Online Appendix to accompany the "Electricity Sector Performance: A Panel Threshold Analysis"

Appendix A – Data

Table A1: Descriptive Statistics and Correlations Between the Variables

	CAP	GEN	LAB	GDP	PRIV	RRI	TPA	WHOL	EXPORT	FRASER	IND	URBAN
Statistical measures												
Cross sections	30	30	30	30	30	30	30	30	30	30	30	30
Mean	3.20	25.26	10.99	10.05	0.17	4.16	0.59	0.73	38.42	7.20	30.81	74.66
Median	3.11	25.26	11.09	10.22	0.00	4.83	1.00	1.00	32.38	7.40	30.45	75.66
Maximum	6.95	29.10	11.75	11.38	1.00	6.00	1.00	1.00	181.78	8.84	47.27	97.46
Minimum	0.36	19.70	9.70	8.22	0.00	0.00	0.00	0.00	5.16	3.55	13.19	42.79
Standard deviation	1.42	1.62	0.38	0.66	0.37	1.81	0.49	0.45	24.82	0.91	5.44	10.80
Coefficient of variation	0.44	0.06	0.03	0.07	2.25	0.44	0.84	0.61	0.65	0.13	0.18	0.14
Skewness	0.03	-0.57	-0.93	-0.85	1.80	-0.62	-0.36	-1.02	2.20	-0.90	0.10	-0.34
Kurtosis	3.34	4.60	3.58	2.98	4.24	2.00	1.13	2.05	10.09	3.63	3.32	3.01
Observations	834	834	834	834	834	834	834	834	834	834	834	834
Correlations												
CAP	1.00											
GEN	0.97	1.00										
LAB	0.13	0.08	1.00									
GDP	0.02	-0.02	0.93	1.00								
PRIV	0.49	0.47	0.26	0.20	1.00							
RRI	-0.28	-0.30	-0.43	-0.33	-0.42	1.00						
TPA	-0.20	-0.22	-0.39	-0.29	-0.20	0.86	1.00					
WHOL	-0.21	-0.21	-0.35	-0.29	-0.19	0.82	0.72	1.00				
EXPORT	-0.59	-0.64	0.33	0.30	-0.15	-0.11	-0.17	-0.06	1.00			
FRASER	0.19	0.17	0.76	0.74	0.28	-0.47	-0.42	-0.35	0.20	1.00		
IND	-0.01	0.04	-0.46	-0.42	-0.20	0.33	0.34	0.32	-0.20	-0.46	1.00	
URBAN	0.06	0.06	0.53	0.53	0.31	-0.23	-0.17	-0.19	0.10	0.43	-0.30	1.00

Note: GEN is the net generating electricity per capita, CAP is the installed electricity capacity, LAB stands for the labour productivity in the electricity sector. GDP stands for the per capita GDP in the sample countries, PRIV stands for the ownership structure of the largest companies in all of the electricity market segments, RRI stands for the OECD regulatory reform index in the industry, TPA accounts for the third party access to the electricity transmission grid, WHOL stands for the existence of a liberalised wholesale market for electricity (wholesale pool), EXPORT measures the exports as a percentage of GDP, FRASER stands for Fraser Index of Economic Freedom, IND, measures the industrialising rate, and URBAN stands for the urbanisation rate. **Source**: Author's elaboration.

Table A2: Country Characteristics in Electricity Performance and Policy Indices (Averages Over the Period 1975-2013).

Country	CAP (Million Kilowatts)	GEN (Billion Kwh)	LAB (US dollars)	GDP (US dollars)	PRIV	RRI	TPA	WHOL	EXPORT (% of GDP)	FRASER	IND (% of GDP)	URBAN (% of total population)
Australia	42.43	168.08	72,861	26,852	0.00	3.78	0.36	0.33	17.14	7.61	31.57	86.61
Austria	17.25	52.06	70,708	29,798	0.00	4.21	0.33	0.25	40.22	7.03	32.18	65.95
Belgium	14.88	69.77	78,445	29,236	1.00	3.35	0.31	0.00	67.68	7.35	29.58	96.42
Canada	109.19	512.46	71,083	28,373	0.00	4.71	0.33	0.25	31.67	8.00	32.68	77.80
Czech Republic	16.37	66.29	41,648	11,182	0.00	4.48	0.31	0.31	56.40	6.52	37.25	74.16
Denmark	10.78	32.62	62,830	38,731	0.00	4.17	0.33	0.42	39.82	7.29	25.76	84.81
Finland	14.30	59.75	59,309	28,612	0.00	3.50	0.44	0.42	33.48	7.31	34.23	78.45
France	104.91	432.16	71,469	28,346	0.00	4.94	0.31	0.25	23.62	6.83	26.16	76.54
Germany	120.76	538.87	64,290	28,562	0.36	3.17	0.58	0.31	29.15	7.47	34.86	73.11
Greece	10.00	40.37	53,932	17,044	0.00	4.92	0.28	0.17	20.70	6.31	-	59.00
Hungary	7.45	31.35	33,564	8,581	0.00	4.39	0.25	0.22	51.86	5.76	37.84	65.39
Iceland	1.36	6.88	64,344	42,063	0.00	5.37	0.22	0.00	36.84	6.83	30.83	90.89
Ireland	4.80	18.00	65,599	46,812	0.00	4.70	0.31	0.11	68.15	7.45	35.44	57.81
Italy	70.69	233.02	71,054	25,493	0.00	4.74	0.33	0.19	23.19	6.44	31.58	67.02
Japan	224.55	853.79	60,325	29,576	1.00	3.29	0.36	0.28	12.21	7.39	33.89	79.84
Korea	50.09	203.48	35,024	10,998	0.00	4.94	0.28	0.00	35.28	6.42	38.33	71.60
Luxembourg	1.38	1.36	102,007	55,838	0.00	4.70	0.31	0.17	120.83	7.78	23.41	82.00
Mexico	37.92	155.40	33,564	6,992	0.00	5.40	0.00	0.00	19.87	6.02	33.76	71.77
Netherlands	20.00	81.50	70,839	31,675	0.00	4.45	0.33	0.33	60.70	7.61	28.50	72.18
New Zealand	7.89	33.85	54,769	22,852	0.00	3.78	0.53	0.42	28.73	7.68	28.09	84.80
Norway	27.23	111.75	83,117	50,177	0.00	3.23	0.56	0.56	40.16	6.94	37.12	73.70
Poland	29.85	137.10	29,007	6,959	0.00	4.82	0.31	0.00	30.43	5.37	34.13	60.25
Portugal	10.03	31.63	39,244	14,261	0.00	4.04	0.31	0.25	26.17	6.55	27.96	50.28
Slovak Republic	7.58	24.41	38,293	9,845	0.00	4.90	0.33	0.00	63.07	6.54	42.83	54.36
Spain	55.91	184.48	63,814	19,959	0.39	3.36	0.47	0.33	21.32	6.86	32.16	74.97
Sweden	33.30	134.35	62,567	32,453	0.00	3.99	0.56	0.42	38.03	6.93	29.58	83.67
Switzerland	16.66	58.11	69,066	47,834	0.00	4.94	0.19	0.00	40.95	8.15	29.23	68.81
Turkey	24.12	93.95	25,728	5,424	0.00	4.89	0.28	0.22	16.63	5.30	29.26	58.20
United Kingdom	75.61	332.91	65,099	28,569	0.58	2.60	0.58	0.58	26.89	7.77	31.70	78.55
United States	800.89	3337.88	80,287	34,741	1.00	3.42	0.53	0.36	9.54	8.20	25.87	77.10
All countries	**65.61**	**267.92**	**59,976**	**26,595**	**0.14**	**4.24**	**0.35**	**0.24**	**37.69**	**6.99**	**31.92**	**73.20**

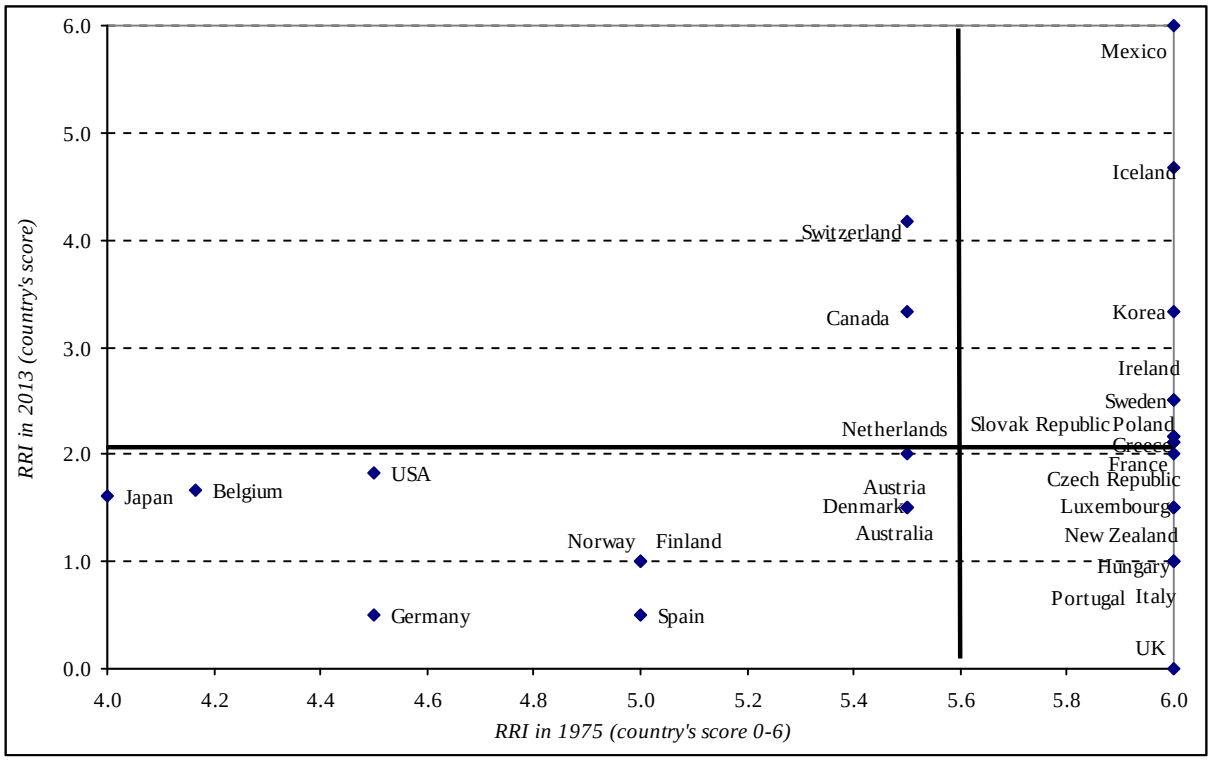
Note: GEN is the net generating electricity per capita, CAP is the installed electricity capacity, LAB stands for the labour productivity in the electricity sector. GDP stands for the per capita GDP in the sample countries, PRIV stands for the ownership structure of the largest companies in all of the electricity market segments, RRI stands for the OECD regulatory reform index in the industry, TPA accounts for the third party access to the electricity transmission grid, WHOL stands for the existence of a liberalised wholesale market for electricity (wholesale pool), EXPORT measures the exports as a percentage of GDP, FRASER stands for the Fraser Index of Economic Freedom, IND, measures the industrialising rate, and URBAN stands for the urbanisation rate.
Source: Author's elaboration.

Table A3: Decomposition of the RRI for the OECD Countries Between 1975 and 2013.

	Entry		Public Ownerhip		Vertical integration	
Country	***1975***	***2013***	***1975***	***2013***	***1975***	***2013***
Australia	6.0	0.0	4.5	4.5	6.0	0.0
Austria	6.0	0.0	4.5	4.5	6.0	0.0
Belgium	5.0	2.0	1.5	1.5	6.0	1.5
Canada	6.0	1.0	4.5	4.5	6.0	4.5
Czech Republic	6.0	0.0	6.0	4.5	6.0	0.0
Denmark	6.0	0.0	4.5	4.5	6.0	0.0
Finland	6.0	0.0	4.5	3.0	4.5	0.0
France	6.0	0.0	6.0	4.5	6.0	1.5
Germany	6.0	0.0	3.0	0.0	4.5	1.5
Greece	6.0	0.3	6.0	4.5	6.0	1.5
Hungary	6.0	0.0	6.0	3.0	6.0	0.0
Iceland	6.0	2.0	6.0	6.0	6.0	6.0
Ireland	6.0	0.0	6.0	6.0	6.0	1.5
Italy	6.0	0.0	6.0	3.0	6.0	0.0
Japan	6.0	0.3	0.0	0.0	6.0	4.5
Korea	6.0	4.0	6.0	3.0	6.0	3.0
Luxembourg	6.0	0.0	6.0	3.0	6.0	1.5
Mexico	6.0	6.0	6.0	6.0	6.0	6.0
Netherlands	6.0	0.0	6.0	6.0	4.5	0.0
New Zealand	6.0	0.0	6.0	4.5	6.0	0.0
Norway	6.0	0.0	4.5	3.0	4.5	0.0
Poland	6.0	2.0	6.0	4.5	6.0	0.0
Portugal	6.0	0.0	6.0	3.0	6.0	0.0
Slovak Republic	6.0	2.0	6.0	4.5	6.0	0.0
Spain	6.0	0.0	3.0	1.5	6.0	0.0
Sweden	6.0	0.0	6.0	6.0	6.0	1.5
Switzerland	6.0	5.0	4.5	4.5	6.0	3.0
Turkey	6.0	0.3	6.0	6.0	6.0	0.0
United Kingdom	6.0	0.0	6.0	0.0	6.0	0.0
United States	6.0	1.0	1.5	0.0	6.0	4.5

Source: OECD International Regulation Database.

Figure A1: Changes in the RRI of the Electricity Sector Between 1975 and 2013.



Note: The vertical line dividing the graph's plot area represents the non-weighted average for the beginning of the period (5.6), while the horizontal one denotes the non-weighted average for the end of the sample period (2.0).

Appendix B - Threshold Model

Let the model be given by the following equation:

$$\{y_t, x_t, q_t\}_{t=1}^{n} \quad \text{(B.1)}$$

Where y_t is a scalar denoting the dependent variable, x_t is a (px1) vector of independent variables and q_t is a scalar variable that defines the range of possible thresholds and can be part of x_t. The subscript t denotes the time. In our model, we use the index of economic risk as the sorting (threshold) variable that classifies countries in a liberalized and a non-liberalized regime. Note that the threshold itself is an unknown parameter and it will be estimated along the other parameters of the model. In its current form as a static panel, the model does not allow for a lagged dependent variable among its regressors. Hansen (1999, 2000) provides an estimation method based on a Concentrated Least Squares (CLS) procedure and he obtains the properties of the threshold and slope parameter estimators. The model can be summarized as follows:

$$y_t = x_t^T \beta_1 + \varepsilon_t, \; q_t \leq \gamma \quad \text{(B.2)}$$

$$y_t = x_t^T \beta_2 + \varepsilon_t, \; q_t > \gamma \quad \text{(B.3)}$$

Equations (2) and (3) describe the relationship between the variables of interest in each of the two regimes and q_t is the threshold variable with γ being the unknown sample split (threshold) value that needs to be estimated. We assume for simplicity that the error term ε_t is independent and identically distributed (i.i.d) with mean zero and finite variance σ_ν^2, although one can also allow for a conditional heteroskedastic error structure and weak dependence. The approach that we employ here does not rely on a known γ. In other words the parameter γ needs to be estimated along-side the other unknown parameters of the model. However, the method is based on first testing for the presence of a threshold effect. Once we reject the null of no threshold we proceed in the estimation of the model that includes the estimation of the threshold and allows for the sample split. The method is based on a CLS method that splits the model into the two regimes, whereby there is a full interaction of all the variables with the (estimated) threshold.

By introducing a dummy variable $d_t(\gamma) = I(q_t \leq \gamma)$, we can write the model above in a single expression (Hansen, 1999, Savvides and Stengos, 2000):

$$y_t = x_t^T \beta \ + x_t^T (\gamma)\theta + \varepsilon_t \quad \text{(B.4)}$$

where $\beta = \beta_2$ and $\theta = \beta_1 - \beta_2$. For testing that there is no threshold the null hypothesis is simply that H_0: θ=0 or H_0: $\beta_1 = \beta_2$. That allows for the comparison between the TR model and the simple linear benchmark without a threshold. It is worth noting that the parameter γ (threshold parameter) is not identified under the null hypothesis of no threshold (θ=0) and usual test statistics have non-standard distributions. For that reason, Hansen (1999, 2000) suggests a bootstrap methodology based on the utilization of a heteroskedasticity consistent Lagrange Multiplier (LM) bootstrap procedure to test H_0 of a linear formulation against a threshold formulation**.** In contrast to a simple case where the sample is split according to a known pre-assigned threshold value, the method that we use first tests for the presence of such a threshold and then estimates it. The methodology is similar in spirit to latent clustering methods with the main difference that in our case the asymptotic theory that we use, even though is nonstandard, allows for testing that that is easier to apply, see Hansen (2000), Caner and Hansen (2004) and Kourtellos et al (2015). In principle, one can test for additional sample splits, something that we did but we were unable to detect.

Appendix C – Linear model

Table C1: Static Panel Fixed Effects Results

Variables	(1) Dependent variable: GEN	(2) Dependent variable: GEN	(3) Dependent variable: GEN	(4) Dependent variable: CAP	(5) Dependent variable: CAP	(6) Dependent variable: CAP	(7) Dependent variable: LAB	(8) Dependent variable: LAB	(9) Dependent variable: LAB
Constant	17.240*** (0.553)	17.800*** (0.275)	17.376*** (0.559)	-0.297 (0.310)	0.194 (0.262)	-0.114 (0.256)	3.843*** (0.153)	3.813*** (0.149)	3.781*** (0.085)
RRI	-0.021* (0.012)	-0.053*** (0.010)	-0.027** (0.011)	-0.001 (0.003)	-0.038*** (0.007)	-0.003 (0.005)	**-0.005* (0.003)**	**0.002 (0.005)**	**-0.007*** (0.002)**
PRIV	**0.029 (0.044)**	**-0.144*** (0.018)**	**-0.028 (0.095)**	**-0.042*** (0.016)**	**-0.154*** (0.033)**	**-0.122*** (0.027)**	**-0.040*** (0.012)**	**-0.021 (0.031)**	**-0.039*** (0.015)**
WHOL	-0.108*** (0.030)	-	-0.215*** (0.063)	-0.008 (0.008)	-	-0.064*** (0.022)	0.007 (0.008)	-	**-0.019** (0.009)**
TPA	-0.029 (0.030)	-0.364*** (0.063)	-	-0.048*** (0.012)	-0.248*** (0.049)	-	0.032*** (0.008)	0.079*** (0.028)	-
lnGDP	0.404*** (0.062)	0.422*** (0.037)	0.396*** (0.062)	0.075*** (0.028)	0.072*** (0.026)	0.070*** (0.027)	0.682*** (0.017)	0.678*** (0.017)	0.701*** (0.010)
IND	0.006** (0.002)	0.008*** (0.001)	0.005** (0.002)	0.006*** (0.001)	0.006*** (0.001)	0.005*** (0.001)	-0.001** (0.001)	-0.001** (0.001)	-0.0004 (0.000)
URBAN	0.041*** (0.003)	0.034*** (0.002)	0.041*** (0.003)	0.027*** (0.001)	0.026*** (0.001)	0.027*** (0.001)	0.002** (0.001)	0.002** (0.001)	-0.000 (0.000)
EXPORT	0.003*** (0.001)	-0.0004 (0.001)	0.003*** (0.001)	-0.001*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	0.0002* (0.000)
FR	0.079*** (0.016)	0.077*** (0.007)	0.077*** (0.016)	0.039*** (0.010)	0.019* (0.013)	0.025** (0.013)	0.042*** (0.004)	0.044*** (0.004)	0.030*** (0.003)
TREND	0.007*** (0.002)	0.010*** (0.001)	0.007*** (0.002)	0.015*** (0.001)	0.016*** (0.001)	0.015*** (0.001)	-0.002*** (0.001)	-0.002*** (0.001)	-0.000 (0.000)
PRIV*RRI	-	0.027*** (0.005)	0.033 (0.024)	-	0.032*** (0.006)	0.037*** (0.006)	-	-0.008 (0.008)	-0.002 (0.003)
PRIV*TPA	-	0.118*** (0.017)	-	-	0.074*** (0.017)	-	-	-0.013 (0.020)	-
PRIV*WHOL	-	-	0.037 (0.069)	-	-	0.044* (0.024)	-	-	0.049*** (0.012)
RRI*WHOL	-	-	0.055* (0.020)	-	-	0.014** (0.006)	-	-	0.005** (0.002)
RRI*TPA	-	0.066*** (0.012)	-	-	0.042*** (0.009)	-	-	0.010* (0.006)	-
Diagnostics									
Observations	994	994	994	866	866	866	994	994	994
Number of countries	30	30	30	30	30	30	30	30	30
Adjusted R^2	0.98	0.99	0.98	0.99	0.99	0.99	0.98	0.98	0.99
Standard error of regression	0.19	0.18	0.19	0.12	0.12	0.12	0.05	0.05	0.05
F-statistic	1798.78*** [0.00]	15736.28*** [0.00]	1717.21 [0.00]	10737.27*** [0.00]	7596.44*** [0.00]	9491.99*** [0.00]	1354.06*** [0.00]	1292.62*** [0.00]	2510.79 [0.00]
D-W	0.16	0.38	0.16	0.19	0.10	0.10	0.13	0.13	0.10

Note: The table reports the fixed effects regression results for the major components of the electricity performance. The dependent variable is either the net generating electricity per capita (GEN), the installed electricity capacity (CAP) and finally the labour productivity in the electricity sector (LAB). GDP stands for the per capita GDP in the sample countries, PRIV stands for the ownership structure of the largest companies in all of the electricity market segments, RRI stands for the OECD regulatory reform index in the industry, TPA accounts for the third party access to the electricity transmission grid, WHOL stands for the existence of a liberalised wholesale market for electricity (wholesale pool), EXPORT measures the exports as a percentage of GDP, FR stands for Fraser Index of Economic Freedom, IND, measures the industrialising rate, URBAN stands for the urbanisation rate and TREND stands for the linear trend capturing time effect. The use of the fixed effects specification is justified after a Hausman test for each model. Robust standard errors are in parentheses. The numbers in square brackets are the p-values. Significant at ***1%, **5% and *10% respectively.

REFERENCES

Caner, Mehmet., and Bruce Hansen. (2004). “Instrumental Variable Estimation of a Threshold Model,” *Econometric Theory* 20: 813–843.

Hansen, Bruce. (1999). “Threshold Effects in Non-Dynamic Panels: Estimation, Testing, and Inference,” *Journal of Econometrics* 93 (2): 345–368.

Hansen, Bruce. (2000). “Sample Splitting and Threshold Estimation.” *Econometrica*, 68 (3): 575-603.

Kourtellos, Andros, Thanasis, Stengos, and Chih Ming Tan. (2015). “Structural Threshold Regression”, *Econometric Theory*, 1-34 DOI: http://dx.doi.org/10.1017/S0266466615000067.

Savvides, Andreas., and Thanasis Stengos. (2000). “Income Inequality and Economic Development: Evidence from the Threshold Regression Model,” *Economics Letters* 69 (2): 207–212.