Energy Expenditure in Egypt: Empirical Evidence Based on a Quantile Regression Approach

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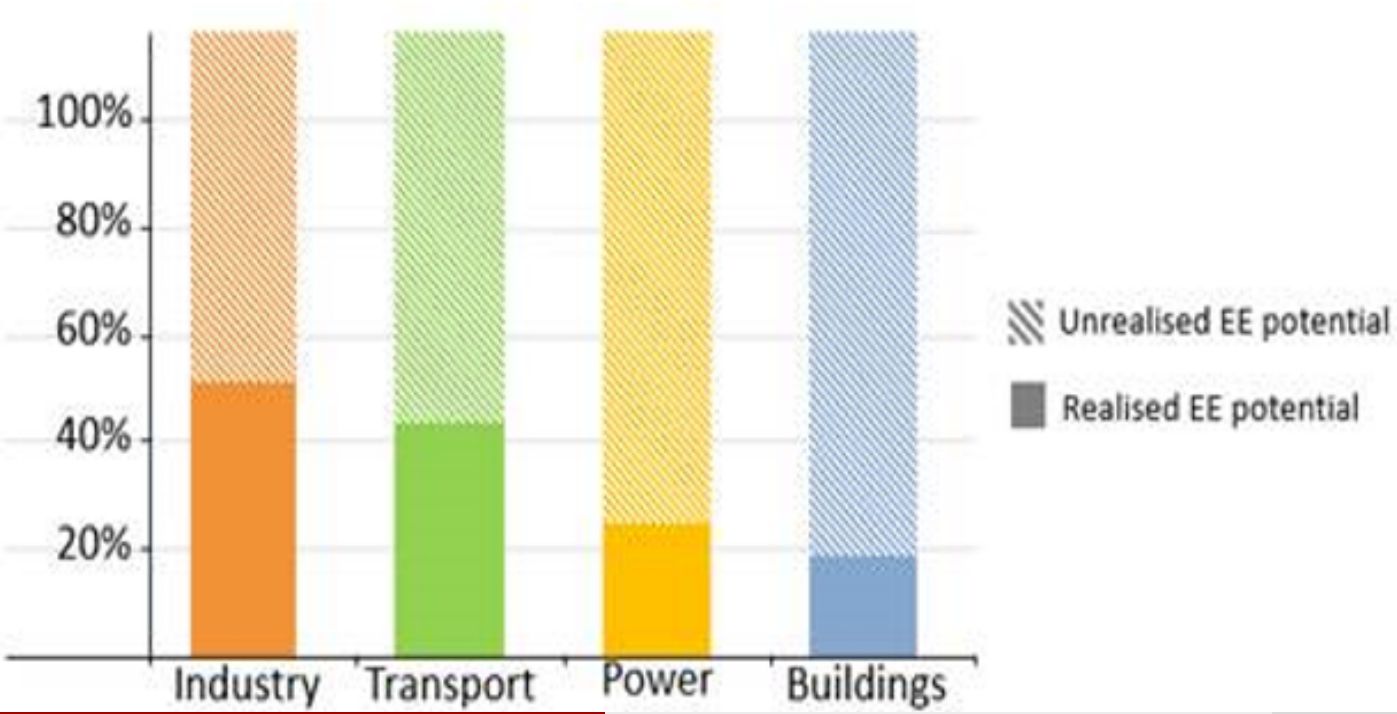
Background

Building energy consumption

- Building sector accounts for one of the major share of total primary energy consumption in most countries.
- Despite efforts EE improvement, the potential to drive further savings is still huge.
- Designated as a key policy to reduce energy consumption.



Egyptian context

Residential dwelling one of the most consuming energy sectors

- the building sector represents about 42% of global energy consumption.
- Activities related to REC represent one of the largest sources of carbon emissions.

Importance of investigating REC:

- Understanding and improving the energy efficiency of the housing stock
- designing the most effective intervention strategies aiming to promote occupant energy-saving behaviors
- Reducing greenhouse gas emissions

Research question

We develop an empirical model based on 2015 Egyptian HIECS Survey to examine:

- The key drivers of energy expenditure

This research builds on a broad and practical conceptual framework:

- Quantile regression model;
- Adaptive Lasso Regularization selection technique
- Several dimensions of EE investment influencing factors.

Research contribution

This research contributes to the literature on residential energy consumption in several ways:

1. We introduce several dimensions of exploring the spectrum of energy expenditure
2. This research is an important empirical contribution to the sparse literature of fuel vulnerability in MENA countries.
3. Empirically, the paper adds valuable new evidence through the analysis of new and rich cross-sectional datasets.
4. Quantile model helps to differentiate the effects of several variables on the entire consumption distribution
5. ALasso Regularization technique enhances the accuracy and stability of the predictors
6. We provide a more elaborate overview on the various facets of household energy-expenditure in Egypt

Literature review I

- The motivation for this research is linked to energy demand literature, which is a complex issue sorely linked to the multitude of inter-related factors.
- Since the late 1970s concerns regarding residential demand triggered a first wave of studies
- Topic stimulated by the issues of global warming, climate change, fossil fuel depletion and volatility of oil prices.
- Household behavioral aspects emerged as a substantial research strand for providing knowledge for EE improvement.
- In recent years, researchers have sought to develop more comprehensive framework of EE drivers.
- Studies on household energy spending in developing countries are limited (Adusah-Poku and Takeuchi, 2019).

Data I

This study is based on the:

1. 2015 Egyptian Household Income, Expenditure, and Consumption Survey

The 2015 HIECS is a rich data set containing over 240 variables. This surveys provides detailed information:

1. Household income and housing expenditure, including electricity, gas and other fuel expenditures.
2. Household socio-economic attributes (e.g., age of the head, marital status, gender, ethnicity, etc.)
3. Housing characteristics and conditions, including housing size, type of structure, source of energy, health facility, etc.

Quantitative modeling variables description

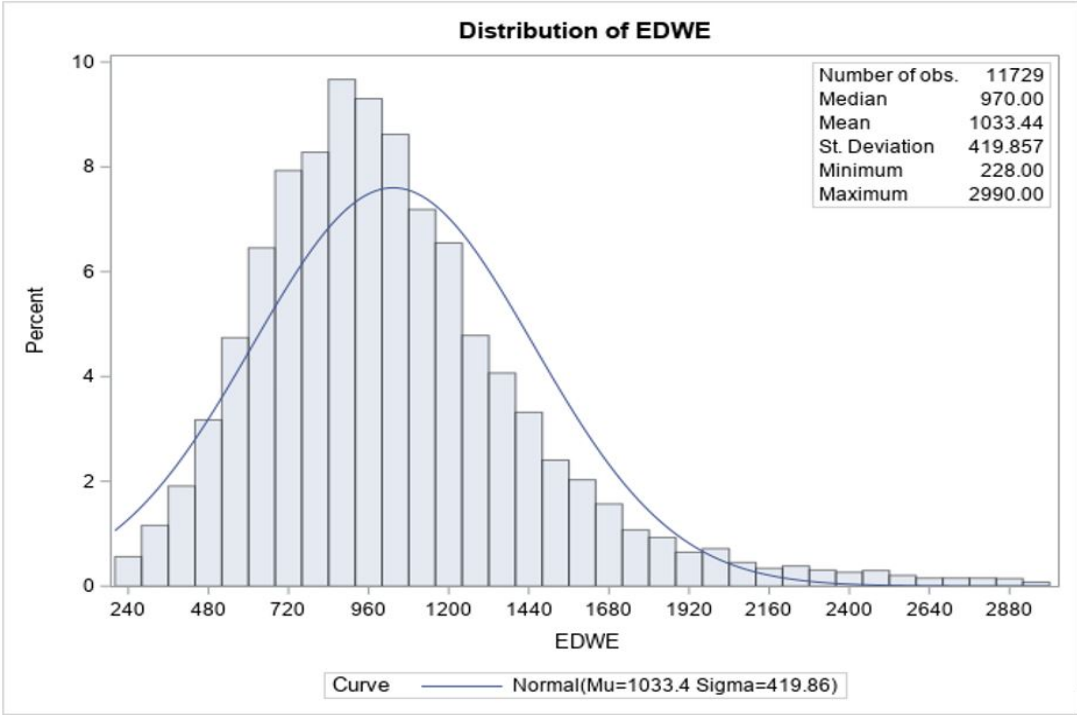


Fig.1. Distribution of energy expenditure in Egypt

Variable	Label	N	Mean	Std. Dev.	Minimum	Maximum
Energy expenditure	EDWE	11729	1033	420	228	2990
Household income	TOTDINC	11729	41903	27160	2745	526000
Age of the head	AGEHD	11729	50	14	18	99

Distribution of EE regarding income

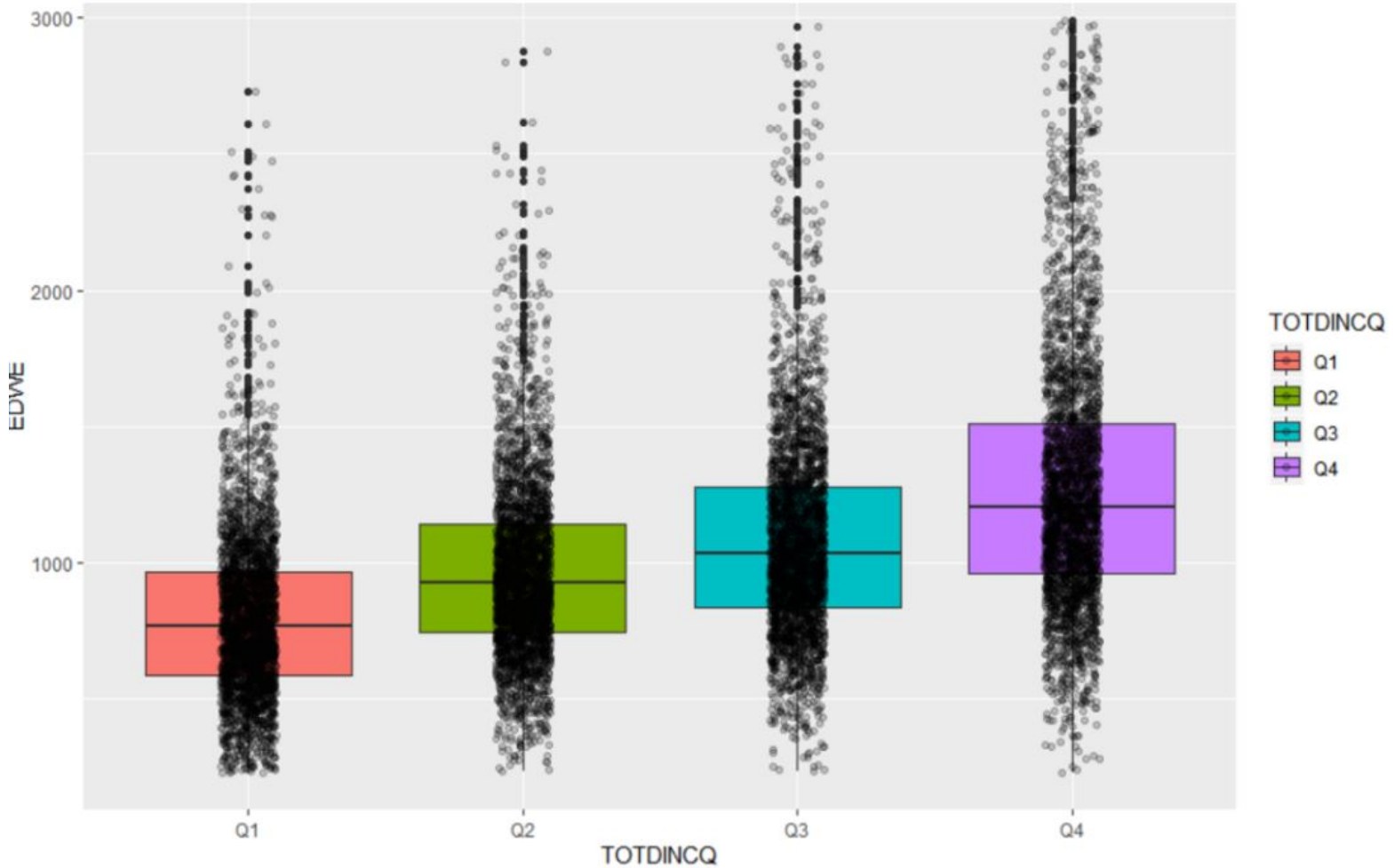
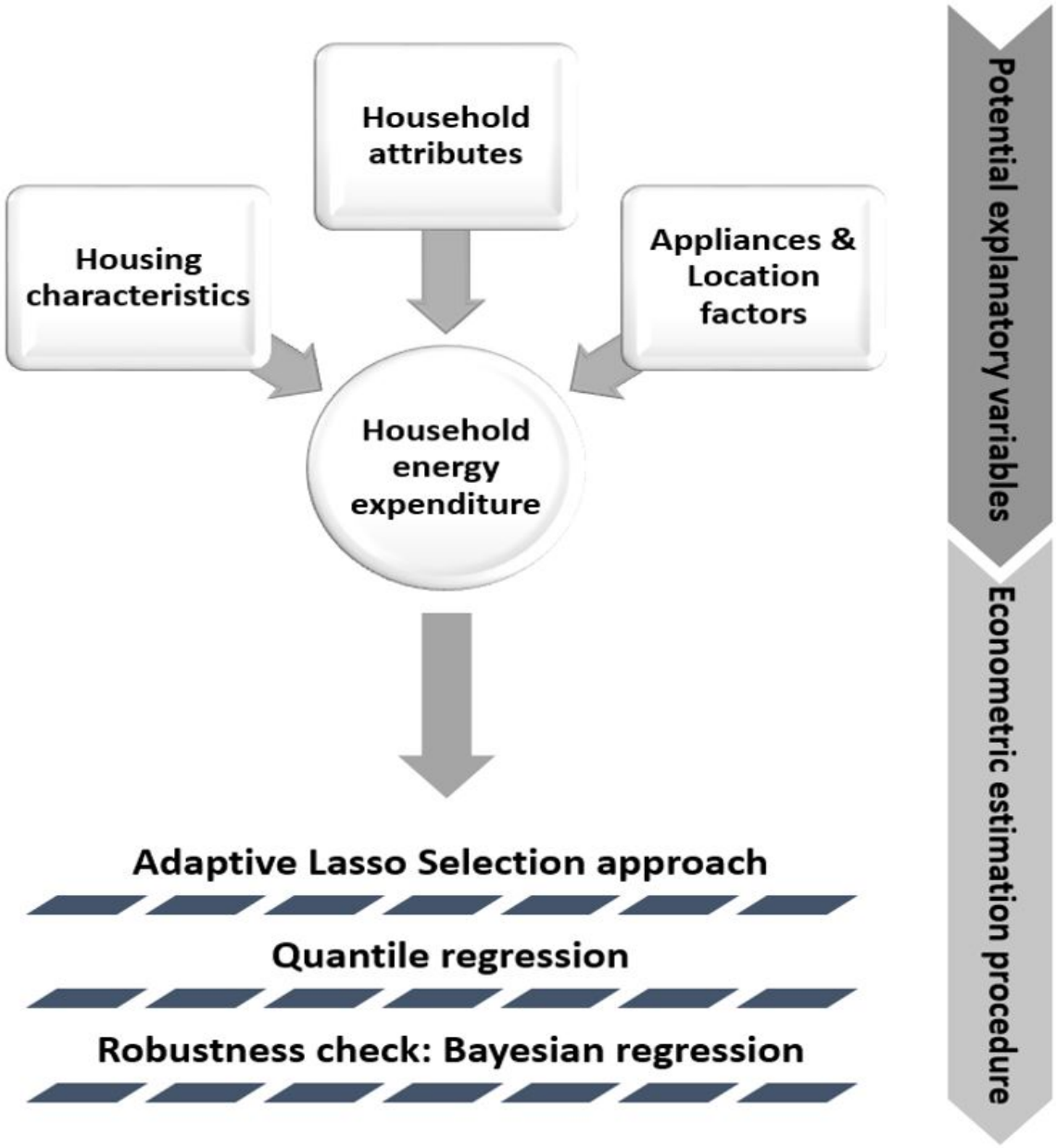


Fig.2. Energy expenditure and income distribution in Egypt.

Modeling approach: Conceptual framework



ALasso Regularization technique

Baseline model:

- Multivariate linear regression

Motivation:

- Avoiding the curse of dimensionality and increase the accuracyy of our model.
- The adaptive lasso solves the OLS problem adding a weighted l_1-norm penalty on the coefficients. Relies on tuning parameters that control the type and degree of penalization

$$\hat{\beta}(adaptive\ \ lasso) = \arg\min_{\beta} ||y - \sum_{i=1}^{p} x_i\beta_i||^2 + \lambda \sum_{i=1}^{p} \hat{w}_i|\beta_i|$$

$$\text{where } \hat{w} = 1/|\,\hat{\beta}\,|$$

Quantile Regression Model

- The θ^{th} quantile is generally defined as :

  $$q_\theta(Y) = inf\{y : F_Y(y) \geq \theta\}, \qquad 0 < \theta < 1.$$

- Log-linear demand equation used to examine the key drivers of EE:

  $$y_i = x_i^{'}\beta_{theta} + u_i \qquad \text{with} \qquad q_\theta(y_i/x_i) = x_i^{'}\beta_{theta}$$

  y : The vector of household EE.
  x : Represents the regressors or independent variables.
  u : The vector of residuals.
  $q_\theta(y_i/x_i)$: The q^{th} quantile of y_i given x_i.

Bayesian linear regression model

As a robustness analysis, we employed:

1. Deterministic multivariate OLS model
2. Bayesian linear regression model

Main advantages of the Bayesian approach:

1. Take into account, and represent the full uncertainties related to the model.
2. Have stronger robustness, mainly against outlying observations.

Quantile and OLS model estimates

	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.90	OLS
Intercept	3.985***	4.401***	4.587***	4.719***	4.329***
Income	0.274***	0.251***	0.254***	0.263***	0.253***
Age of the head	0.008**	0.016***	0.013***	0.013**	0.013***
Business Vs. Salary	0.027**	0.025***	0.026**	0.036***	0.036***
Remittances vs. Salary	-0.014	-0.022	-0.005	0.030	-0.002
Mal vs. Female	0.051***	0.049***	0.031**	-0.006	0.044***
1-2 adults, no children vs. Adults >3, >4 children	-0.234***	-0.262***	-0.200***	-0.188***	-0.211***
1-2 adults, 1-2 children	-0.111***	-0.156***	-0.130***	-0.111***	-0.099***
1-2 adult, 3 or more children	-0.068***	-0.114***	-0.101***	-0.093***	-0.070***
3 or more adults, 0-1children	-0.074***	-0.119***	-0.096***	-0.106***	-0.082***
3 or more adults, 2-3 children	-0.015	-0.086***	-0.075***	-0.091***	-0.037**
Employed vs. Retired	-0.016	-0.014	-0.013	-0.027	-0.017
Homemaker vs. Retired	0.061***	0.049**	0.046**	-0.013	0.047***
Others vs. Retired	0.029	0.020	0.027	-0.001	0.032
Number of Rooms	0.018***	0.021***	0.017***	0.021***	0.028***
Apartment vs. House	-0.172***	-0.123***	-0.104***	-0.114***	-0.130***
Rented vs. Owner	-0.059***	-0.027***	-0.029***	-0.015	-0.039***
Urban vs. Rural	0.017**	-0.020**	-0.042***	-0.062***	-0.005
No conditioner	-0.142***	-0.149***	-0.156***	-0.150***	-0.162***

***, **, * denote significance at 1%, 5% and 10% level.

Quantile and OLS model estimate

1. The results of our robustness approach are in agreement with the results of our previous.
2. Income has a significant positive impact on EE, i.e. an increase in the income implies a systematic increase in energy expenditure.
3. Age of the head has a positive effect on energy expenditure in Egypt. The effect increases from the 25th quantile to the 50th quantile, and decreases over the 0.75 quantile.
4. Household size has a significant impact on EE. This impact is nonlinear and varies across the energy expenditure distribution.
5. Men-headed household energy expenditure is higher compared with women-headed households.
6. House size has a very well determined positive effect on EE.

Conclusions

1. The methodological innovation in this paper is the development of a bottom-up approach based on Quantile and Alasso approach
2. Besides identifying the main drivers of EE, we provided an original contribution by untangling the spectrum of EE.
3. We document that the factors influencing housing EE vary with the distribution of energy expenditure.
4. Housing characteristics have a moderate impact, while socio-economic attributes have a much larger impact.

Policy implications

From policy perspective, the findings suggest that:

1. This analysis constitutes a strategic information vector for policy makers in the implementation of future energy efficiency policies.
2. It suggests that targeting policies toward specific households may improve energy efficiency policy effectiveness.
3. Targeting efforts towards energy incentive policy is vital to enhance energy efficiency.
4. More attention needs to be directed towards changing households habits and find a way to convince them to save energy (e.g., using gentle nudges).

Thank you for your attention

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