income level.

Savacool (2012) pointed out a significant relationship between energy poverty and economic wellbeing of people in the developing countries. Income poverty and energy deprivation move together, where a significant proportion of income is allocated for availing energy services. For an instance, in case of Nepal, the introduction of renewable energy technologies is the centre focus of government policies that has activated the balanced growth and helping out to eradicate poverty [Malla (2013)]. The studies of [Roddis (2000); Cabraal and Barnes (2006); World Bank (2002)] also drawn the same conclusion of bi-directional causality between energy development and poverty.

Above narratives make us available a termination that energy services must be the essential meeting point of any economic agenda and planning for social development. This leads us to put up an augmented system that will connect poverty, growth and inequality with the new no-income dimensions of poverty that is— energy poverty. A plausible causality linkage among these variables may leave new foresights for economic planners.

4. THE ENERGY DEVELOPMENT INDEX (EDI)

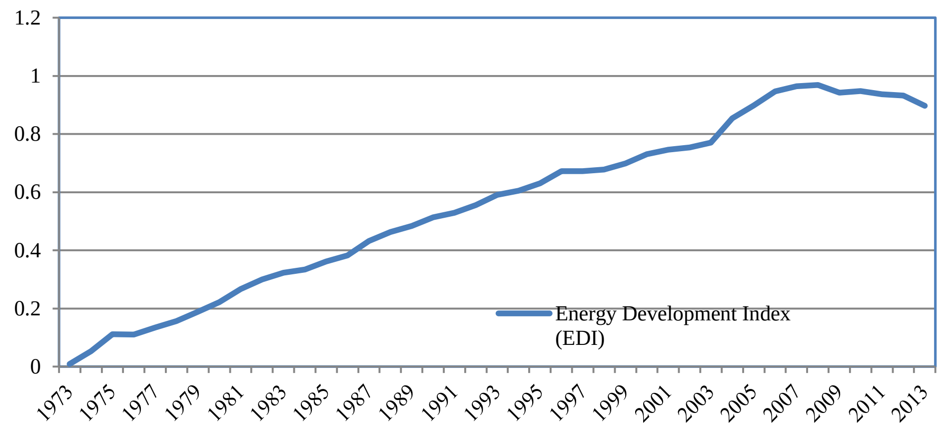
Ecological scientists and social welfare organiser always put forth the need of understanding energy poverty to mitigate it [Pachauri and Spreng (2011)]. It requires apparatus and structure in which it could be measured, monitored, recorded and reported. A number of scientists, over last 20 years, are involved in the energy and development issues to understand the concept of energy poverty [Bravo, *et al*. (1979); Bazilian, *et al*. (2010); Saghir (2004); Krugmann and Goldemberg (1983); Pachauri and Spreng (2004); Goldemberg (1990); Pachauri and Spreng (2011); Foster, *et al*. (2000)]. The present study construct Energy Development Index (EDI) to measure[3] the energy poverty at national level for Pakistan following the definition and computation methods of [IEA (2004); Malla (2013)]. The EDI is a composite index consists of four indicators or components that are equally weighted but this study assigned the weight to each indictor on the basis of principal component analysis (PCA). The Table 4.1 briefly describes the definitions, proxies and measuring units of indicators of energy poverty for Pakistan. Each indicator is normalised first by using the following formula;

$$\text{Indicator} = \frac{\text{Actual value} - \text{Minimun value}}{\text{Maximun value} - \text{Minimum value}}$$

The principal component analysis (PCA) is utilised on all normalised indicators of energy services to find weights for computing the energy development index (EDI). The outcomes of PCA show that (PC 1) explain 97 percent of the standardised variance, the Eigen values of (PC 1) reveal. While (PC 2), (PC 3) and (PC 4) explain standardised variance equals to 0.018 percent, 0.006 percent, 0.0006 percent respectively. So the first component (PC1) is best for assigning the weights to normalised indicators. The individual share of each indicator to EDI is given as under;

[3]Still there is no consensus on the issue of measuring energy poverty [Nussbaumer, *et al*. (2012)]. Different studies on measuring the Energy poverty based on; different approaches; definitions; data availability are being cited as under for reference and not discussed in detail as this is beyond the scope of this paper. [Bazilian, *et al*. (2010); Foster, *et al*. (2000); Mirza and Szirmai (2010); Barnes, *et al*. (2010); Practical Action (2010); Awan, *et al*. (2013); Pachauri, *et al*. (2004); IEA (2004); World Energy Outlook (2010); United Nations Development Program (2010); Jones (2010); Holdren and Smith (2000); Khandker, *et al*. (2012); Sovacool, *et al*. (2012)].

Fig. 4.1. Trends in Energy Development Index (EDI) for 1973-2013



Energy Development Index (EDI) = 0.25(Per capita energy consumption) + 0.244(Excess to electricity) + 0.25(Per capita electricity in residential sector)+ 0.255(Share of modern energy fuel in total residential energy use).

The results of ordinary correlates (provided in Appendix-I) call for a composite index. The outcomes of the Energy Development Index (EDI) are graphed for each year as shown in Figure 4.1. The trend of EDI indicates the development of energy services over the time .Yet this growth in not in line with the growth rates of other developing countries. It is observed that from 2007 to onward a decrease in the trend points out the incidence of energy crisis. The shortage of energy supply, especially of electricity has increased the magnitude of energy poverty in Pakistan.

Table 4.1

Indicators for Energy Development Index (EDI)

Indicator	Definition	Proxy	Units of Measurement
Per Capita Commercial Energy Consumption	It is the amount of energy per capita used in the production process indicates the overall economic development of the country.	Commercial Energy Consumption Per Capita	Tonnes of oil equivalent (Toe)
Excess to Electricity	People from total population availing the facility of electricity which is an indicator for social asymmetry, reliance and ease of life.	Rate of Electrification	Percentage
Per Capita Electricity in Residential Sector	It is per capita consumption of electricity in the residential sector that express the ability of the consumer for the payment of electricity services and basic reliability.	Per Capita Electricity Consumption in Residential Sector	Tonnes of oil equivalent (Toe)
Share of Modern Energy Fuel in Total Residential Energy Use	The excess of modern energy services for cooking purposes out of total energy services provided to household instead of traditional biomass burning for cooking. It includes the use of oil, gas and electricity.	Share of Fossil Fuel Energy Consumption in Total Consumption	Percentage

5. DATA AND METHODOLOGY

The study intends to find out the causality linkages among energy poverty, economic growth, income inequality and income poverty in case of Pakistan. A number of studies have presented a system that provides the scheme in which the poverty, growth and inequality are well studied. The present study augments this system by incorporating the new dimension of poverty that is— energy poverty. Thus, the study estimates the dynamic Granger non-causality relationship between poverty, growth, income inequality and energy poverty by employing multivariate Tota and Yomamto (1995),TY-modeling.

5.1. Data

The study uses annually time series data for Pakistan ranges from 1973 to 2012. The data are sourced from Economic Survey of Pakistan (various issues), the World Development Indicators database CR-ROM, Jamal (2006) and Pakistan labour force survey (various issues), depending upon the availability of data while some absent values of data are interpolated by using software, Eviews 7.0 package.

The study uses four variables for the analysis. GDP Per Capita (GDPPC) is the income per individual measured in Pak rupees, Income Inequality (INEQ) indicates the distribution of income among different income groups of people of country proxies by Gini-coefficient (in percentage), Income Poverty (POV) is measured with head count ratio (percentage) while the energy poverty (EDI) is expressed with the help of energy development index (EDI)[4] measured in percentage. All the variables are expressed in percentage after taking the natural log of GDPPC.

5.2. Time Series Properties of Data

Before proceeding to multivariate TY-procedure, it requires the time series properties of data to be scrutinised for obtaining the maximum order of integration of series. The study uses augmented Dickey- Fuller (1979), ADF test as well as Phillips Perron (1988), PP test for robustness of unit root results.
The ADF test works in the following specification where optimal lag length is selected on the basis of Schwars information criteria (SIC);

$$\Delta s_{i,t} = c + \rho v_{i,t-1} + \sum_{j=1}^{k-1} \Gamma_i s_{i,t-j} + \beta T + \varepsilon_{i,t} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where $S_{i,t}$ indicates the respective time series variables i.e., GDPPC, POV, INEQ, EDI. T specifies time trend, Δ shows first difference operator and $\dot{\varepsilon}_{i,t}$ is the white noise error. The Equation (1) tests the Null hypothesis ($\rho = 0$) for the existence of a unit root process in the series against the alternative hypothesis of ($\rho \neq 0$) mean-stationary.

For an exogenous shock to a time series that already has a deterministic trend (T), the under-rejection of the hypothesis is inevitable that may not supply robust results [Philip and Perron (1988)]. So, permitting for dependence and heterogeneity in the error term, following specification presents the non-parametric adjustment to ADF test statistic;

[4]EDI is measured with the help of a composite index consists of four variables. Definitions, measuring units and proxies of all four variables (indicators) are provided in Table 4.1 under Section 4 in detail.

$$s_{i,t} = c + \beta\left\{t - \frac{c}{2}\right\} + \rho s_{i,t-1} + \varepsilon_{i,t} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Where, $S_{i,t}$ is the corresponding time series (i.e., GDPPC, POV, INEQ, EDI), $\{t - \frac{c}{2}\}$ is the time trend, c stands for sample size and $\dot{\varepsilon}_{i,t}$ is white noise error.

5.3. Econometrics Methodology

Existing Literature presents a variety of methodologies available for causality inferences depending on the characteristics of time series data. Granger non-causality, Johnson and Juselius (1990) ECM causality, ARDL modeling causality suggested by Pesaran and Shin (1998), TY- multivariate model causality and DP nonparametric causality proposed by Diks and Panchenko (2006) are considered the standard causality tests available.

This paper follows Toda and Yomamota (1995) to employ TY-multivariate modeling because of a number of advantages over other methodologies. Unlike Johnson ECM causality which necessitates same order of integration of all time series, TY-Procedure is feasible even when the order of integration of time series is mixed. Thus TY-Procedure is free from pre-testing of co-integration of the series. Likewise, in ECM Granger causality, use of standard Wald F-Stat for coefficient restrictions on parameter after estimating VAR system from OLS, confers non- standard asymptotic distribution of Wald F-stat that may involve nuisance parameters if one or more series contain a unit root [Toda and Phillips (1993); Sims(1990)]. So, TY- modeling is preeminent procedure for causality inferences as it does not demand any co-integration test and presents an *augmented* VAR system narrated as VAR (k+ d^{max}) through which restrictions are implemented with the help of modified Wald Test (MWALD) on VAR(k) after estimating *augmented* VAR system from Seemingly unrelated Regression (SUR) at level. Here, k is the number of lags and d^{max} represents the maximum order of integration among all the time series. Kuzozumi and Yamamoto (2000) asserted that the model will be valid until the condition; $k > d^{max}$ holds.

We examine the dynamic causality among energy poverty, growth, inequality and income poverty by applying the TY- procedure, speified as follows;

$$S_t = \varphi_s + \varphi_1 S_{t-1} + \varphi_2 S_{t-2} + \varphi_3 S_{t-3} + \cdots \ldots \ldots \ldots \ldots \ldots + \varphi_n S_{t-n} + \omega_{\tau,t} \ \ldots \quad (3)$$

Specifying this generalised version of TY-procedure for our concerned variables (i.e.,EDI, INEQ, GDPPC and POV), we obtain the following *augmented* VAR system of equations;

$$EDI_t = \alpha_1 + \sum_{i=1}^{k} \zeta_{1i} EDI_t + \sum_{j=k+1}^{d\max} \zeta_{2i} EDI_{t-j} + \sum_{i=1}^{k} \varphi_{1i} INEQ_t + \sum_{j=k+1}^{d\max} \varphi_{2i} INEQ_{t-j} + \sum_{i=1}^{k} \gamma_{1i} POV_t + \sum_{j=k+1}^{d\max} \gamma_{2i} POV_{t-j} + \sum_{i=1}^{k} \psi_{1i} GDPPC_t + \sum_{j=k+1}^{d\max} \psi_{2i} GDPPC_{t-j} + \omega_{1,t} \ \ldots\ldots\ldots\ldots\ldots\ (4)$$

$$INEQ_t = \alpha_1 + \sum_{i=1}^{k} \gamma_{1i} INEQ_t + \sum_{j=k+1}^{d\max} \gamma_{2i} INEQ_{t-j} + \sum_{i=1}^{k} \varphi_{1i} EDI_t + \sum_{j=k+1}^{d\max} \varphi_{2i} EDI_{t-j} + \sum_{i=1}^{k} \psi_{1i} POV_t + \sum_{j=k+1}^{d\max} \psi_{2i} POV_{t-j} + \sum_{i=1}^{k} \zeta_{1i} GDPPC_t + \sum_{j=k+1}^{d\max} \zeta_{2i} GDPPC_{t-j} + \omega_{2,t} \ \ldots\ldots\ldots\ldots\ldots\ (5)$$

$$GDPPC_t = \alpha_1 + \sum_{i=1}^{k} \psi_{1i} GDPPC_t + \sum_{j=k+1}^{d\max} \psi_{2i} GDPPC_{t-j} + \sum_{i=1}^{k} \varphi_{1i} EDI_t + \sum_{j=k+1}^{d\max} \varphi_{2i} EDI_{t-j} + \sum_{i=1}^{k} \gamma_{1i} INEQ_t + \sum_{j=k+1}^{d\max} \gamma_{2i} INEQ_{t-j} + \sum_{i=1}^{k} \zeta_{1i} POV_t + \sum_{j=k+1}^{d\max} \zeta_{2i} POV_{t-j} + \omega_{3,t} \quad \text{..............} \quad (6)$$

$$POV_t = \alpha_1 + \sum_{i=1}^{k} \psi_{1i} POV_t + \sum_{j=k+1}^{d\max} \psi_{2i} POV_{t-j} + \sum_{i=1}^{k} \varphi_{1i} EDI_t + \sum_{j=k+1}^{d\max} \varphi_{2i} EDI_{t-j} + \sum_{i=1}^{k} \gamma_{1i} INEQ_t + \sum_{j=k+1}^{d\max} \gamma_{2i} INEQ_{t-j} + \sum_{i=1}^{k} \zeta_{1i} GDPPC_t + \sum_{j=k+1}^{d\max} \zeta_{2i} GDPPC_{t-j} + \omega_{4,t} \quad \text{..............} \quad (7)$$

After the *augmented* VAR system is constructed, it is estimated from seemingly unrelated regression(SUR).Standard MWALD is used for the parameter restrictions on VAR(k) from VAR($k+d^{max}$)to get the value of chi-square statistic that is asymptotically normally distributed [Zapata and Rambaldi (1997)].

To demonstrate how MWALD works, we consider equation (4) where we can test the hypothesis that income inequality (INEQ) does not Granger cause energy poverty (EDI) if $\varphi_{1i} = 0 \forall_i$; likewise, income poverty (POV) does not Granger cause energy poverty (EPI) if $\gamma_i = 0 \forall_i$; similarly, growth (GDPPC) does not granger cause energy poverty (EDI) if $\psi_i = 0 \forall_i$. The same mechanism is extended for the Equations (5), (6) and (7).

5.5. The Innovation Accounting System

This system demonstrates how a variable retorts from a shock that comes across in other variables within the system and whether this shock dies or continues over the time. Following Pesaran and Shin (1948) and Koop, *et al*. (1996), we have employed generalised impulse response function (GIRF) to gauge the comparative potency of causality in an out-of-sample period as the TY-procedure tests only the long run causality within the sample period. The generalised impulse response function (GIRF) has advantages of other standard impulse response functions [Ewing and Payne (2005)].

6. RESULTS AND DISCUSSIONS

The empirical evidences of Granger non-causality among poverty, growth, inequality and energy poverty call for a dynamic system as designed in TY-modeling. This representation persists an *augmented* VAR ($k+d^{max}$) system. For this sake, to find the values of k and d^{max} for estimating *augmented* VAR ($k+d^{max}$), unit root properties and lag length selection of variables are thin slices of this segment.

6.1. Stationarity of Data and Lag Length Selection

For any time series analysis, the identification of the unit root in the time series is important. Study used ADF and PP tests for scrutinising the order of integration of series. Results are reported in Table 6.1. Maximum order of integration of concerned variables is (d^{max}=1) which fulfill the requirement of TY-Procedure for Granger non-causality inference.

Table 6.1

Stationarity of Data

	At Level				With First Difference					
	Intercept		Trend and Intercept		Intercept		Trend and Intercept		Max.*	Order of
Variable	ADF	PP	ADF	PP	ADF	PP	ADF	PP	Lag Length	Integration
RGDPC	0.33	1.65	–4.21	–4.42*	–10.5*	–10.92*	–	–	9	I(0)
EDI	–2.69	–2.69	0.31	0.02	–4.23*	–4.24*	–	–	9	I(1)
POV	–0.70	–1.28	–2.35	–1.57	–1.73	–4.12*	–0.40	–4.1*	9	I(1)
INEQ	–2.63***	–2.92**	–2.85	–3.3**	–	–	–	–	9	I(0)

Source: Authors' calculations, * max lag length for ADF test is 9 where optimal lag length is chosen on the basis Schwarz info criterion. For PP test, Bandwidth is opted on the basis of Newey-West using Bartlett kernel. Critical values for different level of significance are cited from MacKinnon (1996). *,**, *** represents 1 percent, 5 percent and 10 percent level of significance respectively.

Next is to find out the maximum lag length (*k*) of the time series variables for the estimation of *augmented* VAR ($k+d^{max}$). Different criterions are available for lag length selection consisting on Akaike information criteria, Likelihood Ratio, Hannan-Quinn, Final prediction error and Schwarz information criterion (SIC). Taking small sample size into account, we supply [1 3] interval for unrestricted VAR output and same for finding maximum lag length (*k*). Results are reported in Table 6.2 which shows that consistent maximum lag length is (*k*=2).

Table 6.2

VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	–362.7281	NA	4777.565	19.82314	19.99730	19.88454
1	–136.2288	391.7825	0.055020	8.444803	9.315569*	8.751788
2	–112.3280	36.17433*	0.037106*	8.017727	9.585107	8.570302*
3	–95.76586	21.48596	0.039199	7.987344*	10.25134	8.785507

Source: Authors calculations.

For dynamic Granger non-causality inferences, we have estimated the *augmented* VAR ($k+d^{max}$) that is—VAR(3) in level. The stability condition of VAR(3) as well Diagnostic tests for each separate equation of VAR system are performed.

Table 6.3

Diagnostic Test Results of VAR(3)

Diagnatic Tests	Test Statistics	*p*-values
Autocorrelation LM	261.90	.158
Residual Noramlity (J–B test)	13.35	.101
White Heteroskedasticity Test	22.98	.114
VAR Stability	-No root lies outside the unit circle-	

Source: Authors calculations.

Now, the diagnostic tests are carried out reported in Table 6.3 for the estimated VAR of order 3. Results indicate that the VAR system is free from any biasness of regression results. The test of stability of VAR(3) shows that roots does not lie outside the unit root circle as confirmed in Figure 6.1. In the same way, we have also applied the diagnostic tests on each endogenous equation of VAR system before proceeding to Granger non-Causality tests. Results are presented in Table 6.4 which indicates that each equation passes the diagnostic tests.

Table 6.4

Diagnostic Tests of Estimated Endogenous Equations

Equations	Autocorrelation-LM	Residual Normality (J–B)	White Heteroskedasticity(ARCH)	CUSUM Test
EDI	.301	13.97	0.244	Within limits
	(.824)	(.497)	(0.62)	
INEQ	1.089	13.54	2.733	Within limits
	(.375)	(.0331)	(.107)	
GDPPC	1.051	.382	.853	Within limits
	(.390)	(.825)	(.361)	
POV	3.026	9.431	7.131	Within limits
	(0.042)	(.097)	(.0329)	

Source: Authors calculations.

6.2. Granger Causality Results

The results of Granger non-causality are reported in Table 6.5. Results provide interesting causality relationship between energy poverty, growth and income poverty and income inequality for Pakistan and exemplify worthy integration of variables within the dynamic system to locate the net collision. We are noteworthy interested in the direction of causality among economic growth, energy poverty and income poverty besides a number of other results. The results show bi-directional long run causality between economic growth and energy poverty; running from energy poverty to economic growth and vis verse. It explores the fact that excess to modern energy services are highly significant for the economic prosperity of Pakistan as energy is considered the main driver of any economic activity that wheel up the production process many fold. Similar results are observed for industrialised, less developed as well as for developing countries like Nigeria, India, Pakistan and Bangladesh [(Paul and Bhattacharya (2004); [Worrell, *et al*. (2001); Mozumder and Marathe (2007); Ojinnaka (1998); Shahbaz and Feridun (2011); Javid, *et al.* (2013); Faridi and Murtaza (2013)].

Table 6.5

Results of Dynamic Granger non-Causality

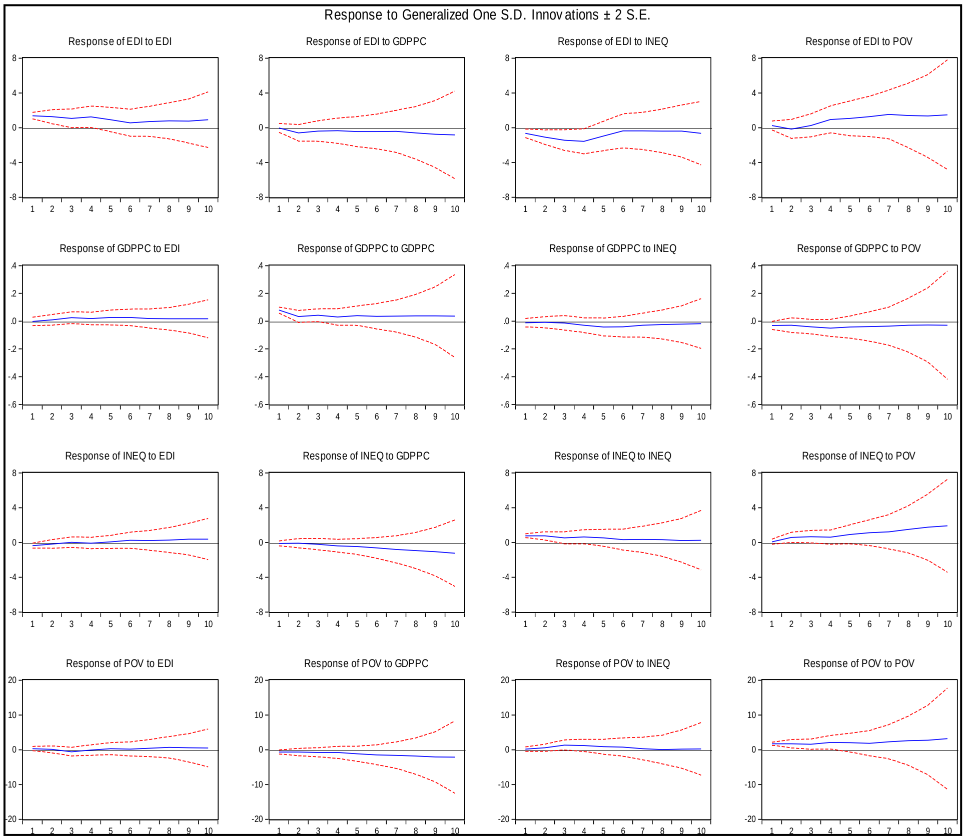
Dependant Variables	MWALD Test				Causality Inferences
	Economic Growth	Income Poverty	Energy Poverty	Income Polarisation	
Economic Growth	1	5.841** (0.053)	16.482* (0.0003)	1.948 (0.377)	Economic Growth← Income Poverty; Economic Growth ← Energy Poverty
Income Poverty	0.521 (0.770)	1	3.972 (0.121)	2.853 (.248)	–
Energy Poverty	17.140* (0.0002)	10.160* (0.006)	1	7.719* (0.021)	Energy Poverty← Economic Growth; Energy Poverty← Income Poverty; Energy Poverty← Income Polarisation
Income Polarisation	3.741 (0.154)	13.850* (0.001)	1.666 (0.4346)	1	Income Polarisation← Income Poverty

Source: Authors calculations. *, ** represent significance level of 1 percent and 5 percent respectively.

On the other hand, results reveal that economic well being may ultimately leads to greater resources to be had to meet the energy demand challenges and to endow the easiness of life regarding clean cooking facilities and making more use of modern home appliances. Likewise, uni-directional causality among energy poverty, income poverty and income inequality; running from income poverty and income inequality to energy poverty is observed. This indicates that low income households, in Pakistan, are not able to afford fully the modern energy services as essentially they have to devote a large share of their income for energy services payments as their there exist high income inequality. The causality linkages also explain that growth is not pro poor in Pakistan as an increase in national income is not translated into lives of the poor because growth is not reducing the size of income distribution imbalances. Consequently, retaining people income poor makes people energy poor depriving them from clean cooking fuel and other modern energy services.

After the investigation of causality between energy poverty, growth, income poverty and inequality, we also estimated the generalised impulse response function to find the response of a shock of a variable to other variable within the dynamic VAR system. In order to find the standard errors, Monte Carlo Simulation is used with 5000 replications. The results shown in Figure 6.1 verified that the long run causality that the shock impacts are persistent for a longer period of time. The impact of income poverty on energy poverty involves a two year lags after that it gets persistent. Yet response of energy poverty to inequality is for shorter period of time and dies out after 5 to 6 years.

Fig. 6.1. Generalised Impulse Response Function

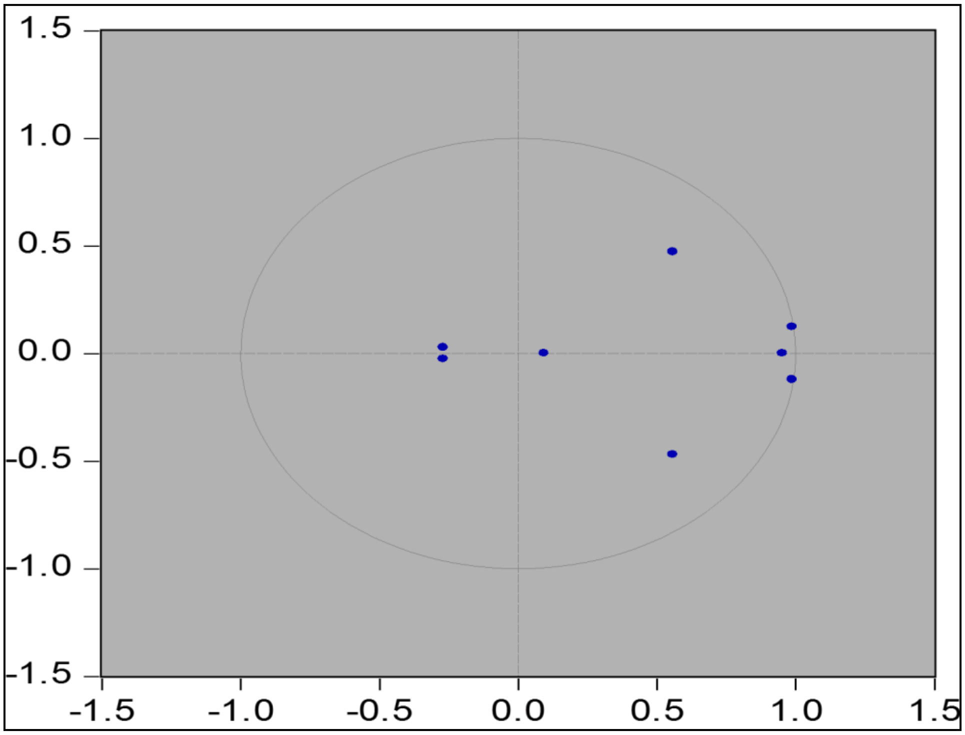


7. CONCLUSIONS AND POLICY SUGGESTIONS

The present study probes the dynamic causality among energy poverty, growth, income poverty and income inequality for Pakistan using the data ranges from 1973 to 2012. The analysis adopts the advanced TY-modelling in a multivariate framework that overcomes the problem of variables omission biasness. The extract of the study goes over the main points that a significant bi-variant causality linkages between growth and energy poverty; uni-variant causality that runs from income poverty to energy poverty and from income polarisation to energy poverty is observed. This furnishes a clear message for the economic planner that for any social and economic policy, state of energy services must be considered indispensably. There is urgent need of pro poor growth policies to depolarise the unfair income distribution and to mitigate the income poverty so that the fruits of growth may be transferred to poor and the excess to modern energy services may become possible to them. That's why, high commercial energy consumption; modern cooking fuel availability—that saves time and protects health of households; excess to electricity especially in rural areas are the limbs of new social and economic development policies that Pakistan should follow for all these concerned intents and purposes.

APPENDIX -I

Fig. 6.1. Inverse Roots of AR Characteristics Poly Nominal



Principal Components Analysis

Sample Size : 1973-2012

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	3.897334	3.822513	0.9743	3.897334	0.9743
2	0.074821	0.049537	0.0187	3.972155	0.9930
3	0.025284	0.022722	0.0063	3.997439	0.9994
4	0.002561	–	0.0006	4.000000	1.0000

Variables	PC 1	PC 2	PC 3	PC 4
Electrification Rate	0.258698	0.823500	0.255691	–0.115485
Fusel Fuel Consumption	0.243443	–0.014865	–0.684998	0.526499
Per Capita Electricity Consumption in Residential Areas	0.259862	–0.451212	0.649089	0.353877
Per Capita Energy Use	0.253636	–0.343562	–0.209958	–0.764352

Ordinary Correlations

Variables	Electrification Rate	Fusel Fuel Consumption	Per Capita Electricity Consumption in Residential Areas	Per Capita Energy Use
Electrification Rate	1.000000			
Fusel Fuel Consumption	0.961786	1.000000		
Per Capita Electricity Consumption in Residential Areas	0.936884	0.970316	1.000000	
Per Capita Energy Use	0.945549	0.990971	0.988608	1.000000

REFERENCES

ADB (2010a) *Inclusive Growth: Impact Stories from Nepal*. Manila: ADB.

ADB (2010b) *Clean Energy in Asia: Case Studies of ADB Investments in Low-Carbon Growth*. Manila: ADB.

AGECC (2010) Energy for a Sustainable Future. *Advisory Group on Energy and Climate Change (AGECC)*. New York: United Nations.

Awan, S. (2013) Determinants of Multidimensional Energy Poverty in Pakistan. *The Pakistan Development Review* 52:4.

Barnes, D. F., S. R. Khandker, Sand H. A. Samad (2011) Energy Poverty in Rural Bangladesh. *Energy Policy* 39, 894–904.

Barnes, Douglas, and Michael Toman (2006) Energy, Equity and Economic Development. In Ramon Lopez and Michael Toman (Eds.) *Economic Development and Environmental Sustainability: New Policy Options*. Oxford: Oxford University Press.

Bazilian, M., P. Nussbaumer, A. Cabraal, R. Centurelli, R. Detchen, G. Gielen, H. Rogner, M. Howells, H. McMahon, V. Modi, N. Nakicenovic, B. O'Gallachoir, M. Radka, K. Rijal, M. Takada, and F. Ziegler (2010) *Measuring Energy Access: Supporting a Global Target*. Earth Institute, Columbia University, NY, USA.

Bravo, V., G. G. Mendoza, J. Legisa, C. E. Suarez, and I. Zyngierman (1979) Estudiosobrerequerimientosfuturos no convencionales de energiaen America Latina. Project RLA/74/030, Report to the UNDP, Appendix 9. *FundacionBariloche, Buenos Aires*.

Dhimal, M., P. Dhakal, N. Shrestha, K. Baral, and M. Maskey (2010) Environmental Burden of Acute Respiratory Infection and Pneumonia Due to Indoor Smoke in Dhading. *Journal of Nepal Health Research Council* 8, 1–4.

Dickey, D. and W. A. Fuller (1979) Distribution of the Estimate for Autoregressive Time Series with a Unit Root. *Journal of American Statistical Association* 74, 427–31.

Diks, C. G. H. and V. Panchenko (2006) A New Statistic and Practical Guidelines for Nonparametric Granger Causality Testing. *Journal of Economic Dynamics and Control* 30, 1647–1669.

Ekouevi, K. and V. Tuntivate (2012) *Household Energy Access for Cooking and Heating: Lessons Learned and the Way Forward*. Washington, DC: World Bank.

Ewing, B. T. and J. E. Payne (2005) The Response of Real Estate Investment Trust Returns to Macroeconomic Shocks. *Journal of Business Research* 58, 293–300.

Faridi Z. and G. Murtaza (2013) Disaggregate Energy Consumption, Agricultural Output and Economic Growth in Pakistan. *The Pakistan Development Review* 52:4.

Foster, V., J. P. Tre, and Q. Wodon (2000) Energy Prices, Energy Efficiency, and Fuel Poverty. Unpublished paper Latin America and Caribbean Regional Studies Program. The World Bank, Washington, DC.

Goldemberg, J. (1990) One Kilowatt Per Capita. *Bulletin of the Atomic Scientists* 46:1.

Goldemberg, J., E. L. La Rovere, and S. T. Coelho (2004) Expanding Access to Electricity in Brazil.

Holdren, J. P. and K. R. Smith (2000) Energy, the Environment, and Health. In Kjellstrom Tord, Streets David, Wang Xiadong (eds.) *World Energy Assessment*: *Energy and the Challenge of Sustainability*. New York: United Nations Development Programme, 61–110.

Hussain, F. (2011) Challenges and Opportunities for Investments in Rural Energy. Presentation to the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) and International Fund for Agricultural Development (IFAD) Inception Workshop on "Leveraging Pro-Poor Public-Private-Partnerships (5Ps) for Rural Development," United Nations Convention Centre, Bangkok, Thailand.

IEA, International Energy Agency (2004) *World Energy Outlook*. Paris.

Jamal, H. (2006) Does Inequality Matter for Poverty Reduction? Evidence from Pakistan's Poverty Trends. *The Pakistan Development Review* 45:3, 439–459.

Johansen, S. and K. Juselius (1990) Maximum Likelihood Estimation and Inference on Cointegration: With Application to the Demand for Money. *Oxford Bull Econ Stat* 52, 169–210.

Jones, R. (2010) Energy Poverty: How to Make Modern Energy Access Universal? Special Early Excerpt of the World Energy Outlook 2010 for the UN General Assembly on the Millennium Development Goals. Paris: International Energy Agency/OECD.

Joshi, H. D., R. Pandey, and B. Dhakal (2009) Health Impact of Indoor Air Pollution. *Journal of Nepal Health Research Council* 7, 69–75.

Khandker, S. R., D. F. Barnes, and H. A. Samad (2012) Are the Energy Poor Also Income Poor? Evidence from India. *Energy Policy* 47, 1–12.

Koop, G., M. H. Pesaron, and S. M. Potter (1996) Impulse Response Analysis in Non-linear Multivariate Models. *Journal of Econometrics* 74, 119–47.

Krugmann, Hartmut and Jose Goldemberg (1983) The Energy Cost of Satisfying Basic Human Needs. *Technological Forecasting and Social Change* 24, 45–60.

Kuzozumi, E. and T. Yamamoto (2000) Modified Lag Augmented Autoregressions. *Econometric Review* 19, 207–31.

Larson, E. D. and S. Kartha (2000) Expanding Roles for Modernised Biomass Energy. *Energy Sustain Dev*. 4:3, 15–25.

Lutkepohl, H. (1993) *Introduction to Multiple Time Series*. 2nd ed. Berlin: Springer.

Malla, M. B., N. Bruce, E. Bates, and E. Rehfuess (2011) Applying Global Cost–benefit Analysis Methods to Indoor Air Pollution Mitigation Interventions in Nepal, Kenya and Sudan: Insights and Challenges. *Energy Policy* 39, 7518–7529.

Malla, S. (2013) Household Energy Consumption Patterns and Its Environmental Implications: Assessment of Energy Access and Poverty in Nepal. *Energy Policy* 61, 990–1002.

Masud, J., D. Sharan, and B. N. Lohani (2007) *Energy for All: Addressing the Energy, Environment, and Poverty Nexus in Asia*. Manila: Asian Development Bank.

Mirza, B. and A. Szirmai (2010) Towards a New Measurement of Energy Poverty: A Cross-Community Analysis of Rural Pakistan. United Nations University, Maastricht Economic and social Research and Training Centre on Innovation and Technology. (UNU-MERIT Working Paper Series 024).

Mozumder, P. and A. Marathe (2007) Causality Relationship Between Electricity Consumption and GDP in Bangladesh. *Energy Policy* 35, 395–402.

Nussbaumer, P., M. Bazilian, and V. Modi (2012) Measuring Energy Poverty: Focusing on What Matters. *Renewable and Sustainable Energy Reviews* 16, 231–243.

Pachauri, S. and D. Spreng (2004) Energy Use and Energy Access in Relation to Poverty. *Economic and Political Weekly* 39:3, 17–23.

Pachauri, S. and D. Spreng (2011) Measuring and Monitoring Energy Poverty. *Energy Policy* 39, 7497–7504.

Pachauri, S., A. Muller, A. Kemmler, and D. Spreng (2004) On Measuring Energy Poverty in Indian Households. *World Development* 32:12, 2083–2104.

Paul., S. and R. N. Bhattacharya (2004) Causality Between Energy Consumption and Economic Growth in India: A Note on Conflicting Results. *Energy Economics* 26, 977– 983.

Pereira, M. G., M. A. V. Freitas, and N. F. D. Silva (2010) Rural Electrification and Energy Poverty: Empirical Evidence from Brazil. *Renewable and Sustainable Energy Review* 14, 1229–1240.

Pesaran, M. H. and Y. Shin (1998) Generalised Impulse Response Analysis in Linear Multivariate Models. *Economics Letters* 58, 17–29.

Pesaran, M. H. and Y. Shin (1998) Impulse Response Analysis in Linear Multivariate Models. *Energy for Sustainable Development* 8:4, 86–94.

Phillips, P. C. B. and P. Perron (1988) Testing for a Unit Root in Time Series Regression. *Biometrika* 75:2, 336–346.

Pokhrel, A. K., K. R. Smith, A. Khalakdina, A. Deuja, and M. N. Bates (2005) Case-control Study of Indoor Cooking Smoke Exposure and Cataract in Nepal and India. *International Journal of Epidemiology* 34, 702–708.

Pokhrel, A. K., M. N. Bates, S. P. Shrestha, I. L. Bailey, R. B. Dimartino, and K. R. Smith (2013) Biomass Stoves and Lens Opacity and Cataract in Nepalese Women. *Optometry and Vision Science* 90, 257–268.

Practical, Action (2010) *Poor People's Energy Outlook*.

Sagar, A. D. (2005) Alleviating Energy Poverty for the World's Poor. *Energy Policy* 33, 1367–1372.

Saghir, J. (2004) Energy and Poverty: Myths, Links, and Policy Issues. Energy Sector Notes. Energy and Mining Sector Board, 4, World Bank, Washington, DC.

Scheikman, J. A. (2002) An Agenda Perdida–diagno´ sticos e propostas para a retomada do crescimento com maiorjustic¸a social. Rio de Janeiro, Instituto de Estudos do Trabalho e Sociedade (IETS).

Shahbaz, M. and M. Feridun (2011) Electricity Consumption and Economic Growth Empirical Evidence from Pakistan. Qual Quant.

Shrestha, I. L., and S. L. Shrestha (2005) Indoor Air Pollution from Biomass Fuels and Respiratory Health of the Exposed Population in Nepalese Households. *International Journal of Occupational and Environmental Health* 11, 150–160.

Sims, C. and J. Stock (1990) Watson M. Inference in Linear Time Series Models with Unit Roots. *Econometrica* 58, 113–44.

Sovacool, B. K., C. Cooper, M. Bazilian, K. Johnson, D. Zoppo, S. Clarke, J. Eidsness, M. Crafton, T. Velumail, and H. A. Raza (2012) What Move Sand Works: Broadening the Consideration of Energy Poverty. *Energy Policy* 42, 715–719.

Toda, H. Y. and P. C. B. Phillips (1993) Vector Autoregressions and Causality. *Econometrica* 61, 1367–93.

Toda, H. Y. and T. Yamamoto (1995) Statistical Inference in Vector Autoregression with Possibly Integrated Processes. *Journal of Econometrics* 66, 225–250.

UNDP (2007) *Energy and Poverty in Nepal: Challenges and the Way Forward. Regional Energy Programme for Poverty Reduction*. Kathmandu: UNDP.

UNDP (2012) *Energy to Move Rural Nepal Out of Poverty: The Rural Energy Development Programme Model in Nepal*. Kathmandu: UNDP.

UNDP, WHO (2009) *The Energy Access Situation in Developing Countries: A Review Focusing on the Least Developed Countries and Sub-Saharan Africa*. New York.

United Nations (1954) *Rural Electrification. Prepared by the Secretariat of the Economic Commission for Asia and the Far East*. Geneva: Department of Economic Affairs.

United Nations Development Program (2010). *Human Development Report.* New York: UNDP.

WHO (2006) *Fuel for Life: Household Energy and Health*. Geneva: World Health Organisation (WHO).

WIN (2005) *Household Energy, Indoor Air Pollution and Health Impacts: Status Report for Nepal*. Kathmandu: Winrock International Nepal (WIN).

World Bank (1985) Energy Assessment Status Report: Nepal. World Bank, Washington, DC. (Report No. 028/84).

World Bank (2002) Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits. Energy Sector Management Assistance Programme (ESMAP), 255/02. World Bank, Washington, DC.

Worrell, E., L. Price, and LBNL (2001) Pew Centre/NCEP 10-50. Improving Industrial Energy Efficiency in the U.S.: Technologies and Policies for 2010 to 2050. Workshop Proceedings. "The 10-50 Solution: Technologies and Policies for a Low-Carbon Future."

Zapata, H. O. and A. N. Rambaldi (1997) Monte Carlo Evidence on Cointegration and Causation. *Oxford Bulletin of Economics and Statistics* 59, 285–98.