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Fateh Belaid

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Send correspondence to:
Fateh Belaid
Lille Catholic University
fateh.belaid@univ-catholille.fr

[1] Faculty of Management, Economics and Sciences, Lille Catholic University, UMR 9221-LEM-Lille Économie Management, F-59000 Lille, France. Email: fateh.belaid@gmail.com

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Abstract

This article, using ERF-LIS harmonized microdata, develops an empirical model to investigate the unexplored extent and fuel poverty explanatory factors in Egypt and Jordan. First, we use the "Low income – High Consumption" indicator to measure the fuel poverty extent. Second, we implement a multivariate statistical approach to untangle the fuel poor household profile. Then, to explore the factors driving the risk of falling into fuel poverty situations we use a logistic regression model. This research is an important empirical contribution to the sparse literature of fuel vulnerability in MENA countries. It puts forward an empirical approach, which is helpful in discerning and targeting families most in need of energy and financial related assistance. From policy perspectives, the findings provide promising ways of accounting for the fuel poverty phenomenon as a vector of inequality trends in the MENA region. The main findings of the research point to the crucial instrumental role of economic conditions, reducing inequalities and access to education facilities in attenuating fuel poverty in Egypt and Jordan. Policies that mitigate fuel poverty may thus have direct impacts on both well-being and inequalities reduction.

Keywords: Fuel poverty; Energy Justice; Inequality; Residential energy consumption.
JEL Classifications: C1, D1, I3 Q4.

1. Introduction

The recent heightened awareness of energy security, climate change, poverty, and inequality have drawn attention to the fuel poverty- and energy-social justice nexus. In the past decade, various reports and research have demonstrated that access to energy must be a crucial part of all development, poverty and equality alleviation programs, and policy (WB, 2000, UNDP, 2000; Pachauri and Spreng, 2004). Therefore, fuel poverty has been recognized as a distinct form of inequality (Galvinand Sunikka-Blank, 2018; Burlinson et al., 2018). Its adverse impacts on household conditions led to a flurry of concern both in policy and in academic debate. One core of investigation has been the measurement of fuel poverty extent, and the determinants of fuel poverty situation. Nevertheless, there is a remarkable agreement among economists about the crucial role of addressing fuel vulnerability and cold home-related negative health impacts in improving the life quality of many households by making their homes warmer and more efficient. Furthermore, reducing fuel poverty could substantially reduce inequalities in health, as well as making an important contribution to tackling residential greenhouse emissions. Accordingly, this study subsumes the energy cost and income-induced- fuel poverty definition within the "Low income – High Consumption" indicator (Hills, 2012) to examine a crucial question, which has come up in recent years in both policy and economic literature; that is, fuel poverty as a new dimension of inequality.

The context of our analysis is the fuel poverty scope in Egypt and Jordan, growing MENA counties. Egypt and Jordan are an interesting setting for our analysis as the two countries experienced substantial economic and energy reforms in recent years while, as our finding will suggest, large numbers of households are exposed to a significant risk of fuel poverty. In addition, as far as we know, despite the expanding literature on the field of fuel poverty, there have been no empirical studies about fuel poverty in MENA countries, particularly in Egypt and Jordan.

The concept of fuel poverty first appeared in the UK in Boardman's (1991) ground-breaking study. Defined in broad terms in the early 80s (Moore, 2012). Accordingly, a household is considered as fuel poor, if it is unable to afford adequate warmth due to the poor energy performance of the house (Boardman, 1991). This notion updated recently in the light of the nascent body of knowledge and research agenda (Hills, 2012; Moor 2012). Main themes in this body of knowledge include definitions of fuel poverty situation (Moor, 2012); household energy demand (Bélaïd, 2016, 2017; Bélaïd and Garcia, 2016; Lévy et al., 2014; Lévy and Bélaïd, 2017, Belaïd and Joumni, 2020); energy justice (Galvina and Sunikka-Blankb, 2018); assessment of fuel poverty extent and its relation to energy poverty (Hills, 2012); technical measures and policy schemes to reduce fuel poverty (Ambrosio et al., 2015); energy efficiency as a policy instrument to alleviate fuel poverty exposure (Bakaloglou and Bélaïd, 2018); and the interaction between the key component of fuel poverty situation, income poverty, energy price, and housing energy performance (Galvina and Sunikka-Blankb, 2018; Belaid et al., 2018, 2019).

Nevertheless, the impact of limited income and rising energy costs on people's ability to 'keep warm' and to attain a necessitated level of energy services in their homes has been the subject of rigorous studies in developed countries, however, this topic is understudied in the developing countries. Nonetheless, Makdissi and Wodon (2006), based on the 1998/99 National Survey of Household Income and Expenses, investigated fuel poverty in Guatemala. They compared the extent to which households without access to electricity are more likely to experience fuel poverty compared with a household with access to electricity. In this study, fuel poverty was linked to cooking fuel.

In addition, despite the growing interest regarding fuel poverty assessment and the main factors driving the fuel poverty phenomenon, gaps in evidence remain (Moher, 2018). This conjecture is the foundation of the present study, aiming to answer calls in recent literature to outline why the measurement and understanding of fuel poverty are important in policy formulation. As well, it describes how the mitigation of the phenomenon is important in reducing inequalities (Moore, 2012; Poruschi et al., 2018). Given the struggle that policies have had to eradicate the fuel poverty phenomenon, it is clear that the fuel poverty concept may cause huge divergence among scholars and policymakers, since it focuses on an issue pertaining to household income and energy costs, with energy efficiency improvement, as a policy intervention and a bridge between the two factors.

In embarking on this path, this research contributes to this nascent stream of literature in several ways. First, our empirical evidence contributes to the existing literature in terms of how low income and energy-cost-induced drive fuel poverty and inequality. Surprisingly, as far as we know, MENA countries have paid little consideration of this issue. Second, this study provides an overview of fuel poverty definitions and extent and puts forward an empirical strategy, which can help to identify and target the households most in need of energy and financial-related assistance. Understanding the scope of fuel poverty is important for various reasons including the reduction of inequality (Boardman, 2013); improving health conditions of households living in cold housing units (Hernández, 2016); considering and upgrading housing stock energy efficiency (Boardman, 2012); and mitigating carbon emissions (Herrero and Ürge-Vorsatz, 2012). Third, this research is an important empirical contribution to the sparse literature of fuel vulnerability in MENA countries. This is the first study aiming to provide a fuel poverty profiles in Egypt and Jordan. Fuel poverty profiles are an easy way of summarizing information on the fuel poverty levels and the fuel poor households attributes. In addition, they provide crucial clues to the underlying drivers of fuel poverty situation. Finally, developing a model in two different countries will help to test the robustness of the proposed methodology. Moreover, Egypt and Jordan offer an interesting comparison, as their energy and economic situations face very different challenges. The proposed cross-country comparative analysis will be useful in exploring the extent to which various national policies have differentially affected the vulnerability of poor households.

Given the existence of ambitious policy goals aimed at reducing overall fuel poverty phenomena, the effects of various economic and technical factors on fuel poverty uncertainty represent a challenging issue for both researchers and policymakers as unintended side effects of the future conditions. The proposed study relates to two strands of research, at least. First, we contribute to the studies related to the fuel poverty measurement in developing countries. This literature focuses on the definition and measurement of fuel poverty concept. Exploring UK government policies and instrument to alleviating fuel poverty over the recent years, and especially the recent emphasis incarnated in the Hills study (Hills, 2012), Middlemiss (2017) asserts, all the key component of fuel poverty must be tackled to reduce its adverse impact on vulnerable households, including income inequality, energy price, and dwelling energy efficiency. This argument illustrates the complexities in defining the fuel poverty situation and recognizing the families who match the definition. Recent research recommended shifting from "spending more than 10% on income on energy bill" to "Low income and High costs" definition of fuel poverty (Hills, 2012; Mohr, 2018).

Second, there is another nascent strand of research, which is mainly composed of studies outlining the predictors of fuel poverty situation. This topic focuses mainly on the role of socio-economic and dwelling technical factors in shaping the fuel poverty situation. Recently, focusing on the role of different predictors on fuel poverty in the US, Mohr (2018) used a logistic regression based on the US Energy Information Administration's 2009 Residential Energy Consumption Survey (RECS). Aiming to untangle reasons behind vulnerability to fuel poverty burden, Moher (2018) provides an overview of fuel poverty extend in the US, and emphasized that head education level, marital status, age of the head, and employment status are principal drivers for fuel poverty. Further, Motivated by exploring the determinants of the dwelling-cost induced dimension of fuel poverty in the UK, Burlinson et al. (2018) used a multinomial regression model based on data from the English Housing Survey. They argued that the fuel poverty dimensions induced from the LIHC indicator are each linked with a specific group of housing and socio-economic attributes.

As stated above, given the importance of fuel poverty as a distinct form of poverty, surprisingly, little attention has been paid to the extent of fuel poverty in MENA. Aiming to fill this gap, we provide an overview of fuel poverty in Egypt and Jordan using three main economic factors, including household income, dwelling costs, and energy costs. In addition, we develop an empirical approach to explore the key predictors of fuel poverty. The methodological innovation is the use of (i) recent and rich individual microdata; and (ii) the implementation of an empirical method based on innovative indicators and an innovative logistic regression model. Finally, besides the question of enriching the recent policy debate regarding fuel poverty and inequalities, this research provides promising ways of accounting for the fuel poverty phenomenon as a vector of inequality trends in the MENA region. The findings of this research bear important policy implications that may generalize well beyond the Egypt and Jordan context. Our results provide clear motivation for policy interventions to reduce household's exposure to fuel poverty trap. They also suggest that the resulted fuel poverty profiles may serve as a basis for targeted energy policy interventions tailored to specific socio-economic groups.

The remainder of this article is organized as follows. Section 2 describes the data, introduces the main variables used in the empirical analysis, and presents the empirical modeling approach. In Section 3 we display the main empirical results. Section 4 provides some concluding remarks and the policy implications of this study.

2. Data and empirical methodology

2.1. Data

Based on the latest 2015 Egyptian Household Income, Expenditure, and Consumption Survey (HIECS) and the latest 2013 Jordanian Household Expenditure and Income Survey (HEIS) provided by ERF-LIS[2], we develop an empirical model of exploring the "Low income – High Consumption" definition to measure the extent of fuel poverty and illustrate the poor household profile. Further, we question the explanatory factors of the fuel poverty situation in both Egypt and Jordan.

The 2015 HIECS and 2013 HEIS are rich data sets containing over 240 variables. These surveys provide detailed information on household income and housing expenditure, including electricity, gas, and other fuel expenditures. In addition to valuable information on household socio-economic attributes (e.g., age of the head, marital status, gender, ethnicity, etc.), the survey contains rich data on housing characteristics and conditions, including housing size, type of structure, source of energy, health facility, etc. Descriptions and descriptive statistics for the factors used in the multivariate statistical and econometric analysis are displayed in Table 1.

[2] Economic Research Forum (http://www.erfdataportal.com/index.php/catalog), and Luxembourg Income Study (LIS) Database, http://www.lisdatacenter.org (multiple countries; { microdata runs completed during July and December 2019}). Luxembourg: LIS.

Table 1. List and description of modeling and classification variables

		Original sample		Clustering sample	
		Egypt	Jordan	Egypt	Jordan
Variable	Categories	Freq.	Freq.	Freq.	Freq.
Household income (per quartiles) (TOTDINCQ)	Less than 20249 (Jordan 4771)	25.00	24.99	24.98	24.87
	From 20250 to 26636 (4772 to 6909)	25.00	25.01	24.98	25.13
	From 26637 to 34133 (6910-10282)	25.00	24.99	24.98	25.00
	More than 34134 (More than 10282)	25.00	25.01	25.07	25.00
Gender of the head (SEXHD)	1 Mal	82.45	86.21	79.70	83.12
	2 Female	17.55	13.79	20.30	16.88
Education level of the head (EDUHD)	1. None	41.71	21.07	59.30	30.63
	2. Primary/Lower secondary	14.16	48.78	15.82	48.56
	3. Secondary	31.95	19.20	20.90	16.23
	5. University	12.18	10.95	3.98	4.58
Household composition (HCOMP)	1 1-2 adults, no children	17.23	12.04	18.91	10.73
	2 1-2 adults, 1-2 children	18.28	14.52	14.13	8.38
	3 1-2 adult, 3 or more children	23.53	26.45	13.83	20.16
	4 3 or more adults, 0-1children	23.92	23.55	29.45	24.74
	5 3 or more adults, 2-3 children	13.17	12.97	15.42	15.45
	6 3 or more adults, 4 or more children	3.88	10.47	8.26	20.55
Main activity status of the head (MASHD)	1. Employed	72.95	56.56	62.09	42.41
	3. Homemaker (Housewife)	8.70	10.58	11.54	13.74
	5. Pensioners/retired/disabled	1.25	19.36	24.78	24.21
	6. Others	17.10	13.51	1.59	19.63
Head living in couple (MARRIEDC)	0 No couple present in household	21.47	16.54	22.99	20.29
	1 Married couple head and spouse	78.52	83.46	77.01	79.71
Age of the head (AGEHD)	Less than 39	23.63	28.49	14.33	14.79
	From 40 to 48	24.82	27.38	22.09	29.45
	From 49 to 59	26.06	20.60	30.65	25.92
	More than 60	25.49	23.53	32.94	29.84
Number of rooms (ROOM)	1 to 2 Rooms	9.54	10.39	8.76	7.85
	3 Rooms	39.86	32.68	44.38	32.46
	4 Rooms	36.91	31.22	34.83	34.55
	More than 4 Rooms	13.69	25.71	12.04	25.13
Type of dwelling (DWLTYP)	1 House	17.58	54.14	20.60	45.94
	3 Apartment	77.66	45.81	75.52	53.93
	4 Others	4.76	0.04	3.88	0.13
Type of tenure (DWLTEN)	1 Rented	14.37	17.42	14.63	21.99
	2 Owned	72.09	78.97	76.52	75.79
	3 Provide free	13.54	3.61	8.86	2.23
Urban structure (RURURB)	0 Rural	56.45	37.09	58.11	33.38
	1 Urban	43.55	62.91	41.89	66.62
Has Internet (INTERNET	0 No	82.79	66.99	89.15	71.20
	1 Yes	17.21	33.01	10.85	28.80
Has a computer or laptop (COMPUTER)	0 No	68.65	55.15	79.20	59.16
	1 Yes	31.35	44.85	20.80	40.84
Has a Vacuum (VACUUM)	0 No	78.41	42.16	89.75	51.70
	1 Yes	21.59	57.84	10.25	48.30
Has an air conditioner (COND)	0 No	87.12	83.67	90.15	83.38
	1 Yes	12.88	16.33	9.85	16.62

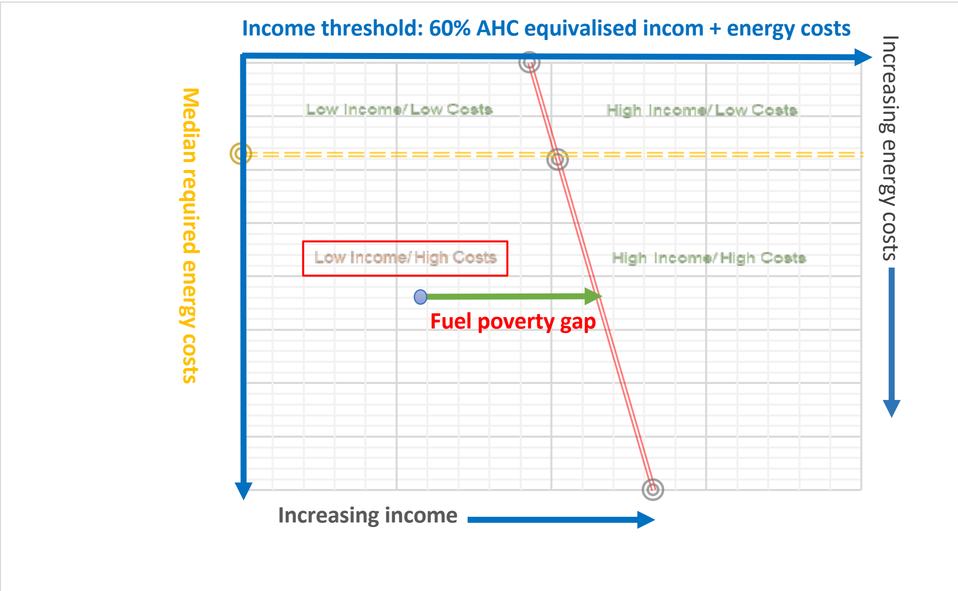
2.2. Empirical methodology

To be able to adequately address the main research questions of this study we developed an empirical approach based on three key steps. First, we present an overall picture of fuel poverty in Egypt and Jordan based on the LIHC definition. Further, we provide a description of the fuel poor households under the LIHC definition using a multivariate statistical approach. Finally, we explore the role of key factors driving fuel poverty using a binary logit model.

2.2.1. Measurement of fuel poverty

First, to outline the role of income and energy expenditure in shaping the fuel poverty situation in Egypt and Jordan, we use the "Low income – High Consumption" index proposed by Hills (2012). Accordingly, as illustrated in Fig.1, is considered as fuel poor: (i) who spend more than the national median level on fuel costs, and (ii) are left with a residual income below the official poverty line (i.e. below 60% of the national median level). The chief advantage of the proposed measure is that it allows the assessment of the so-called fuel poverty gap, which depicts the additional income needed to overcome fuel poverty. It is worth noting that up to now, there is no consensus on how best to measure whether an individual is being trapped in fuel poverty. A ten percent threshold of household actual fuel expenditure has been widely used at the European level (Roberts et al., 2015). Nevertheless, indicators of who are in fuel poverty based on actual expenditure have widely been criticized. The rational argument is that these indicators miss those households responding to energy vulnerability by reducing thein energy expenditure (Roberts et al., 2015). This shifted the definition of fuel poor to "low income- High cost". This new measure, introduced in the UK based on the Hill's independent review of fuel poverty (Hills, 2012), captures the dual aspects of the problem arising from income poverty and poor dwelling energy performance (efficiency).

Figure 1. Fuel poverty measurement under the LIHC approach



2.2.2. Fuel poor household profiles illustration

Second, we develop a multivariate statistical approach based on Multiple Correspondence Analysis and Ascendant Hierarchical Classification (HCA) technics to describe the poor household profile based on several factors, including household features, and housing characteristics. The resulting fuel poor classes may serve as a basis for targeted energy policy interventions tailored to specific socio-economic groups of households, which are in severe fuel precariousness. The identified profiles are particularly crucial in evaluating targeted policy interventions, which allows policy measures to be oriented towards specific groups of individuals, particularly households that are in severe fuel precariousness.

2.2.3. Investigating the explanatory factors of fuel vulnerability

Finally, we develop a logistic regression model to examine the factors driving the risk of falling into fuel poverty situations. The main purpose is to untangle the reasons households may be more or less vulnerable to high risk of fuel poverty. The results will have important policy implications and will be valuable in determining the most efficient policy interventions to mitigate the fuel poverty phenomenon. For this study, being in fuel poverty includes spending more than the median level on domestic energy and having a residual income below the poverty line**.** We estimate a binary logit model for each country. The logit model for the binary response y is specified as follows:

$$P(y = 1|x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k$$

y represents the dependent variables and defended as follows:

$$y_1 = \begin{cases} 1: \; if\ the\ houshold\ is\ in\ fuel\ poverty \\ 0: \; otherwise \end{cases}$$

x_i are the dependent factors (explanatory). Assuming that x_1 is not functionally related to other explanatory factors, $x_1 = \partial P(y = 1|x)\partial x_1$. Accordingly, $x_1$represents the change in probability of success given a one-unite increase in x_1. In our case, β_1 represents the difference in the probability of success when $x_1 = 1$ and $x_1 = 0$, holding the other factors x_j fixed.

The list of potential determinants of fuel poverty is identified drawing a systematic review of the existing policy and academic literature (See Table 1). This list includes household equalized income, age of the head, education status, employment status, household composition, marital status, tenure type, housing type, housing size, urban structure, and some control variables (e.g., having internet, computer, and vacuum).

3. Empirical results discussion

3.1. Fuel poverty extent in Egypt and Jordan

In this study, we used LIHC index to measure the fuel poverty extent both in Egypt and in Jordan. Accordingly, households with an energy bill above the national median level, and a residual income (equalized income after housing costs) below the poverty line are considered as fuel poor. Results in Table 2 indicate that the proportion of fuel poor households in Egypt is about 8.4%, which is lower than Jordan (16%). The difference in fuel poverty extend depends on the interaction between three main factors, including domestic energy price, income structure and housing energy performance. It is worth noting that despite the increase in electricity prices in recent years, energy prices in Egypt range among the lowest in the world. The electricity price in Egypt is about 0.03 U.S. Dollar/ kWh, where in Jordan the price is about 0.09 U.S. Dollar/ kWh.

Table 2. Proportion of households in fuel poverty and the average gap

Country	Households in fuel poverty proportion of	Households in fuel poverty numbers	Average fuel poverty gap
Egypt	8.38%	2.075 million	250
Jordan	15.75%	0.207million	117

The average fuel poverty gap in Egypt, which depicts the average reduction in the energy bill that the fuel poor household needs to leave the fuel poverty situation, is estimated at 250 Egyptian Pounds (15 US $) in Egypt and 117 Jordanian Dinars Jordan (165 US $). These results indicate that the average fuel poor family needs a reduction of 250 and 117, respectively, to move out of fuel poverty situation. The distributions of the fuel poverty energy gap are displayed in Fig. 2. and Fig.3.

Figure 2. Fuel poverty gap distribution in Egypt

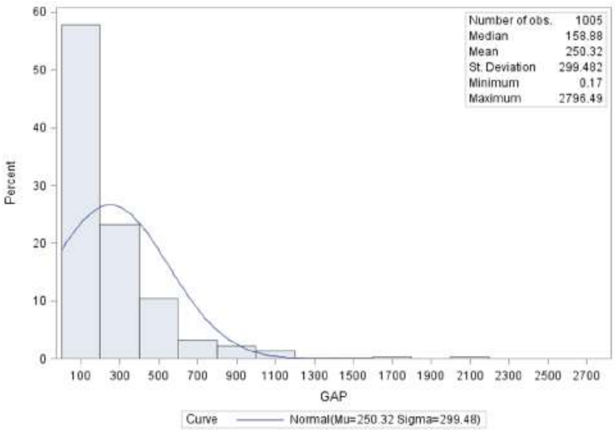
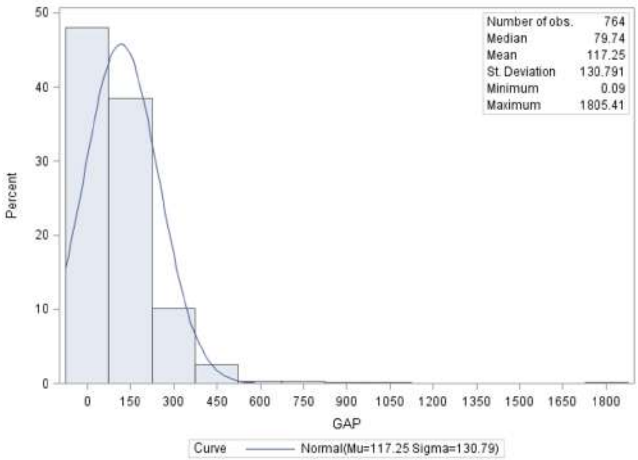
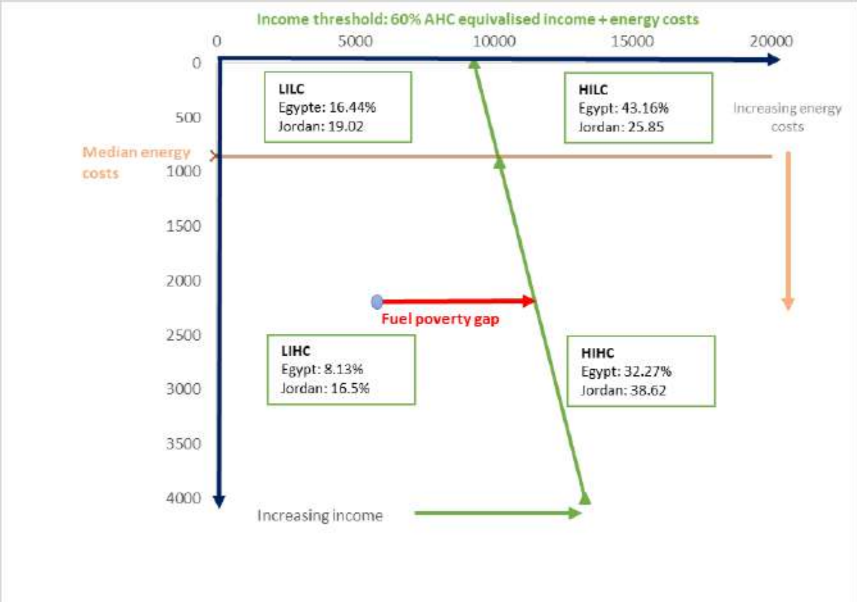


Figure 3. Fuel poverty gap distribution in Jordan



Based on a combination of a household's income and energy expenditure, the LIHC index allows group households into four dimensions. Fig. 4. Presents the proportion of households in each category.

Figure 4. Proportion of all households classified as fuel poor under LIHC in Egypt and Jordan



According to our analysis, 25% of households were classed as having a low income in Egypt (with 75% having a high income) and 40.42% of households were classed as having high fuel costs. Within the group of household with low income, an estimated 33.08% were fuel poor, and within the group with high-energy costs, an estimated 21 % were considered as fuel poor. However, in Jordan 35.52% of households were categorized as having a low income (with 64.47 having a high income), and 55.12% of households were classed as having high-energy costs. Within the category of household with low income, an estimated 43.76% were fuel poor, and within the group with high-energy costs, an estimated 31.51% were considered as fuel poor.

3.2. Fuel poverty profiles

To examine the profile of fuel poor households, we used multiple correspondence analysis and hierarchical clustering statistical approach. Four different profiles have been provided for each country. The hierarchical clustering on the factor map and the cluster dendrograms are displayed in figures **Fig. 5** and **Fig. 6**. The features of each profile are displayed in Table 3.

Based on the common descriptive factors, four homogeneous profiles of households experiencing fuel poverty under LIHC definition were defined in each country. The identified fuel poverty profiles provide a comprehensive overview of the dimensions of fuel poverty in Egypt and Jordan.

Figure 5. Cluster dendrogram and clustering on the factor map in Egypt

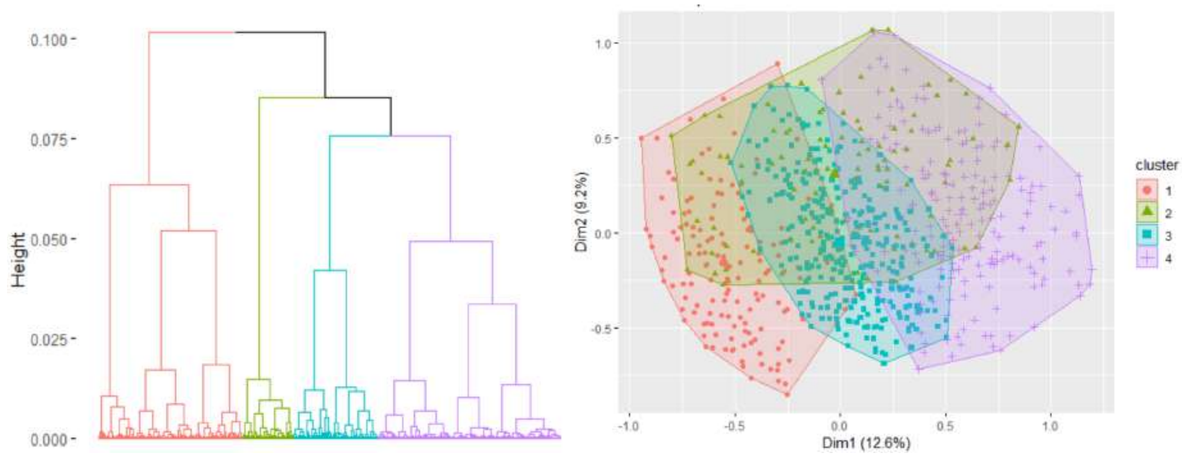


Figure 5. Cluster dendrogram and clustering on the factor map in Jordan

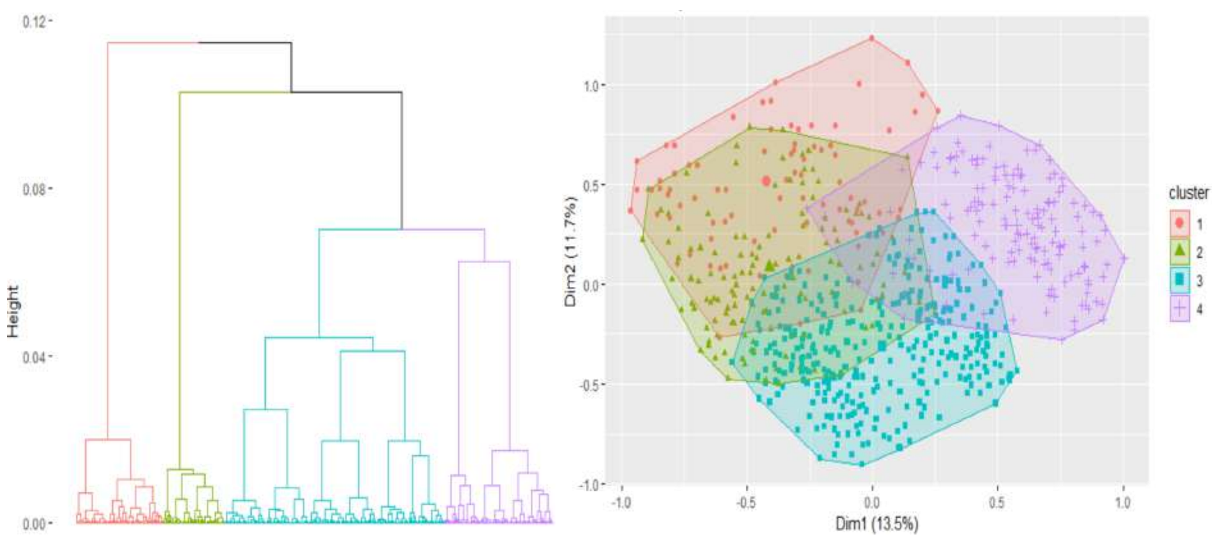


Table 3. Fuel poverty profiles description based on the LIHC indicator

		Composition of the clusters	
		Household	**Dwelling**
Cluster 1	**Egypt (20.6 %)**	Retired head (30%), Without any education level (78%), Age of the head > 60 years (49%), Highest income quartile: Q3 and Q4 (54% more than 34133), No computer (94%), No internet (99%).	Dwelling owner (92.27%); House (86%), 1-2 rooms (37%), More than 5 rooms (35%), Rural area (88%)
	Jordan (13.22 %)	Homemaker (99%), Unmarried (100%), Without any education level (70%), Age of the head > 60 years (50%) and 31% from 49 to 59 years, lower-income quartile (60% have less than 3680), No computer (78%), No internet (86%).	Dwelling owner (87%), Apartment (51%) Urban area (68%), Three rooms (41%)
Cluster 2	**Egypt (11.34 %)**	Homemaker (100%), Married (100%), Age of the head Q2 43% from 49 to 59 years, Lower-income quartile (40% have less than 20249), No computer (67%), No internet (84%)	Apartment (77%); Dwelling owner (81%); Rural area (54%); 95% more than two rooms.
	Jordan (19.63 %)	Retired head (74%), Without any education level (71%), Age of the head> 60 years (84%), Lower-income quartile (36% have less than 3680), No computer (84%), No internet (86%).	Dwelling owner (95%), House (64%), Urban area (50%), More than 2 rooms (91%)
Cluster 3	**Egypt (47.36 %)**	Employed (54%), Married (53%); No computer (88%); No internet (98%), No education level (61%), University level (2%); Age of the head Q3 and Q4 (64% more than 50 years; income Q1 and Q2 (49% less than 26636)	Dwelling owner (93%); Apartment (99%), Rented home (48%), Rural area 63%, 1 to rooms 49%
	Jordan (46.47 %)	Employed (61%); Married (97%); Primary education level (63%), Age of the head Q2 and Q3 (73% 40 to 60 years), Income Q3 (36%) (From 4979 to 6529) and 34% Q4 more than 6529; Computer (55%), Internet (39%).	Dwelling owner (98%), House (52%) More than Three rooms (73%), Urban area (62%).
Cluster 4	**Egypt (20.70%)**	University education level (12%); Secondary education level (43%), Age of the head Q1 and Q2 (50% less than 50 years), Income from Q2 (26%) (From 20249 to 26636), Internet (39%), Computer (51%).	Rented home (88%), Apartment (96%); Urban area (81%), Three rooms (49%).
	Jordan (20.68%)	Employed head (63%), Married (87%), Primary education (56%), Age of the head Q1 and Q2 (60% less than 50 years), Income Q1 less than 3680 (34%) and Q2 from 3680 to 4978 (30%), No computer (54%), No internet (70%).	Not owner (100%), Urban area (92%), Apartment (87%), More than 2 rooms (90%).

Looking for the fuel poverty profiles in Egypt, the first group represents about 20.6% of the total sample. People who fall into this category are characterised by their older age and highest income comparing the rest of fuel poor households. Most of the households are homeowners living in rural area. The smallest cluster, group 2, contains about 11.34% of the total population. This group exclusively composed by married homemaker, 81% of them are homeowner, and 77% living in apartment. The largest cluster is group 3, covering about 47.36% of the fuel poor people in Egypt. Households in this cluster have a low income comparing to the other people experiencing fuel poverty. Further, this group extensively composed by homeowners (93%), living in apartment (99%). Finally, fuel poor households in cluster 4 (20.7%), generally have the highest level of education compared with other clusters. Household who falls in this category characterized by the use of computer and high access to internet. In addition, this group of people tends to live in rural area, widely in rented apartment.

Concerning the fuel poverty profiles in Jordan, the structure of clusters is quasi-similar to that in Egypt. However, the composition and characteristics are different. The first group, the smallest one, accounts for 13.22% of the total sample. Households in this category characterized by aged head with high income compared to the others groups. Households who falls into this category are mostly unmarried homemaker, homeowners of apartment, and living in rural area. The group 2 represents 19.63 of the sample. Households in this category have generally an aged and retired head without any education level. People falling in this group are mostly homeowners of a house in urban area. The cluster 4, cover a wide range of households experiencing fuel poverty compared to other clusters, characterized by a married and employed head, with a high-income level, compared to other group. People who fall into this cluster is more likely to be dwelling-owner of house (98%), in urban area (62%). Finally, the last group composed of about 21% of the total sample, generally have a married and employed head with primary education level and low income compared with others clusters. Occupants in this group are exclusively not owners, living in apartment in an urban area.

The resulted fuel poverty profiles are remarkably helpful in investigating policy opportunities geared towards various household groups, because they have the potential to support examination of domestic energy demand trends and patterns at more disaggregated levels. In addition, profiles may be used to perform prediction by exploring variation in household economic conditions and fuel poverty situation. However, while this analysis has informed policy concerning the need of a tailored and multidimensional approach to alleviating fuel poverty, there is little information about the housing attributes of these archetypes, making it difficult to control their implementation in practice and thus the way to use them for fuel poverty attenuation.

3.2. Explanatory factors of fuel poverty

We use a logit regression model to examine variables that make being in fuel poverty more likely in Egypt and Jordan. For this analysis, being in fuel poverty includes spending in fuel more than the national median level, and having a residual income below the poverty line. We estimate one logit model for each country (Egypt and Jordan). The coefficient estimates for the econometrics models are reported as odds ratios. The odds of an event affecting the dependent factor is estimated using the exponential formula $e^{\beta' x}$. The association of the predicted probabilities and observed responses are reported in table 4. The results of our regression analysis are presented as odds-ratios in Table 5.

Table 5. Logit estimates of fuel poverty drivers within LIHC definition

	Coef.	Odd ratio	Coef.	Odd ratio
Intercept	8.01***		8.7609***	
Household income (Q1 vs Q4)	4.73***	113.640	5.82***	337.968
Household income (Q2 vs Q4)	3.75***	42.385	5.01***	149.151
Household income (Q3 vs Q4)	2.65***	14.227	3.63***	37.675
Age of the head	-0.46***	0.628	-0.63***	0.532
Source of income (Business vs. Salary)	-0.0384	0.962	0.26	1.301
Source of income (Remittances vs. Salary)	0.36***	1.437	-0.03	0.975
Gender of the head (Male vs. Female)	0.23*	1.258	0.22	1.250
Household composition (HCOMP 1 vs. HCOMP 6)	0.79***	2.212	-0.16	0.852
Household composition (HCOMP 2 vs. HCOMP 6)	0.19	1.212	-0.61**	0.543
Household composition (HCOMP 3 vs. HCOMP 6)	-0.76***	0.469	-0.91***	0.404
Household composition (HCOMP 4 vs. HCOMP 6)	0.88***	2.406	0.08	1.079
Household composition (HCOMP 5 vs. HCOMP 6)	0.22	1.249	-0.04	0.961
Education level of the head (None vs. University)	0.32*	1.388	0.35	1.425
Education level of the head (Primary vs. University)	0.35*	1.429	0.20	1.224
Education level of the head (Secondary vs. University)	0.18	1.197	0.21	1.239
Main activity status of the head (MASHD1 vs MASHD 3)	0.02	1.016	-0.06	0.943
Main activity status of the head (MASHD2 vs MASHD 3)	0.15	1.165	0.31	1.364
Main activity status of the head (MASHD4 vs MASHD 3)	-0.20	0.821	0.15	1.164
Housing size	0.10***	1.108	0.24***	1.276
Housing type	-0.23	0.791	1.15*	3.186
Housing type (House vs. apartment)	-0.48***	0.62	0.99	2.711
Type of tenure (Tenant vs. Owner)	-0.27***	0.765	-0.06	0.938
Urban structure (Rural vs. Urban)	-0.26***	0.772	-0.26**	0.768
Has a computer (No vs. Yes)	-0.16	0.852	-0.21*	0.807
Has internet (No vs. Yes)	-0.21	0.814	-0.24**	0.782
Has a conditioner (No vs. Yes)	-0.56***	0.573	-0.52***	0.589
Has a vacuum (No vs. Yes)	0.17	1.192	-0.0755	0.927

Note. ***refers to $p < 0.01$, ** refers to $p < 0.05$, and * refers to $p < 0.1$.

The Hosmer and Lemeshow test (Hosmer and Lemeshow, 2004) is statistically insignificant at the 0.01% level, which validates our logistic model. To examine the accuracy of the developed models and their discrimination quality we use the Receiver Operating Characteristics Curve (ROC) (Wodon, 1997). The curve of the two models, constructed by plotting the true positive rate against the false-positive rate, is displayed in Fig. 6. We see from Fig. 6 that the ROC curves for both models are far from the 45-degree diagonal line.

Figure 6. ROC curve of the Logistic model estimates

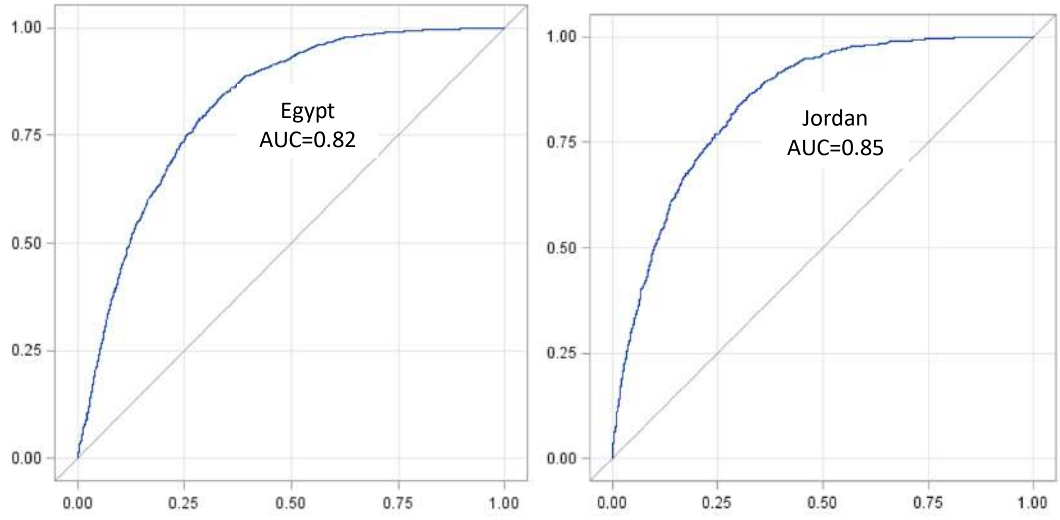


Table 4. Association of Predicted Probabilities and Observed Responses

	Egypt	Jordan		Egypt	Jordan
Percent Concordant	82.1	84.6	**Somers' D**	0.642	0.692
Percent Discordant	17.9	15.4	**Gamma**	0.642	0.692
Percent Tied	0.0	0.0	**Tau-a**	0.099	0.184
Pairs	11037915	3121704	**c**	0.821	0.846

The results show that C-statistics, which are the area under our curve (AUC), are 0.82 and 0.85 indicating better predictive models. In fact, the C-statistics may range from 0.5 (no predictive ability) to 1 (perfect discrimination). The empirical results suggest that most of the variables used in our econometric analysis are significant and have an impact on the likelihood of being fuel poor.

First, we notice that the residual income is positive with highly significant impact on the likelihood of being in fuel poverty in both countries. For the both models, the results highlight that the risk of being fuel poor increase significantly for the families with low income. For example, the odds of being in fuel poverty for families in the first quartile is 113 and 334 higher than for families in the fourth quartile in Egypt and Jordan respectively, all things being equal. The results point-out demonstrate that economic inequality is one of the most determinant of being in fuel poverty. The factor of poverty as a determinant of fuel poverty is evident and highlighted by several recent studies (Bélaïd, 2018, 2019; Galvin and Sunikka-Blank, 2018).

Based on study on housing in eight European cities, Braubach and Savelsberg (2009) asserted that within those households that reported having problems paying their housing expenditure, 20.9% of the occupants were dissatisfied with the indoor air quality in their house, compared to 8.4% occupants in higher socio-economic groups. The study highlighted that cold indoor temperature problems in winter were most frequent in families in the lowest socio-economic group, about 44% compared with 40% and 31% in middle and high-income groups.

Unsurprisingly, our empirical results show that household composition, age of respondent, education status, type of dwelling and urban structure are important predictors for fuel poverty. Household size composition increases the odds of being in fuel poverty significantly. The odds of being in fuel poverty is highly correlated with the household size. These results indicate that larger families are more likely to experience fuel poverty and the impact is similar in the two countries. Results show that households with 3 or more adults and 4 or more children are more likely to experience fuel poverty as are those with 1-2 adults and no children, with and odds of being in fuel poverty about 10 times higher. This result is consistent with the finding of Bélaïd (2018) who conclude that small household lowers the odds of being in fuel poverty in France. However, this statement is different from the result of Masuma (2013) who find that small household has higher risk fuel poverty exposure than larger families.

Unsurprisingly, age of the head is an important predictor of fuel poverty. The estimated impact on the likelihood of being in fuel poverty in Egypt (odds ratio of 0.38) is quasi similar to the estimated impact in Jordan (odds ratio of 0.36). Elderly persons are more likely to experience fuel poverty as are youngest person. The odds of being in fuel poverty is about three times higher for household head aged over 50 in both countries. This result differs from that of Masuma (2013) in England who highlighted that aged household (aged over 60) has almost half the odds of being in fuel poverty compared to younger household head. One possible explanation of this result is that such group of households have reduced housing costs, and accordingly a higher equalized disposable income level, compared to elderly household head.

Looking at the education status of the household head, the results reveal that education status is an important predictor of fuel poverty in Egypt and Jordan and the magnitude of impact is quasi similar in the two countries. In particular, having a high education level lowers the probability of experiencing fuel poverty. Accordingly, household head with any education level have higher odds of being fuel vulnerable with an odds-ration of 1.6 in Egypt and 1.4 in Jordan. Our results coincide with the proposition of Datt and Jolliffe, (2005) who documented the positive role of education in enhancing the living standards in Egypt. The finding of a significant effect of educational level on fuel poverty also supports a recent policy argument of the poverty alleviation literature (Silva-Laya et al., 2019) which attests that paying attention to the education quality is fundamental poverty and inequality reduction.

Looking at the dwelling type, our empirical results provide some evidence that the link between fuel poverty and housing type is significant. However, the impact of the dwelling type of fuel poverty in Egypt and Jordan is very different. Living in house or in apartment actually lowers the odds of being in fuel poverty in Jordan and increases the odds of experiencing fuel poverty in Egypt. Accordingly, not living in apartment in Egypt is associated with a lower odds of experiencing fuel poverty (odds-ratio =0.46), however not living in apartment in Jordan is associated with a greater risk of being in fuel poverty (odds-ratio= 2.71). The strong impact of dwelling type of fuel poverty exposure has been documented in the previous literature. Poruschi and Ambrey (2018) conclude that having a low income and leaving in apartment is associated with a high odds of being in fuel poverty in Australia.

Looking at the leaving area factor, we notice that living in rural area lowers the odds of being in fuel poverty significantly in the two countries. The magnitude of the impact is quite similar with an odds-ratio of about 0.77 and 0.76 in Egypt and Jordan respectively. We interpret this result as possible evidence of a high level of overall poverty in urban areas in Egypt and Jordan. This finding reciprocates the results of Roberts et al. (2015), who document that, the experience of fuel poverty in the UK urban areas is longer with higher odds of fuel poverty persistence, in average. However, rural fuel poor, on average, was found to be more vulnerable to fuel price increases than urban fuel poor. Further, our result contrasts with the argument of Thomson and Snell (2013), who claim that households residing in rural area in EU are significantly more likely to be in fuel poverty.

Finally, if we compare the logistics regression estimates, we notice that there are more similarities than differences in terms of predictors of fuel poverty in Egypt and Jordan. Expect the housing type; all the explicative factors have quite similar effect on the odds of being fuel poor in the two countries. Building on the logistic regression estimates, which argues that the drivers of fuel poverty in Egypt and Jordan are quite similar, we contend that the experience of fuel poverty in Egypt and Jordan is driven generally by the same factors. Nevertheless, Jordan's households appear more vulnerable and the share of fuel poor are higher. One rational explanation of this finding is that energy prices in Jordan is three times higher than in Egypt.

4. Conclusions and policy implications

Our current study explores fuel poverty extent and the fuel poor profiles using data from two recent survey (2015 Egyptian HIECS and 2013 HEIS). In addition, we develop a logit model to examine for differences in predictors of fuel poverty in Egypt and Jordan. The main purpose of this study is to outlines why the measurement and understanding of fuel poverty is important in policy formulation and describes how the mitigation of phenomenon is important in reducing inequalities. Fuel poverty is a complex and multi-scale issue, which relating the household-level to the country-level and the demand-side to the supply-side. The fuel poverty situation is shaped by various factors, including household economic conditions, housing energy performance, and fuel prices. This research project aims to investigate how access and use of energy are related to poverty. It focuses mainly on the measurement of fuel poverty extent, describing fuel poor household profiles, and investigate the risk to fuel poverty exposure.

The analysis yielded several interesting results. First, the LIHC indicator used to measure the fuel poverty extent suggests that the proportion of fuel poor households in Jordan (16%) is higher than Egypt (8.8%). The chief advantage of the proposed measure is that it allow the assessment of the so-called fuel poverty gap, which depicts the abatement in energy bill or the additional income needed to lift-out of fuel poverty situation.

Second, the multiple correspondence analysis and hierarchical clustering statistical approach provided the profiles of fuel poverty in Egypt and Jordan. Four different profiles have been provided for each country. Each of these groups contains specific characteristics linked with household and dwelling attributes based on multivariate statistical analyses of the recent consumption surveys. Building on the clustering results, we contend that the structure of clusters is quasi-similar in both countries. However, the profiles composition and characteristics are slightly different. One possible explanation of these dissimilarities lies mainly on the differences in economic conditions and housing characteristics in Egypt and Jordan. For example, electricity prices in Jordan are three times higher in Jordan compared to Egypt. The resulted fuel poverty profiles are helpful in illustrating the extent of the problem and in contrasting the different groups of occupants who differs in both energy demand and income. Further, various energy efficiency measures and policy instruments may be relevant for each of the distinct group of people, experiencing fuel poverty in Egypt and Jordan.

Finally, unsurprisingly, household equalized income, age of the head, household composition, education level of the head, dwelling type, and area of leaving are important predictors for fuel poverty in Egypt and Jordan. In addition, the logistic regression estimates argued that the factors influencing the likelihood of being in fuel poverty in Egypt and Jordan are quasi similar. This suggest that the fuel determinants of fuel poverty in Egypt and Jordan are similar and there is a strong link between the income inequality and fuel poverty. Therefore, the high rate of fuel poverty in Egypt and Jordan is a clear consequence of growing economic inequality in the recent years.

The empirical results of this study have several implications on the policy-making process and policy choices, as fuel poverty is now widely recognized as problem worldwide. Therefore, the results are important not only for the LIHC definition of fuel poverty in Egypt and Jordan, but also for any poverty (fuel) action relying on the income after-dwelling-cost (fuel-costs) procedure in any country. The resulted fuel poor classes may serve as a basis for targeted energy policy interventions tailored to specific socio-economic groups of household. The identified profiles are particularly crucial in evaluating targeted policy interventions, which allows policy measures to be oriented towards specific groups of individuals, particularly households that are in severe fuel precariousness. Findings from Logistic regression model have and important policy implications and will be valuable in determining the most efficient policy interventions to mitigate fuel poverty phenomenon.

The challenge of addressing fuel vulnerability and cold home-related negative health impacts in Egypt and Jordan is greatly important to improve the quality of life of many households by making their homes warmer and more efficient. Furthermore, reducing fuel poverty could substantially enhance health outcomes and reduce inequalities in health, as well as making an important contribution to tackling residential greenhouse emissions. The findings confirm the prominence of specific combinations of household housing and socio-economic characteristics in determining the odds of being in fuel poverty. It also advocate that monitoring not only the dynamics but also the levels of fuel poverty may play an important role in ensuring the policy mechanisms effectiveness. Given the broader policy interest in fuel poverty worldwide, the empirical analysis suggested in this article could be usefully implemented to similar micro-level data available in other MENA countries. We would expect different findings across countries not least because the economic conditions fuel prices, and housing characteristics differs across countries.

Finally, a valuable topic for future research in MENA region is the examination of households' required spending on energy. This is challenging because of data availability. Therefore, investigating specific new survey, with more comprehensive data on household life style, required energy spending on fuel, and energy use behaviour may help to specify the nature of fuel poverty in more detail. In addition, richer sources of information-dedicated survey of energy poverty can help to develop a comprehensive framework and economically efficient policies to deliver significant reductions in fuel poverty.

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