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Research Article

An Empirical Investigation of the Causal Relationship amongst Energy Consumption, Net Fixed Capital Stock and Economic Growth in India

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Abstract: Purpose- in this paper, an effort has been made to establish the causal relationship amongst energy consumption, net fixed capital stocks and economic growth measured in terms of Gross Domestic Product (GDP) in India. Further attempt has been made to fix the direction of causality by taking into account the disaggregated energy consumption such as petroleum, coal, electricity and gas consumption.

Design/ methodology/ approach- the methodology is based on the Engle-Granger method of co-integration and Johanson-Juselius multivariate method and uses a time series data of disaggregated energy consumption, net fixed capital stocks and GDP over the period 1970-2002. Since no co-integration was found amongst the concerned variables, Standard Granger method is used to find out the causality between energy consumption and economic growth as well as energy consumption and net fixed capital stocks.

Findings- the empirical results infer that there is bi-directional causality between energy consumption and economic growth and unidirectional causality running from energy consumption to net fixed capital stocks. The research concluded that since India is a net energy importer, especially petroleum, it has to pay a high oil import bill every year. Therefore, using oil more efficiently and/or substituting petroleum and gas by coal and electricity wherever possible could be a good policy measure. Perhaps, an energy conservation policy regarding petroleum and natural gas consumption would not lead to any adverse side effects on economic growth in India.

Keywords: Granger causality, co-integration, energy consumption, net fixed capital stocks, Gross Domestic Product.

Introduction:

Energy is one of the major inputs for economic development of any country. In developing countries, the energy sector assumes a critical importance in view of the spiraling energy needs due to accelerated economic development. The energy requirement of an economy is sensitive to the rate of economic growth and energy intensity of producing sectors. The energy intensity is the function of technological progress and it varies from sectors to sectors. All production and many consumption activities involve energy as an essential input. It is a very important and primary input in the aggregate production function. It is the key source of economic growth, industrialization and urbanization. Continued economic development and population growth are driving energy demand faster than India can produce it. On the other hand economic growth, industrialization and urbanization may induce use of more energy, particularly commercial energy. For example, Government of India estimated that to support an annual growth rate of 8% of Gross Domestic Product (GDP), the electricity supply will have to increase by more than 10% annually. Thus, energy consumption function as an engine of growth and fuelled the economic activities. India has been passing through an economic reform since 1991, the general aim of which is to quadruple its economic growth and remove the problems of poverty and unemployment. One of the obstacles to achieve these objectives has been the frequent occurrence of energy shortage in the economy. For example India's electricity sector currently faces capacity problems, poor reliability and frequent blackouts. Moreover, industry cities power supply as one of the biggest limitations on progress. So the relation between energy consumption and economic growth is of great importance to the energy economists. It is not possible to achieve high growth without ensuring sufficient energy demand. Again, Net Fixed Capital Stocks (NFCS) which is the plants, machinery, equipment etc. excluding the depreciation also affects energy consumption and thereby, GDP in the economy.

Energy Scenario in India:

India pertains 1.8 % of the World GDP and 5.3 % of the World energy consumption. Commercial energy consumption in India overtime has been growing at a compound annual growth rate (CAGR) of about 6%, which is more than the CAGR of GDP during the last two decades. For example, Ministry of Power, Government of India estimates that to support Government targets of 8% annual GDP, the electricity power supply will have to increase by more than 10 % annually. Among others, coal constitutes the main source of commercial energy and accounts for over 60% primary consumption in the country. Oil and natural gas together account for 35 % of primary commercial energy consumption. Sector-wise Industry accounts for nearly half of final commercial energy consumption, followed by transport and residential sectors. While the share of domestic consumption has remained more or less same, the share of transport sector has gone up by a percentage point. Agriculture accounts for about 5% of total primary energy consumption.

Every country formulates its own policy to optimize the use of different energy sources for meeting the demands of its domestic, agricultural, industrial and commercial sectors. This necessitates an integrated and updated database of the production and consumption of different energy sources viz. – coal, crude petroleum, natural gas and electricity (hydro and nuclear). India annually consumes about three percent of the world's total energy. The country is the world's 6^{th} largest energy consumer and accounts for 5% of total world demand. In India, commercial energy consumption overtime has been growing at a compound annual growth rate (CAGR) of about 6%, which is more than the CAGR of GDP during the last two decades.

Thus, to fill up the production-consumption gap or supply-demand gap of energy, India has to incur a huge energy import bill every year. Thus, India is a net importer of energy and imports nearly 70% of its requirement for petroleum and petroleum products. This energy gap i.e. the expected energy demand growth posses challenge for India. By 2020, India's demand for commercial energy is expected to increase by more than 2.5 times. Underpinning this trend will be the ongoing growth in population, urbanization, income, industrial production and transport demand.

Among others, coal constitutes the main source of commercial energy and accounts for over 60% primary consumption in the country. Oil and natural gas together account for355 of primary commercial energy consumption in the country. An analysis of consumption by sectors shows that industry accounts for nearly half of final commercial energy consumption, followed by transport and residential sectors. However, the share of industry in consumption has fallen by over 2% from a high of 50.4% in 1990-91 to 47.8% in 1997-98. While the share of domestic consumption has remained more or less same, the share of transport sector has gone up by a percentage point. Agriculture accounts for about 5% of consumption.

Theory behind Policy:

The direction of causation between energy consumption and economic or GDP has significant policy implications. If foe example, there exits unidirectional Granger causality running from economic growth or income to energy consumption, it may be implied that energy conservation policies may be implemented with little adverse or no effects on economic growth or income. In the case of negative causality running from NFCS to energy consumption, total NFCS could rise if energy conservation policy were to be implemented. On the other hand, if unidirectional causality runs from energy consumption to economic growth or income, reducing energy consumption by energy conservation policies could lead to a fall in income. The finding of no causality in either direction, the so- called 'Neutrality Hypothesis' would imply that energy conservation policies do not effect economic growth or GDP (*Asafu-Adjaye, 2000*) e.g. energy consumption and economic growth/ GDP are independent of each other.

Survey of Literature:

In India not much attention has been devoted to investigate the causal relationship between economic growth and energy consumption. *Pachuri (1977)* and *Tyner (1978)* using the regression approach have found a strong relation between energy consumption and economic growth in India. *Asafu-Adjaye (2000)* estimated the causal relationships between energy consumption and income for India, Indonesia, Philippines and Thailand by using co-integration and error-correction modelling techniques. The study found a short-run unidirectional Granger causality runs from energy to income for India and Indonesia, while bidirectional Granger causality runs from energy to income for Thailand and Philippines. *Paul and Bhattacharya (2004)* by using sample data over the period 1950-1996 for India, have found a bi-directional causality between energy consumption and economic growth, e.g. energy consumption causes economic growth as well as economic growth causes energy consumption. *Tsani (2010)* investigated the causal relationship between aggregated and disaggregated levels of energy consumption and economic growth for Greece during the period 1960-2006 and found the presence of a uni-directional causal relationship running from total energy consumption to real GDP. *Dhungel (2010)* attempted to examine the causal relationship between per capita consumption of coal, electricity, oil and total commercial energy and per capita real GDP for Nepal by using a co-integration and vector error correction model. The study found that increase in real GDP, among other things, indicates a higher demand for a large quantity of commercial energy such as coal, oil and electricity. *Kalyoncu (2013)* investigated the relationship between energy consumption and economic growth in Georgia, Azerbaijan and Armenia during the period of 1995-2009 by using Engle- Granger co-integration and Granger causality tests. The study found that though the two variables are not co-integrated in case of Georgia and Azerbaijan, but are co-integrated in case of Armenia and exists a unidirectional causality from per capita GDP to per capita energy consumption. *Zhang, et.al. (2017)* investigated the causal relationship between energy consumption and economic growth for three industries in Beijing during the period of 1980-2008. The study found a bidirectional Granger causality in the short run, but unidirectional Granger causality running from energy consumption to economic growth in the long run. *Meher (2016)* investigated the causal relationship between electricity consumption and economic growth in the state of Odisha in India for the period 1980-2014 by using the co-integration and vector error correction modelling. The study found unidirectional long run Granger causality running from economic growth to electricity consumption, indicating that economic growth in Odisha stimulates electricity consumption in the long run, thereby supporting the conservation hypothesis. *Behera (2015)* examined whether energy consumption fuels economic growth or vice versa in India over the period 1970-2011 and found that economic growth drives for more demand of electricity consumption and similarly growth of energy consumption causes economic growth. *Ighodaro (2010)* examined co-integration and causality relationship between energy consumption and economic growth for Nigeria over the period 1970-2005 and found long-run relationship between the variables. The study also found that electricity and gas consumption affects economic growth. *Lise and Mantfort (2005)* tried to establish the linkage between energy consumption and GDP for Turkey over the period 1970-2003. The study found that energy consumption and GDP are co-integrated and established a unidirectional causality running from GDP to energy consumption. *Narayan, et.al (2007)* studied the residential demand of electricity consumption for G7 countries over the period 1970–1997 and found that both income and price have an impact on electricity consumption, and income and price policies could be effectively facilitated in electricity demand management.

Methodology:

The causality is established by applying Granger Causality test which requires the data to be stationary and co-integrated. If no co-integration is found among the variables, then Standard Granger Causality test can be used for finding out the short-term relationship between the variables.

Standard Granger Causality:

Traditionally, to test the causality relationship between two variables, the standard Granger (1969) test has been employed in the relevant literature. This test states that, if past values of a variable Y significantly contribute to fore-caste the value of another variable X_{t+1}, then Y is said to Granger cause X and vice-versa. The test is based on the following regressions: -

$$Y_t = \beta_0 + \sum_{k=1}^{m} \beta_k Y_{t-k} + \sum_{i=1}^{n} \alpha_i X_{t-1} + U_t$$

$$X_t = \gamma_0 + \sum_{k=1}^{m} \gamma_k X_{t-k} + \sum_{i=1}^{n} \delta_i Y_{t-1} + V_t$$

Where, Y_t and X_t are the variables to be tested; U_t and V_t are mutually uncorrelated white noise errors; t denotes the time period and k and i are numbers of lags. **The null hypothesis (H_0): $\alpha_i = \delta_i = 0$ for all i's versus the alternative hypothesis (H_1): $\alpha_i \neq 0$ and $\delta_i \neq 0$ for at least some i's.** If the coefficient α_i's are statistically significant, but δ_i's are not, then X causes Y and vice-versa. But if both α_i and δ_i are significant, then causality runs both ways.

Empirical Investigations:

Unit Root Tests:

Table 1: Results of Unit Root Tests

Variables	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)	
	Levels	First Difference	Levels	First Difference
TEC	$-0.66^t(1)$	-4.25(1)	$-0.45^t(1)$	-4.40(1)
GDP	$5.30^c(1)$	$-3.71^t(1)$	$8.93^c(1)$	$-5.84^t(1)$
NFCS	$-0.88^t(1)$	$-4.13^t(1)$	$-0.31^t(1)$	-3.48(1)
CP	$-0.13^t(1)$	$-3.88^t(1)$	$0.48^t(1)$	$-3.96^t(1)$
NG	$-1.70^t(1)$	$-3.43^t(1)$	$-1.62^t(1)$	-3.48(1)
Coal	$-1.06^t(1)$	$-3.39^t(1)$	$-0.98^t(1)$	-3.48(1)
Electricity	$-1.99^t(1)$	$-5.44^t(1)$	$-2.03^t(1)$	$-3.38^t(1)$
Critical Values				
1%	-4.28		-4.27	
5%	-3.56		-3.55	
10%	-3.21		-3.21	

Note: GDP – Gross Domestic Product, TEC - Total Energy Consumption, NFCS – Net Fixed Capital Stock, CP – Crude Petroleum, NG- Natural Gas

Since OLS estimates of relationship between non-stationary variables are inefficient and biased, we have first tested whether the variables GDP, TEC and its various component and NFCS are stationary or not by using the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests. From the results in table above, it is clear that in the levels form, all the variables are non-stationary. But when the first difference is taken, both the tests reject the null hypothesis of non-stationarity for all the variables i.e. all the variables become stationary and integrated of order one i.e. I (1).

Test of Co-integration:

As a second preliminary step, we have tested whether the two variables TEC & GDP or TEC and NFCS are co-integrated.

Granger's Co-integration Test: TEC & GDP:

$TEC = \alpha_o + \alpha_1 GDP + U$

Or TEC = -1167.163 + 0.020 GDP + U

(-3.54)* (45.99)*, $\bar{R}^2 = 0.98$

The ADF test statistic on the residual series is –0.032, which is less than the critical value representing no co-integration between TEC and GDP.

Granger's Co-integration Test between TEC & NFCS:

$TEC = \alpha_o + \alpha_1 NFCS + U$

Or TEC = -3423.596 + 0.035 NFCS + U

(-11.02)* (54.58)* ; $\bar{R}^2 = 0.98$

The ADF statistics on the residual series is –2.79 greater than the critical value –2.63 which is significant at 1% level. That is, there may be co-integration between the two. But this is not robust result. By using Error Correction Model (ECM), it will be confirmed whether there is co-integration between TEC and

NFCS.

Error Correction Method (ECM):

Δ TEC = C + ΔTEC (-1) + ΔNFCS (-1) + U_t

Or ΔTEC = 159.95 + 0.431 ΔTEC (-1) + 0.11 ΔNFCS (-1) – 0.116 ECT

(1.28) (2.22)** (1.90)*** ↓ (-1.43)

(Not Significant)

Thus, ECM also confirms that there is no co-integration.

*Notes: * = Significant at 1%; *** = Significant at 10% and ** = Significant at 5%*

Alternative Co-integration Test:

Table-2: Johansen – Juselius Test of Co-integration: TEC, GDP & NFCS

Hypothesis	Eigen value	Likelihood Ratio	5% Critical Value	1% Critical Value
None*	0.482990	35.15774	29.68	35.65
At most 1	0.348701	14.04757	15.41	20.04
At most 2	0.010148	0.326386	3.76	6.65

The above table also shows that there is no co-integration between TEC, NFCS and GDP, where the first column gives the number of co-integrating vector. Since, no co-integration or long-run relationship between TEC and GDP or TEC and NFCS were found, Standard Granger Causality test has been applied to see whether there is short-run causality or relationship among the variables.

Table-3: Standard Granger Causality Test:

Direction of Causality	F-Statistics	Results
ΔTEC → ΔGDP	10.51*	TEC causes GDP
ΔGDP → ΔTEC	6.01**	GDP causes TEC
ΔGDP → ΔCP	6.54*	GDP causes CP
ΔCP -- ΔGDP	***0.74***	CP does not causes GDP
ΔGDP -- ΔCoal	1.21	GDP does not causes Coal
ΔCoal → ΔGDP	4.97**	Coal causes GDP
ΔGDP -- ΔElectricity	2.12	GDP does not causes electricity
ΔElectricity → ΔGDP	2.89***	Electricity causes GDP
ΔGDP → ΔNG	12.92*	GDP causes NG
ΔNG -- ΔGDP	***1.54***	NG does not causes GDP
ΔTEC → ΔNFCS	4.94**	TEC causes NFCS
ΔNFCS --- ΔTEC	2.55	NFCS does not causes TEC

*Note: * = Significant at 1%; ** = Significant at 5% and *** = Significant at 10%*

From the above table, it is clear that there is *bi-directional* causality between total energy consumption and economic growth in India i.e., energy consumption causes economic growth as well as economic growth also causes energy consumption. So any energy conservation policy, which may cut the present energy consumption for more use in future, would lead to fall in economic growth in income. In the context of TEC and NFCS, there is unidirectional causal relation and the causality runs from TEC to NFCS. Thus, any change in NFCS in the economy does not affect the energy consumption in the economy. In case of GDP and various components of energy consumption (i.e., CP; NG; Coal and Electricity), there is unidirectional relations and the causality runs from GDP to CP; Coal to GDP; Electricity to GDP and GDP to NG. Thus, the causality does not run from CP to GDP and also from NG to GDP. So some logical inferences could be drawn from the above results. It seems that increased economic activities causes growth in energy consumption and since petroleum products are largely imported, is also affected by growth in GDP.

Lag-relations between the Variables TEC & GDP:

Further to find out the magnitude of causal relations between energy consumption and GDP, the following regressions have drawn by taking into account the leg-relations.

$\Delta GDP = \alpha_o + \alpha_1 \Delta TEC_t + \alpha_2 \Delta TEC_{t-1} + \alpha_3 \Delta TEC_{t-2} + U_t \rightarrow (1)$

Or GDP = -7214.648 + 26.15 Δ TEC_t + 27.68 ΔTEC_{t-1} + 11.65 ΔTEC_{t-2} + U_t

(-0.934) (2.77)* (2.22)** (1.01)

Adjusted – R^2 = 0.55

$\Delta TEC = \beta_0 + \beta_1 \Delta GDP_t + \beta_2 \Delta GDP_{t-1} + \beta_3 \Delta GDP_{t-2} + V_t \rightarrow (2)$

Or TEC = 255.41 + 0.0085 ΔGDP_t + 0.0057 ΔGDP_{t-1} – 0.0015 ΔGDP_{t-2} + V_t

(2.47)** (2.88)* (1.82)* (-0.44)

Adjusted – R^2 = 0.50

The above equation (1) shows that GDP in the present period is affected by energy consumption in the present period (=t) as well as energy consumption in the previous period (=t-1) but not by energy consumption in the previous period (=t-2) which is also the same in case of equation (2). The adjusted R^2 is also high in both these two equations which also implies the close causal relations (bi-directional) between energy consumption and GDP

Policy Implications:

From the empirical analysis, we have found that there is no co-integration between TEC and GDP in the long-run, but have *bi-directional* causality or relationship in the short-run. This implies that in the long-run, though energy consumption is one of the factors that affect economic growth, but its impact is not significant. However, in the short-run, both TEC and GDP impact each other as energy is the primary fuel for vehicles of economic growth such as industrialization, manufacturing, construction etc.

This paper has important policy implications as India is a net energy importer, especially petroleum and pays a high oil import bill every year. Therefore, using oil more efficiently and /or substituting petroleum and gas by coal and electricity wherever possible could be a prudent policy measure. The implications of the present study suggest that an energy conservation policy regarding petroleum and natural gas consumption would not lead to any adverse side effects on economic growth in India. Whereas energy growth policy in case of coal and electricity should be adopted in such a way that growth in these sectors stimulates economic growth and as such growth would lead to expand NFCS in the economy.

Revisiting the global energy scenario reveals that the U.S. for its energy hungry image, actually has 33% of world's GDP but uses only 24.4% of the world's energy. This is because its economy has a higher level of services and knowledge intensity and is, therefore, relatively insulated from energy crisis. Japan has 6 to 7 % of the global economy, but still uses only 5.1% of the world's energy. Again Japan and China have high export components, and a significant part of their energy is used for exports. But only with 1.8% of the world's economy, India has to take the stresses and strains of 5.3% of the world's energy consumption. No surprise then that India may become one of the biggest victims of any future energy crisis.

The solution lies, either get into value added areas that capture greater Dollar 'Value' per unit of energy (i.e. through more efficient manufacturing and exports), or fixed low-energy avenue of growth (like the IT; BPO; Knowledge based services- KPO; Tourism; entertainment etc.). It is believed that especially in developed countries- the share of GDP is being accounted for by services while the share of goods including petroleum is declining. These depressing forces will continue and probably intensify. It is already evident that in India, services have been the major driver of GDP growth for long. The services sector contributes nearly 60% GDP in India. The industrial sector, which consumes nearly 50% of total energy consumption in the country, contributes only about 20 to 25% of GDP. Whereas Agriculture which consumes nearly 5% of total energy consumption in the country, contributes nearby 15% of GDP in India.

Moreover, the declining importance of energy in GDP across the World means that the current crude oil price spike is less significant than previous spikes and should do less damage to the world economy. Again, Denmark is another country that has successfully de-linked energy consumption and economic growth. High taxes on heating oil and electricity for homes helped. In Japan also one major reason was the shift from heavy industries such as iron and steel to machine based and high tech ones like automobiles and consumer electronics. The official India, Hydrocarbon Vision 2025 report, for example shows says that the oil elasticity with respect to GDP is currently around 1.2, what it means is that India needs 1.2 units of oil to produce one extra unit of GDP today. Thus, the diversification of the economy from manufacturing to services will improve India's oil efficiency. But again, these gains are offset by the wastage and the high costs of energy. Global experiences shows that economic growth and energy consumption can be successfully de-linked. Part of it comes naturally: higher oil prices acts as an incentives to conserve, while the move from manufacturing to services also helps. However, policy initiatives shall be headed well to show determination to reduce our thirst for oil.

Conclusion:

India no longer enjoys the liberty of fuelling economic and industrial expansion in commodities and sectors that are inherently energy intensive. Importing of commodities that consume more energy in their production is a more viable option than importing oil to produce such commodities locally.

References:

1. *Akarca, A.T. and Long, T.V. (1980)*, "On the relationship between energy and GDP: a re-examination", Journal of Energy and Development, Vol 5, 1980, pp. 326-331.
2. *Asafu-Adjaye, J. (2000)*, "The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian Developing Countries", Energy Economics, 2000, Vol. 22, issue 6, ISBN-615-625.
3. *Behera, J. (2015)*, "Energy Consumption and Economic Growth in India: A reconciliation of Disaggregate Analysis", Journal of Energy Technologies and Policy www.iiste.org ISSN 2224-3232 (Paper) ISSN 2225-0573 (Online) Vol.5, No.6, 2015.
4. *Center for Monitoring Indian Economy (CMIE)*, Energy Statistics, CMIE, India
5. National Accounts Statistics, Central Statistical Organization (CSO), Ministry of Statistics and Programmed Implementation, Government of India.
6. *Dhungel, K.R (2007)*, "A causal relationship between energy consumption and economic growth in Nepal", Asia-Pacific journal of rural development 15(1):137-150, January 2007
7. *Yu, E.S.H. and Choi, J.Y. (1985)*, "The causal relationship between energy and GNP: an international comparison", journal of Energy and Development, Vol 10, No. 2, 1985, pp. 249-272.
8. *Yu, E.S.H. and Jin, J.C (1992)*, "Co integration tests of energy consumption, income and employment", Resource and Energy, Vol 14, 1992.
9. *Central Statistical Organization (2010)*, Ministry of Statistics and Programmed Implementation, Government of India, Energy Statistics.
10. *TERI (1996)*, "Environmental Considerations and options in managing India's long term energy strategy", The Energy Resources Institute, New Delhi, India.
11. *Fisher, J. C. (1974)*, "Energy crisis in perspective", Wiley & Sons Canada, Limited, 1974, ISBN-13: 978-0471261414.
12. *Henderson, P.D. (1977)*, "India: the Energy Sector", Energy Policy, 1977, vol. 5, issue 1, 80-81.
13. *Ighodaro, C.A.U. (2010)*, "Co-integration and causality

relationship between energy consumption and economic growth: Further empirical evidence for Nigeria", Journal of Business Economics and Management, ISSN: 1611-1699 (Print) 2029-4433 (Online).

14. *Kalyoncu, H. (2013)*, "Causality relationship between GDP and energy consumption in Georgia, Azerbaijan and Armenia", International Journal of Energy Economics and Policy 3(1):111-117, January 2013
15. *Meher, S. (2016)*, "The Dynamic Causal Relationship between Electricity Consumption and Economic Growth: Empirical Evidence from Odisha, India", Working Paper No. 66, Nabakrushna Choudhury Centre for Development Studies, Bhubaneswar, www. http://ncds.nic.in/sites/default/files/WorkingandOccasionalPapers/WP66NCDS.pdf
16. *Ministry of Petroleum and Natural Gas*; Economics and Statistics Division, India petroleum and natural gas statistics, India.
17. *Narayan, P., et.al (2007)*, "Electricity consumption in G7 countries: A panel co-integration analysis of residential demand elasticities", Energy Policy, 2007, vol. 35, issue 9, 4485-4494
18. *Pachauri, R.K. (1977)*, "Energy and Economic Development in India", New York, Praeger, 977, ISBN-0030223717, 9780030223716
19. *Shyamal Paula, S. and Bhattacharya, R.N. (2004)*, "Causality between energy consumption and economic growth in India: a note on conflicting results", Elsevier, Energy Economics 26 (2004) 977 – 983.
20. *Tsani, S. (2010)*, "Energy consumption and economic growth: A causality analysis for Greece", Energy Economics 32(3):582-590, May 2010
21. *Tyner, W.E. (1978)*, "Energy resource and Economic Development in India", Springer, ISBN 978-1-4613-4083-6.
22. *Vaishampayam, J.V. (1996)*, "Energy and Economic Development: An analysis of energy-economy interactions", Ajanta, 1996, ISBN-8120204611, 9788120204614.
23. *Lise, W. and Mantfort, K. (2005)*, "Energy consumption and GDP in Turkey: Is there a co integration relationship?", Paper presented at EcoMod 2005 International Conference on Policy Modeling, June 29 – July 2, 2005, Istanbul, Turkey.
24. *Zhang, X., et.al. (2017)*, "Causality between Energy Consumption and Economic Growth in Beijing: Evidence from Cross-Industry Panel Data", International Conference on Computer Science, Environment, Eco-informatics and Education", CSEE 2011, Vol 217, pp 233-237