Dynamic conditional score models for electricity prices in Central America

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MOTIVATION

• In several Central American countries electricity market has been liberalized recently. See Table 1.

• We would like to find an appropriate model for Central American energy prices that may help to predict energy prices. This may help to develop future energy related projects.

• We would like to understand energy prices and determine if they have cyclical movements.
Objectives

• **Compare different models for energy price volatility.**

• A) Traditional models studied:
  – normal-GARCH; t-GARCH (Engle, 1982; Bollerslev, 1986; Taylor, 1986)

• B) Recent dynamic score models studied:
  – Beta-t-EGARCH; Gamma-GED-EGARCH; EGB2-EGARCH (Harvey and Chakravarty, 2008; Harvey, 2013; Caivano and Harvey, 2014)
Highlights

• Central American electricity sector and its regulation are reviewed for Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. See Table 1.

• The dataset includes unique spot electricity prices of El Salvador, Guatemala and Panama. See Table 2 for descriptive statistics on daily return.

• Statistical performance of normal-GARCH, t-GARCH, Beta-t-GARCH, Gamma-GED-EGARCH and EGB2-EGARCH is compared. See Table 7.
Highlights

• For El Salvador, **Beta-t-EGARCH** is the most effective conditional scale specification, followed by Gamma-GED-EGARCH.

• For Guatemala, **t-GARCH** is the most effective model of conditional scale, followed by Gamma-GED-EGARCH.

• For Panama, **Gamma-GED-EGARCH** is the most effective model of conditional scale, followed by t-GARCH.
Introduction

• Application of the adequate electricity price models, which control for price shifts, is very important for the countries of Guatemala, El Salvador and Panama.
Literature

• In electricity prices large jumps or falls can be observed sometimes.

• Duffie, Gray and Hoang (1998) mention that using a GARCH model for electricity price volatility, we can estimate an *integrated volatility series*; i.e. inadequate volatility formulation.

• Escribano, Pena and Villaplana (2011) use GARCH *model with time-dependent jumps* to avoid integrated volatility series. This is a first way to model electricity price volatility.
New approach

• In this work, a new approach is used based on the recent *dynamic conditional score volatility models*; introduced by Andrew Harvey (2013).

• These volatility models endogenously control for outliers, therefore, we can use dynamic conditional score models without considering a jump component in the model.

• We compare these new models with the traditional GARCH model.
Data

• Electricity price data for El Salvador and Panama:
  • 1 January 2010 to 31 December 2014.
• Electricity price data for Guatemala:
  • 1 January 2009 to 31 December 2013.
• $T=1,826$ days for all countries (same sample size for robustness)
• Unit of electricity prices: USD/MWh
• See Table 2.
FIGURES (energy prices)
Step 1: Control for weekly seasonality

Linear regression model

\[ \tilde{y}_t = \delta_1 D_{Mo,t} + \delta_2 D_{Tu,t} + \delta_3 D_{We,t} + \]
\[ + \delta_4 D_{Th,t} + \delta_5 D_{Fr,t} + \delta_6 D_{Sa,t} + \]
\[ + \delta_7 D_{Su,t} + \gamma_t \]

- OLS estimation (with heteroskedasticity and autocorrelation consistent standard errors)
- \( \gamma_t \) is the seasonality corrected electricity return
- See Table 3.
Step 2: volatility models for corrected prices

**MA(7)-GARCH(1,1):**

\[
y_t = \mu_t + \nu_t
\]

\[
\nu_t = \sigma_t \epsilon_t
\]

\[
\mu_t = \omega + \theta_1 \nu_{t-1} + \ldots + \theta_7 \nu_{t-7}
\]

\[
\sigma_t^2 = \alpha_0 + \beta_1 \sigma_{t-1}^2 + \alpha_1 \nu_{t-1}^2
\]

- \( \mu_t \) is MA(7) to control for the remaining weekly seasonality.
- \( \epsilon_t \sim N(0,1) \) is normal-GARCH; \( \epsilon_t \sim t(v) \) is t-GARCH
Step 2: volatility models for corrected prices

MA(7)-DCS(1,1) models:

\[ y_t = \mu_t + \nu_t \]
\[ \nu_t = \exp(\lambda_t)\varepsilon_t \]
\[ \mu_t = \omega + \theta_1 \nu_{t-1} + \ldots + \theta_7 \nu_{t-7} \]
\[ \lambda_t = \alpha_0 + \beta_1 \lambda_{t-1} + \alpha_1 u_{t-1} \]

- \( \mu_t \) is MA(7) to control for the remaining weekly seasonality. \( \lambda_t \) and \( \varepsilon_t \) are specified as follows for different models:
Step 2: volatility models for corrected prices

MA(7)-DCS(1,1) models:

Beta-$t$-EGARCH: $u_t = \frac{(\nu + 1)\nu_t^2}{\nu \exp(2\lambda_t) + \nu_t^2} - 1$

$\epsilon_t \sim t(\nu)$ i.i.d.

Gamma-GED-EGARCH: $u_t = \frac{\nu}{2} |\epsilon_t|^\nu - 1$

$\epsilon_t \sim \text{GED}(\nu)$ i.i.d.

General Error Distribution (GED)
Step 2: volatility models for corrected prices

MA(7)-DCS(1,1) models:

\[
\text{EGB2-EGARCH: } u_t = (\xi + \zeta) \frac{\epsilon_t \exp(\epsilon_t)}{1 + \exp(\epsilon_t)} - \xi \epsilon_t - 1
\]

\[
\epsilon_t \sim \text{EGB2}(0, 1, \xi, \zeta) \text{ i.i.d.}
\]

- Exponential Generalized Beta distribution of the second kind (EGB2)
- See quasi-maximum likelihood (QML) estimation results in Tables 4 to 6.
Likelihood-based model performance

• Model quality is compared by:
  • Log-Likelihood (LL)
  • Akaike Information Criterion (AIC)
  • Bayesian Information Criterion (BIC)
  • Hannan-Quinn Information Criterion (HQC)
• The last three criteria include the value of the log-likelihood (LL) and penalize it for the number of parameters estimated.
• See Table 7.
Likelihood-based model performance

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<th>Country</th>
<th>Model Type</th>
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References


References


References


Thank you for your attention!