Clean Cooking Fuels And Economic Development In Developing Countries

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ABSTRACT

Access to modern forms of energy is crucial in tackling current global economic and social development problems as well as attaining environmental goals of reducing carbon emissions. However, despite increased attention from numerous organizations and governments, energy poverty remains an acute development problem: especially in developing countries where access to modern energy services is predominantly incipient. Still, until now, literature has focused primarily on broader access to electricity as well as the generation of clean energy to substitute fossil fuels. Failing to tackle the lack of basic access to modern energy for cooking and heating.

In this paper, we address this gap by reviewing the problem of lack of access to modern energy for cooking and/or heating, as well as presenting empirical evidence of the effect of household lack of modern cooking fuels on economic development (using Gross Domestic Product (GDP) per Capita as indicator).

Keywords: Cooking fuels, Developing countries, Economic development, GDP per Capita.

1. INTRODUCTION

Recently, it has become extensively recognised that whilst access to affordable modern energy services by itself, would not fix all development issues in developing countries, it is essential for all dimensions of development United Nations Children's Fund (UNICEF) (2013); Kebede et al. (2010). This absence of adequate energy services; often referred to as energy poverty, affects people's productivity, earnings and well-being González-Eguino (2015); Omri (2013). Broadly speaking, energy poverty inhibits the attainment of development goals: including the Sustainable Development Goals (SDGs) set by the United Nations (UN).

To address this issue, academic and policy attention have been directed towards access, equity and investment in socio-technical systems. However, much of these attention have been placed on electricity services: overlooking cooking services. The underlying theory of change perceives access to modern electricity service(s) as a catalyst for broader economic development Elias and Victor (2005); Payne (2010); Karanfil and Li (2015). Yet, whilst access to electricity is clearly important, we would argue that the view that only with access to electricity can economic development occur, is ungrounded. In addition, although it could be argued that access to electricity could indeed satisfy cooking needs; due to high costs, unreliable supply, amongst other factors; ongoing situations in developing countries have proven these assumptions futile.

With regards to existing literature, studies investigating the effect of energy poverty on economic development have also done so, focusing on the relationship between electricity and economic

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development only. Empirical studies exploring the relationship between inaccessibility to modern energy services for cooking and sustainable economic development are few and far between. At most, some studies have illustrated the relationship between use of traditional cooking fuels and health World Bank Group (2014); Makonese et al. (2017). Other studies have demonstrated the opportunity cost of the traditional cooking fuels on productive hours: particularly for children and women United Nations Children's Fund (UNICEF) (2013); Schlag and Zuzarte (2008). Taken together, it can be anticipated that the absence of modern energy for cooking and/or heating would undoubtedly directly or indirectly, influence economic development. Hence, we seek to address this gap in knowledge, in this paper.

A thorough search of the relevant literature shows that there are currently no empirical studies which quantify the relationship between the use of traditional energy fuels for cooking and/or heating and economic development. To investigate economic effects, empirical studies such as Christopoulous and Tsionas; Akinlo; Esso et al. and Menegaki, amongst others, have done so using Gross Domestic Product (GDP) as a variable Christopoulos and Tsionas (2004); Akinlo (2008); Esso and Keho (2016); Menegaki and Tugcu (2016). Accordingly, we utilise the same approach.

With regards to inaccessibility to modern cooking fuels, we use population relying on solid fuels for cooking and/or heating as indicator. Therefore, using Gross Domestic Product per capita (hereafter 'GDP') as indicator for economic development, we analyse the relationship between inaccessibility to modern cooking fuels and economic development across the three most energy deprived regions in the world: South Asia, East Asia, sub-Saharan Africa. The remainder of this paper is organised as follows. Section 2 gives an overview of the data and methodologies used in the analyses. Section 3 presents the results while section 4 discusses and concludes.

2. MATERIALS AND METHODS

2.1 Data

Regarding the data used in this work, the aggregate annual time series data on access to clean cooking fuels and GDP per Capita are utilized. These variables are used in natural logarithm forms.

2.2 Methods

The panel cointegration method is applied to establish the relationship between use of traditional[1] cooking fuels (hereafter 'solid') and GDP. This is due to its ability to allow for heterogeneity amongst individual panel members whilst demonstrating their relationships.

Four stages of analyses were applied in this work. First, to investigate the stationarity properties of the variables - solid and GDP, the panel unit root tests were performed. Next, upon satisfying the condition that all variables are stationary when integrated at first differencing .i.e. at order one (1), cointegration tests are performed. Following this, based on the results from the cointegration analyses, if the variables are found to be cointegrated, using panel Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS), we examine the cointegration elasticities. Finally, a panel error correction model is used to establish the direction of causality before determining the shortrun causality between the variables.

2.2.1 Panel unit roots tests

Nsiah et al., Wang et al., and Inglesi-Lotz, are amongst econometric studies which have used panel unit root tests to examine the degree of integration between variables Inglesi-Lotz (2016); Nsiah

[1] sometimes referred to as 'solid'

and Fayissa (2013); Wang et al. (2011). In this study, to comprehensively investigate the stationarity properties of Solid and GDP, we utilise five panel unit root tests: Levin, Lin and Chu (LLC); Im, Pesaran and Shin (IPS); ADF and PP Fisher (MW); Breitung and Hadri.

The LLC test is based on the Augmented Dickey-Fuller (ADF) test and is the most commonly used test amongst the five. It assumes the panel to be homogeneous .i.e. have the same autoregressive (AR) coefficients under both null and alternative hypotheses. The IPS test on the other hand, allows for heterogeneity by considering the averages of the ADF tests as well as the likelihood ratio. Yet, both tests suffer a shortcoming of assuming cross sectional independence across the panel units Hoang and McNown (2006). As such, to consider potential cross sectional correlation, we further utilise MW, Breitung and Hadri tests.

In comparison to the LLC and IPS tests which use bias-corrected estimators, due to its use of unbiased estimators, the Breitung test produces a higher test power Breitung (2000).

However, unlike the LLC, IPS and Breitung tests which are asymptotic, the MW test which is based on Fisher test, is non-parametric Maddala and Wu (1999). Due to its use of combined p-values of respective unit root tests for analyses, compared to the LLC and IPS tests, the MW test has a higher test power Maddala and Wu (1999).

Lastly, using a residual-based Lagrange Multiplier (LM) approach, the Hadri test regresses the output on a constant to produce OLS residuals Hadri (2000).

With regards to the null hypotheses for the tests; LLC and IPS assume a unit root (non-stationarity) as null hypothesis; the Breitung and MW tests also assume a non-stationary (unit root) null hypothesis while the Hadri and Heteroscedastic consistent z-stat tests assume a stationary null hypothesis.

2.3 Panel cointegration

At this stage of the analysis, the Pedroni panel cointegration tests are utilised to investigate the relationship between solid and GDP. The Pedroni methods determine cointegration between variables by applying heterogeneous panel and group mean test statistics Pedroni (1996, 1999).

From the tests, seven statistics which are grouped into two categories are obtained. Derived by pooling the residuals from the within dimension of the panel, the 'panel cointegration statistics' group is obtained. The *panel v-statistic*, *panel ρ-statistic*, *panel PP-statistic* and *panel ADF-statistic*; all belong to this group Pedroni (1999). On the other hand, the 'group panel cointegration statistics' comprising of *group ρ-statistic*, *group PP-statistic* and *group ADF-statistic* are derived by pooling the residuals from the between dimension of the panel Pedroni (1999). However, Pedroni tests assume cross-sectional dependency across the panels. As such, the Kao and Fisher cointegration tests are applied as robustness checks. The Kao test, uses the Engle-Granger (residual based) approach whilst the Fisher cointegration test uses a maximum likelihood (non-parametric based) approach.

2.4 Long run cointegration estimation

Upon observing cointegration between solid and GDP, the long-run relationship between the two variables is assessed. The panel DOLS and FMOLS tests are applied at this stage. The DOLS test, proposed by Mark and Sul, adjusts errors by augmenting the static regressor with lags and leads of first differences Mark and Sul (2002). Thus, resulting in lowered degrees of freedom. Contrarily, the FMOLS test proposed by Pedroni, only analyses the correlation between the first differences of the regressor and the error term. As a result, the FMOLS has higher degrees of freedom: due to fewer assumptions.

Consequently, in spite of both methods generating consistent error estimates, there are varied opinions regarding which of the tests is more robust Kao (1999); Wongkhae and Sriboonchitta (2012); Bispham (2008).

2.5 Panel Granger causality

Using the long-run relationship results obtained in section 2.4, we apply the Granger causality test to determine the direction of causality between the variables. For this stage, firstly the residuals from the DOLS and FMOLS models are analysed. Following this, the evaluated residuals are then fitted into a vector error correction model. The speed of adjustment .i.e. the coefficient as well as the significance of the error correction models are then analysed to establish the presence (or absence) of both long-run and short-run causality.

3. RESULTS

Table 1 shows the results obtained from the different unit root models. The results express the presence (or absence) of unit root in the variables. As detailed in section 2.2.1, the first five tests have a null hypothesis of unit root whilst the last two have a null hypothesis of no unit root.

For the GDP variable, at level with and without trend, the null hypothesis of unit root cannot be rejected at 1%, 5% or 10% significance levels across the first five tests whilst for the Hadri and Heteroscedastic consistent z-stat tests, the null hypothesis of no unit root can be strongly rejected at 1%, 5% or 10% significance levels.

For Solid (with and without trend), results similar to the GDP variable are obtained. The null hypothesis of non-stationarity cannot be rejected for the LLC, IPS, Breitung and Fisher-Chi tests whilst the null hypothesis of stationary can be strongly rejected at 1%, 5% or 10% significance levels for the Hadri and Heteroscedastic consistent z-stat tests.

Table 1: Results for panel unit root tests for GDP and Solid.

		Null: Unit root					Null: No unit root	
	Tests / Variable	Levin, Lin and Chu (LLC)	Im, Pesaran and Shin (IPS)	Breitung	ADF - Fisher Chi square	PP - Fisher Chi square	Hadri	z-stat
Level	GDP	-1.1212 (0.1311)	0.8918 (0.8137)	–	2.5593 (0.8618)	0.9222 (0.9884)	3.7246 (0.0001)	3.7883 (0.0001)
	GDP (trend)	1.2035 (0.8856)	0.8443 (0.8007)	1.8563 (0.9683)	4.1453 (0.6570)	5.4072 (0.4927)	2.3169 (0.0103)	2.3335 (0.0098)
	SOLID	3.0007 (0.9987)	4.4253 (1.0000)	–	0.2544 (0.9997)	3.5888 (0.7321)	4.1189 (0.0000)	4.1257 (0.0000)
	SOLID (trend)	1.0347 (0.8496)	0.7132 (0.7621)	2.2630 (0.9882)	10.3157 (0.1120)	22.7917 (0.0009)	2.3967 (0.0083)	8.1739 (0.0000)
First difference	GDP	-1.7974 (0.0361)	-1.8103 (0.0351)	–	13.4810 (0.0360)	20.0668 (0.0027)	0.4403 (0.3299)	0.7129 (0.2379)
	GDP (trend)	-2.5189 (0.0059)	-0.4539 (0.3249)	0.6455 (0.7535)	7.3869 (0.2865)	9.9007 (0.1289)	3.6883 (0.0001)	5.0667 (0.0000)
	SOLID	-3.0472 (0.0012)	-2.6253 (0.0043)	–	22.7102 (0.0043)	21.9717 (0.0012)	0.7658 (0.2219)	2.8634 (0.0021)
	SOLID (trend)	-3.8279 (0.0001)	-2.4380 (0.0074)	- 1.1177 (0.1319)	20.4387 (0.0023)	25.0760 (0.0003)	4.4272 (0.0000)	8.0983 (0.0000)

Moving to the first differenced variables, for GDP and Solid with trend, we can strongly reject the null hypothesis of unit root at 5% significance for the first five tests but can not accept the

null hypothesis of stationarity for the Hadri and z-stat tests.
However, for GDP and Solid without trend, at 5% or 10% significance levels, we can strongly reject the null hypothesis of unit root for the LLC, IPS, Breitung and Fisher-Chi tests whilst for the Hadri and Heteroscedastic consistent z-stat tests, we cannot reject the null hypothesis of no unit root at 5% or 10% significance levels. Thus, we accept the null hypothesis of no unit root for these tests.
As such, we can conclude that the panel unit condition required for cointegration analysis has been fulfilled. The variables are non-stationary at level but stationary when integrated of order one (I(1)).

Table 2: Results for Pedroni residual cointegration tests.

Tests	Within panel statistics			Between panel statistics		
	Type	Statistic	p-value	Type	Statistic	p-value
GDP, SOLID	panel v-statistic	1.4016	0.0805	group rho-statistic	0.3668	0.6431
	panel rho-statistic	-0.4226	0.3363	group PP-statistic	-1.6914	0.0454
	panel PP-statistic	-2.2655	0.0117	group ADF-statistic	-1.9650	0.0247
	panel ADF-statistic	-2.9228	0.0017			
GDP, SOLID (weighted statistic)	panel v-statistic	0.6680	0.2521			
	panel rho-statistic	-0.2901	0.3859			
	panel PP-statistic	-1.8934	0.0292			
	panel ADF-statistic	-1.9883	0.0234			

The results from the Pedroni cointegration tests are given in Table 2. Considering the unweighted cointegration tests, the null hypothesis of no cointegration can be strongly rejected at 5% significance in four (4) out of the seven (7) tests, and rejected at 10% significance in a 5th test. With regards to the weighted tests, the null hypothesis of no cointegration can be strongly rejected at 5% for the panel PP and ADF tests but cannot be rejected for the other two (2) tests. Taken together, out of eleven (11) tests, we can strongly reject the null hypothesis of no cointegration in 7 tests. Consequently, it can be deduced from these results that there is a strong possibility of a long-run relationship between Solid and GDP.

Table 3: Results for Kao's residual cointegration test.

Model	ADF	p-value
GDP, SOLID	-0.6996	0.2421

However, the Kao test is applied for robustness check. In Table 3, the results obtained from the Kao residual test are presented. The result shows that the null hypothesis of no cointegration cannot be rejected. As such, for the Kao test, we have to accept the hypothesis of no cointegration between Solid and GDP.
Considering the results from Pedroni and Kao tests, we conduct further robustness checks using Fisher-type cointegration tests.

Table 4: Results for Fisher-type cointegration tests.

Null hypothesis	Fisher stat* (trace test)	p-value	Fisher stat* (max-eigen test)	p-value
ce = 0	27.61	0.0001	24.68	0.0004
ce ≤ 1	10.29	0.1130	10.29	0.1130

The results from the Fisher-type cointegration tests are presented in Table 4. For *ce = 0*, the null hypothesis here indicates that the number of cointegration between Solid and GDP is zero. In this case, for both the trace and max-eigen tests, we can strongly reject the null hypothesis at 1% significance. In the case of *ce = 1*, which implies an existence of at least one cointegration in the model, we cannot reject the null hypothesis. As such, we accept the hypothesis that there exists at least one cointegration in the model.
Therefore, considering that we can strongly accept the premise of cointegration between Solid and GDP, in three (3) out of the four (4) cointegration tests performed, the next stage involving the estimation of the long-run elasticities is implemented.

Table 5: Results from DOLS and FMOLS tests.

	Models	
	DOLS	FMOLS
Co-efficient	-61.0918	49.8929
Std.Error	3.0834	8.2559
t-statistic	-2.0307	6.0433
p-value	0.0515	0.0000

The results from the DOLS and FMOLS models using GDP as the dependent variable are presented in Table 5. For this stage, due to the test statistics, we particularly focus on the results from the DOLS test. For the DOLS test to be valid, two conditions must be met: the *coefficient* must be negative and the *p-value* must be significant. The results obtained from our DOLS model show a negative and significant relationship between Solid and GDP - satisfying both conditions. The obtained results can thus be interpreted as such: a unit increase in Solid fuel use, would result in a 61.09 unit decrease in GDP per Capita.

Table 6: Results for Granger causality test (L = lags).

Independent variable	f-statistic	p-value	Sense of causality
	GDP		
SOLID (L = 1)	1.2340	0.2729	
SOLID (L = 2)	1.7639	0.1855	SOLID → GDP
SOLID (L = 5)	1.3122	0.2952	
	SOLID		
GDP (L = 1)	39.2465	2e-07	
GDP (L = 2)	6.7489	0.0032	GDP → SOLID
GDP (L = 5)	2.8013	0.0418	

Upon establishing the cointegration in the long run, we investigate the direction of causality between the two variables. Table 6 shows the obtained results for the optimal lag structure of 1, as well as lag structures of 2 and 5. The results obtained from the models can be interpreted as follows: when considering a long-run causal relationship which runs from Solid to GDP per Capita, the null hypothesis of no causality cannot be rejected for the optimal lag structure, the second lag or fifth lag structures.

When considering a long-run causality running from GDP per Capita to Solid, the null hypothesis of no causality can be strongly rejected at 1% significance for the optimal and second lag structures, and 5% significance for the fifth lag structure.

Consequently, we can conclude that the long-run causality flows from GDP per Capita to Solid.

Finally, using Wald test, we consider the short-run relationship between the two variables. The obtained results are presented in Table 7.

Table 7: Short-run causality results.

Dependent variable	Chi-square	p-value	Sense of causality
SOLID	14.4803	0.0007	GDP → SOLID
GDP	0.7798	0.6771	SOLID → GDP

When considering the f-statistic and chi-square statistics, the results in Table 7 can be interpreted as follows. With GDP as the dependent variable, the null hypothesis of no short-run causality can not be rejected meaning that there is no short-run causality running from Solid to GDP per Capita. Considering Solid as the dependent variable, the null hypothesis of no short-run causality can be strongly rejected at 1% significance. Therefore, we can conclude that there is a short-run causality that runs from GDP per Capita to Solid.

4. CONCLUDING REMARKS

This paper has empirically analysed the relationship between the household use of traditional fuels for cooking and/or heating and economic development in the three energy most impoverished regions in the world - South Asia, East Asia and sub-Saharan Africa: using the aggregate data for these regions over a period of 15 years.

The relationship between energy[2] and economic development has been hypothesised to fall into one of the following categories: neutrality, conservation, growth and feedback hypotheses.

The results obtained from the analyses strongly indicate cointegration between the two variables of interest. In fact, the result from the DOLS model (Table 5) which demonstrates the cointegration elasticities, indicate that solid as a dependent variable, negatively influences GDP per Capita. What's more, our causality analyses indicate a uni-directional causality relationship, running from GDP per Capita to Solid. Thus, strongly supporting the energy-economy conservation hypothesis; implying that in the case of these impoverished regions, the economic developments in the regions actively influence the level of household usage of traditional fuels.

These findings have important implications. To exemplify, although it could be argued that improved economic conditions would increase access to clean, modern cooking alternatives, the results from the DOLS model would suggest that the continued use of traditional fuels might hamper the potentialities of improved economic conditions. Of course, the economic performances of countries and/or regions are complex dynamics influenced by many factors. Nonetheless, the results suggest that inaccessibility to modern cooking energy forms negatively impacts on the economy. As such, to improve economic conditions, this aspect of the energy poverty issue would have to be addressed.

From a policy perspective, energy conservative policies such as traditional-fuel use reduction strategies, demand management measures, amongst others, might positively impact on the economic development

[2] Here, we talk about general energy consumption

of these regions.

To conclude, it can be implied that when looking to address general poverty, developing countries need to address energy poverty as an aspect of the issue. All in all, as a part of improving general economic development and addressing general poverty, it would be beneficial for developing South Asian, East Asian and sub-Saharan African countries to continue to progress from traditional cooking fuels to modern cooking alternatives.

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