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LATIN AMERICA ENERGY TRILEMMA: PERSPECTIVES ON THE ENERGY TRANSITION

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Núcleo de Estudos em Ciências Empresariais
Research Centre in Business Sciences

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Agenda

Motivation

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Conclusion



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Motivation

❑ The Energy Trilemma:

- ❑ Energy security: the effective management of primary energy supply from both domestic and external sources, the reliability of energy infrastructure, and the ability of participating energy companies to meet current and future demand.
- ❑ Energy equity: the accessibility and affordability of energy supply across the population.
- ❑ Environmental sustainability: the achievement of supply and demand-side energy efficiencies and the development of renewable and other low-carbon energy supply.

(Song et al. 2017)

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- ❑ The context of the energy matrix of Latin American countries is different from that of other regions
 - ❑ **It makes no sense to compare rich and poor countries.**
- ❑ Limitations of the trilemma indicator:
 - ❑ Final index calculation is assessed as inadequate; reliability questioned (Polana, 2019);
 - ❑ Countries adjust weights to favor their own interests (Neil Gunningham, 2013; Lian Song, 2017);
 - ❑ Need for variables sensitive to the social context of Latin America (Lazaro, 2024).

The need to adapt the trilemma to the reality of Latin America is identified

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- ❑ Objective:
 - ❑ To calculate the Energy Quadrilema Index according to the OECD (2008) in Latin American countries with available data.
- ❑ Dimensions:
 - ❑ **Energy Security:** Availability, accessibility, reliability and sustainability.
 - ❑ **Energy Equity:** Access to affordable and reliable energy.
 - ❑ **Sustainable Environmental Development:** Minimizing environmental and climate damage.
 - ❑ **Social Context (new):** Assessment of poverty, income, essential services and social protection.

Methodology - Data

Data from 2014 To 2020
11 LAC countries

1ª Step

- ❑ Build a database with variables that measure the 3 dimensions of the trilemma proposed by the (World Energy Council - WEC) as well as the social context dimension;
- ❑ Standardize with OECD (2008) manual for indicators and apply the Kalman filter (1960) to estimate missing values in the series;
- ❑ Obtain Cronbach's alpha and perform the K-M-O test to validate the construct.

2ª Step

- ❑ Principal Component Analysis (PCA): Creation of sub-indicators from relevant variables (Silva et al., 2015).
- ❑ Composite indicator: Simple aggregation with equal weights for each theme.

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Data

Quadriema Dimension	Variables	Sources
Energy Security	1 - Energy sufficiency index ;	OLADE
	2 - External energy dependency index;	
	3 - System average interruption duration index;	Doing Business
	4 - System average interruption Frequency index	
Cronbach's alpha	0,8	
Kaiser-Meyer-Olkin factor	0,54	
Energy Equity	1 - Energy access (Rural and urban);	WDI
	2 - Clean energy for cooking (Rural and urban);	
	3 - Biomass residential consumption index;	OLADE
	4 - Electricity prices	
Cronbach's alpha	0,94	
Kaiser-Meyer-Olkin factor	0,81	
Sustainable Development	1 - Co2 Emissions per capita;	OLADE
	2 - Final energy intensity GDP PPP;	
	3 - Electricity Efficiency sector;	
	4 - Index of emissions per energy consumed;	
	5 - Total supply renewability index	
Cronbach's alpha	0,77	
Kaiser-Meyer-Olkin factor	0,59	
Social Context	1 - Population with incomes below 2.15, 3.65 and 6.85 PPP per day;	WDI
	2 - Households, by availability of basic services in urban housing (Water and sanitation);	
	3 - HDI Inequality adjusted;	UNDP
	4 - GINI (Rural and urban);	
	5 - Relationship of average income between quintile 5 and quintile 1;	CEPAL
	6 - Social protection spendures	
Cronbach's alpha	0,74	
Kaiser-Meyer-Olkin factor	0,51	

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Energy Security PCA

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Principal Component Analysis

Component Loadings

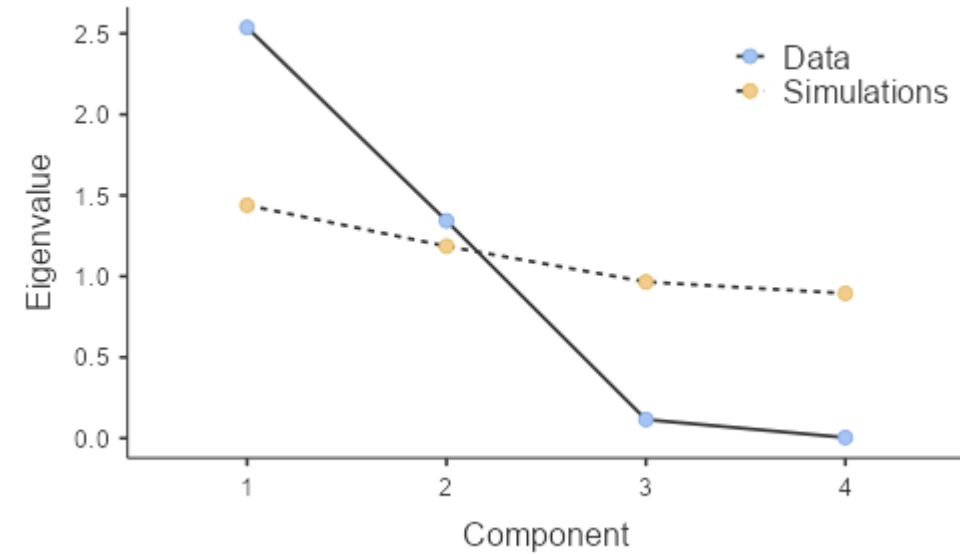
	Component		Uniqueness
	1	2	
EnergySufficiency	1.00	0.03	0.00
EnergyDependence	1.00	0.02	0.00
system_interrupt_freq	0.26	0.94	0.06
system_interruption_duration_index	0.29	0.93	0.06

Note: 'varimax' rotation was used

Eigenvalues

Initial Eigenvalues			
Component	Eigenvalue	% of Variance	Cumulative %
1	2.54	63.43	63.43
2	1.34	33.58	97.01
3	0.12	2.88	99.89
4	0.00	0.11	100.00

Scree Plot



Energy Equity PCA

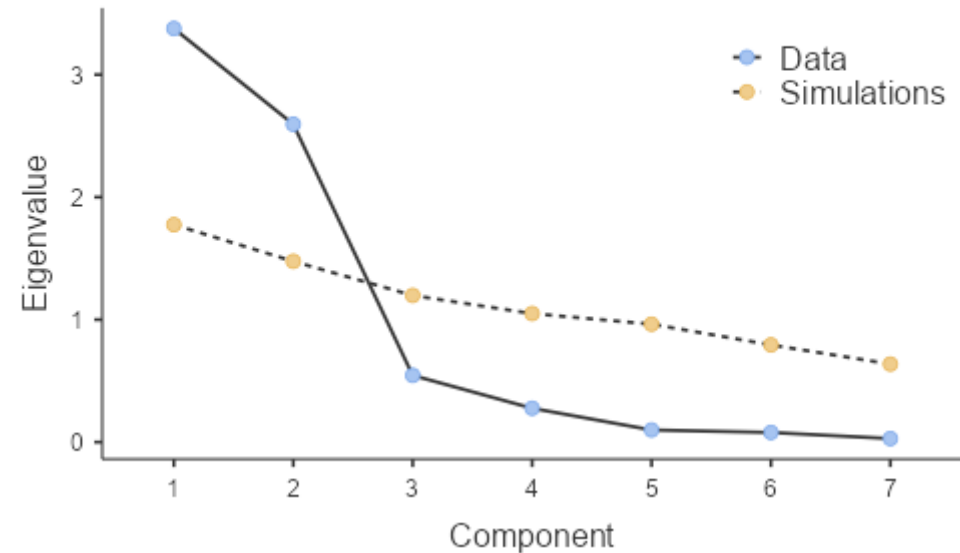
Principal Component Analysis

Component Loadings

	Component		Uniqueness
	1	2	
ResidBiomassCons	-0.94		0.05
CookEnergyRural	0.94		0.06
CookEnergyUrban	0.93		0.12
accessEnergyRural	0.82	0.31	0.23
Eletricity_residential		-0.81	0.34
Gasoline_Transport		0.91	0.15
Diesel_Transport		0.96	0.08

Note: 'varimax' rotation was used

Scree Plot



Eigenvalues

Initial Eigenvalues

Component	Eigenvalue	% of Variance	Cumulative %
1	3.38	48.24	48.24
2	2.60	37.08	85.32
3	0.54	7.78	93.10
4	0.28	3.95	97.05
5	0.10	1.41	98.47
6	0.08	1.12	99.59
7	0.03	0.41	100.00

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Sustainable development PCA

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Principal Component Analysis

Component Loadings

	Component		Uniqueness
	1	2	
EnergyRenew	0.95		0.09
FootPrint	-0.40	0.86	0.10
co2EnergyCons	0.96		0.07
EffEletricSector	0.88		0.21
co2perCapita	0.53	0.78	0.11

Note. 'varimax' rotation was used

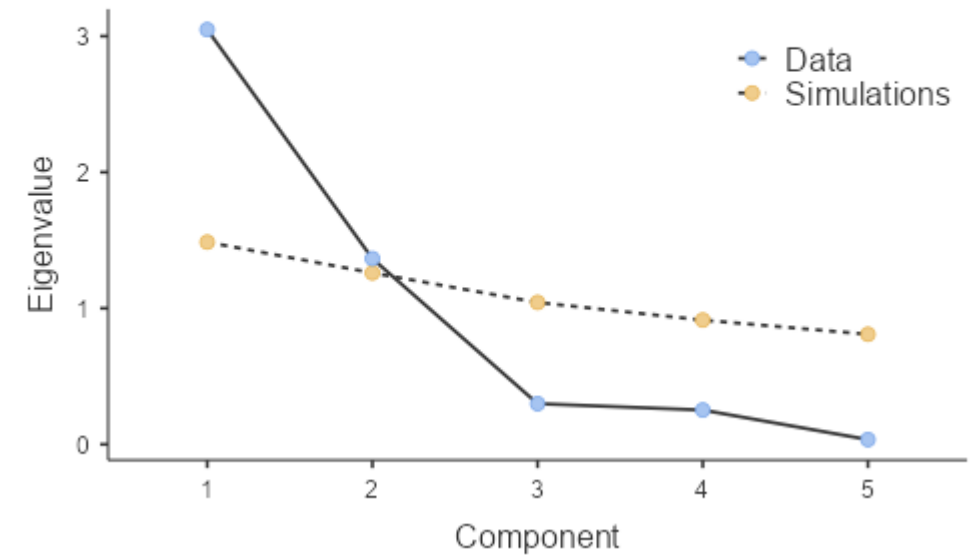
Component Statistics

Summary

Component	SS Loadings	% of Variance	Cumulative %
1	3.05	60.96	60.96
2	1.37	27.31	88.27

Eigenvalues

Scree Plot



Social context PCA

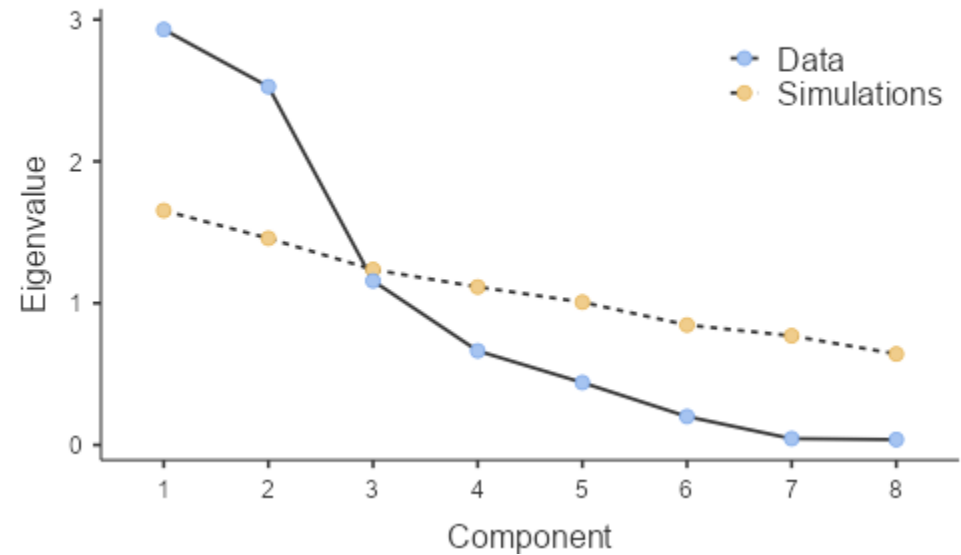
Principal Component Analysis

Component Loadings

	Component		Uniqueness
	1	2	
ihdi	0.90		0.12
sanitation	0.88		0.22
water	0.72		0.38
povert365perday	0.66		0.45
socialExp	0.60		0.54
QuintilRatioUrban		0.86	0.17
GiniRural		0.83	0.28
GiniUrban		0.82	0.18
QuintilRatioRural		0.79	0.31

Note. 'varimax' rotation was used

Scree Plot



Eigenvalues

Initial Eigenvalues

Component	Eigenvalue	% of Variance	Cumulative %
1	2.93	36.62	36.62
2	2.53	31.59	68.21
3	1.16	14.47	82.68
4	0.66	8.29	90.97
5	0.44	5.50	96.47
6	0.20	2.50	98.97
7	0.04	0.55	99.53
8	0.04	0.47	100.00

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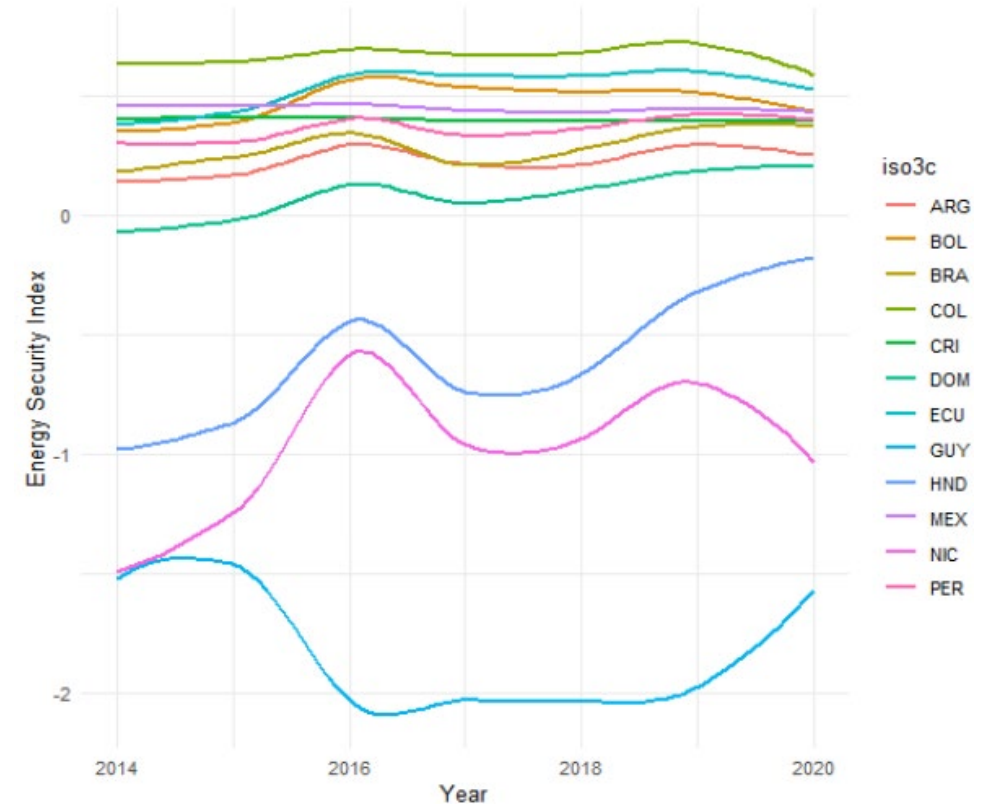
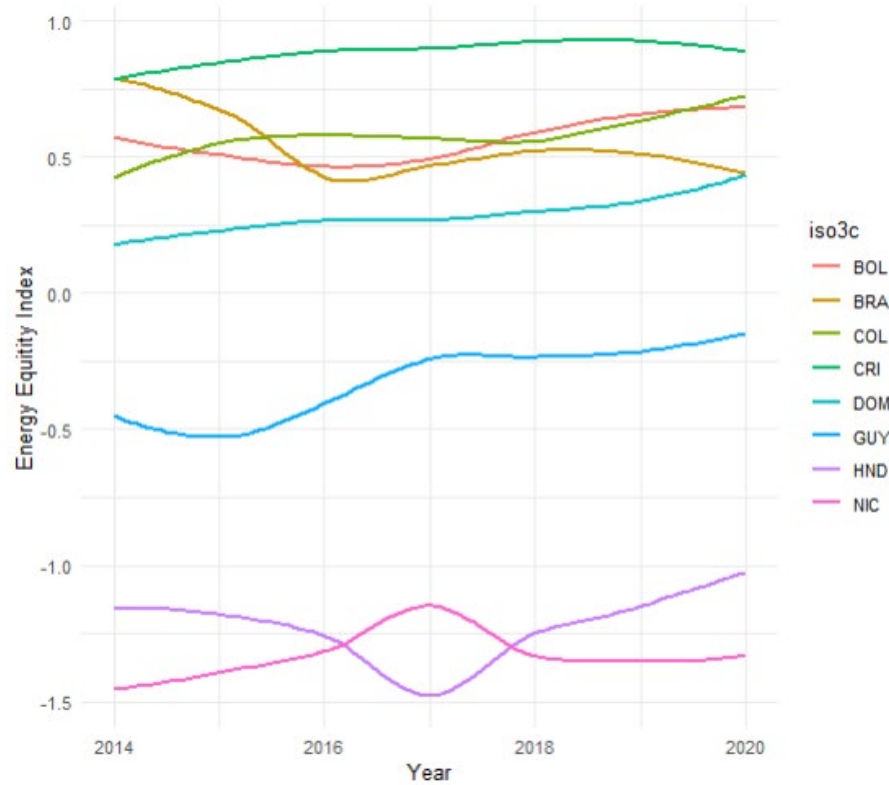
Dimensional Index

Motivation

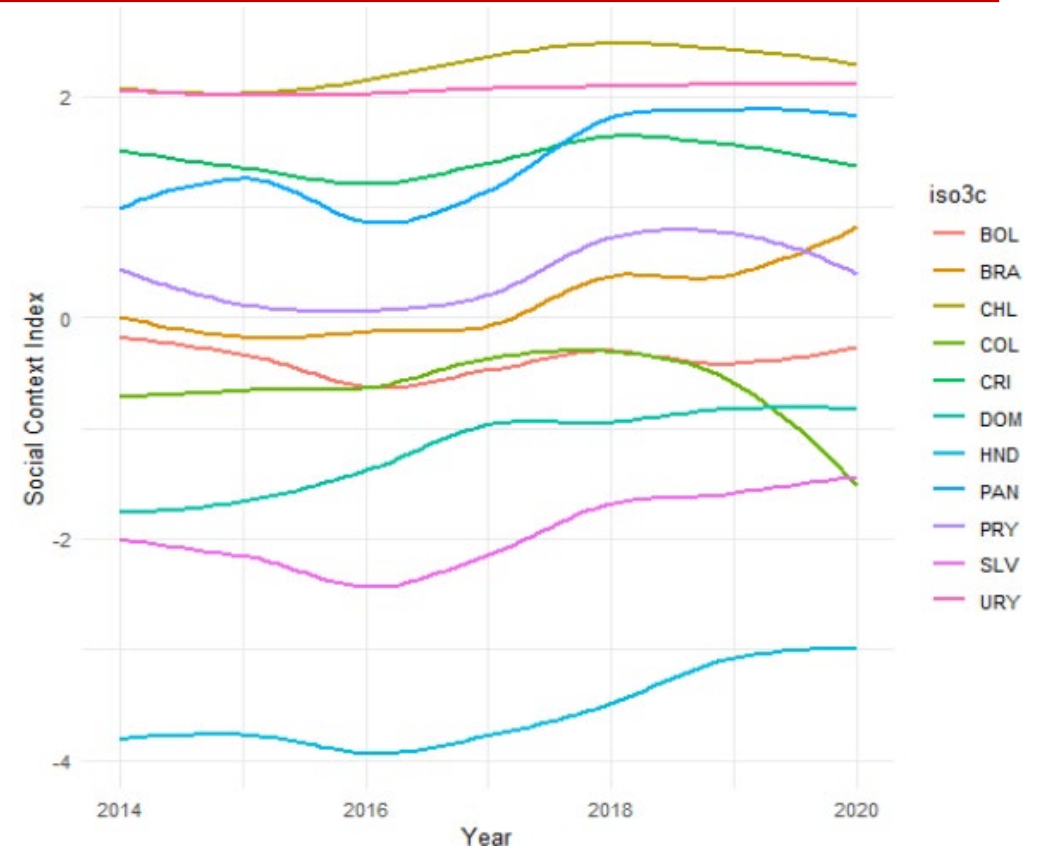
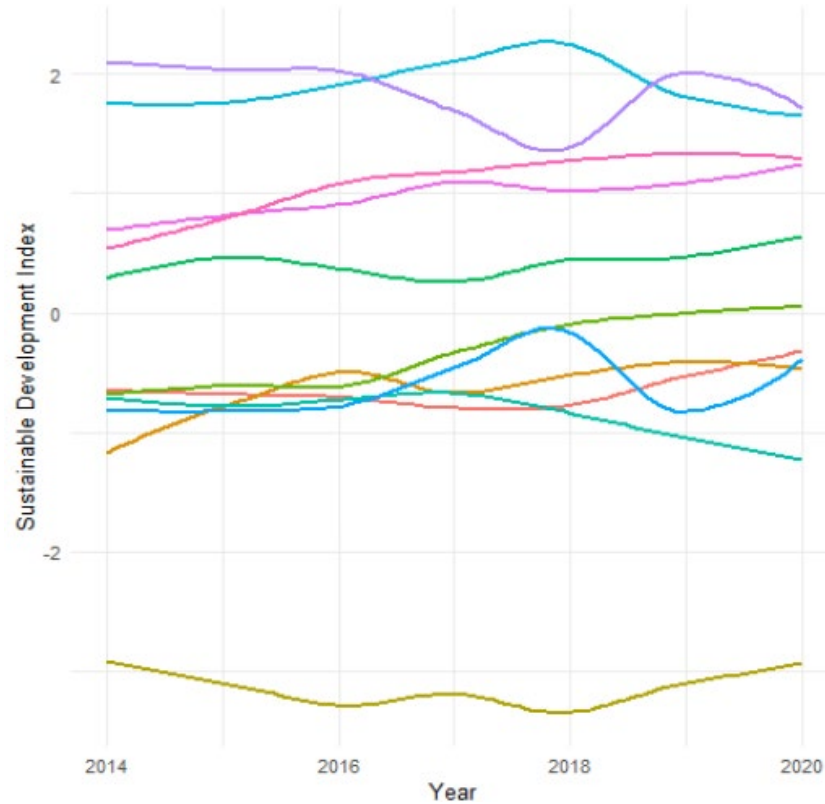
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Dimensional Index



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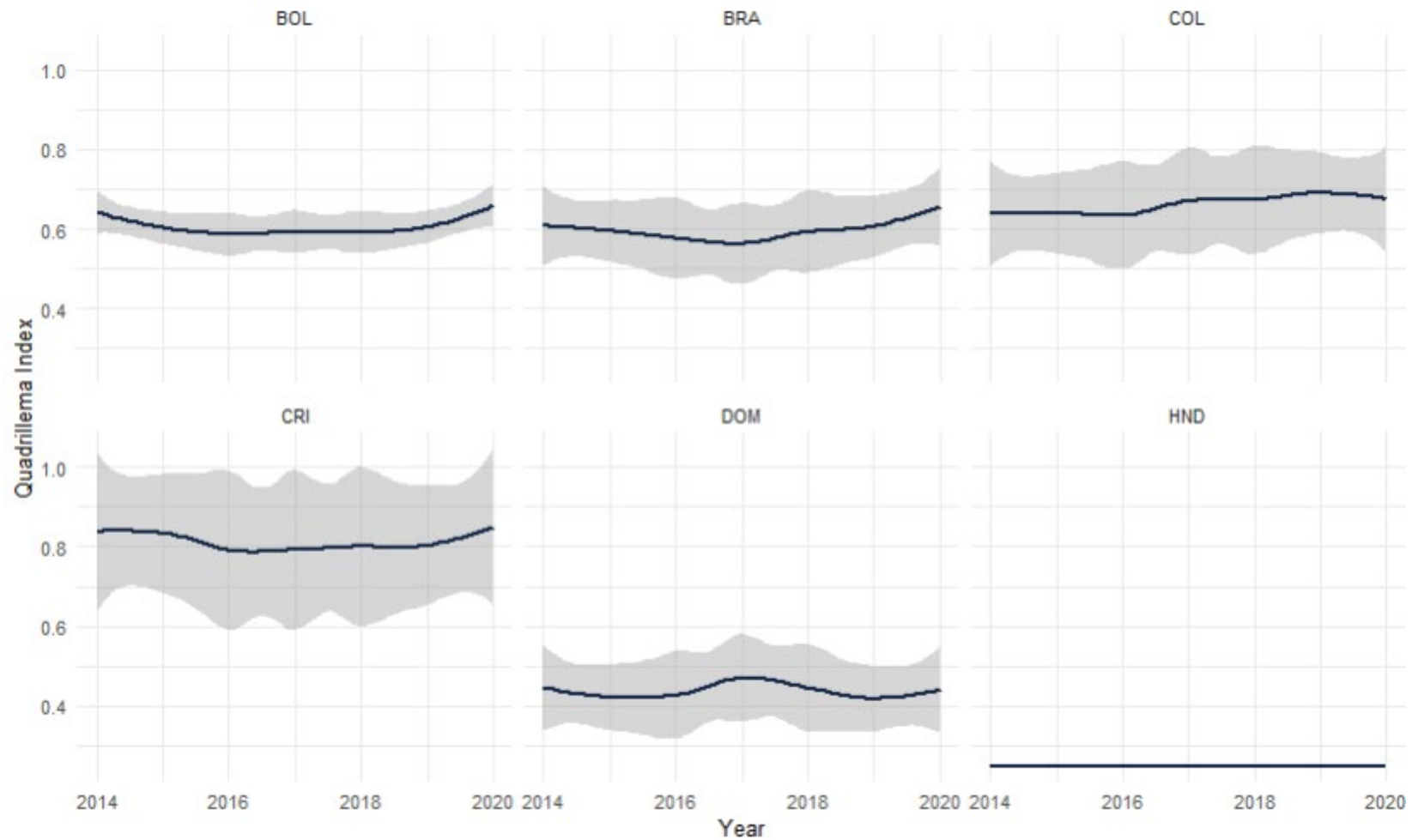
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Dimensional Index



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Final considerations

- ❑ The Energy Security sub-indicator reveals that many countries continue to depend **heavily on the export** of oil and derivatives.
- ❑ Energy Equity: There is progress in energy access. However, the indicator of access to modern energy for cooking reveals **disparities between urban and rural areas**, indicating that a segment of the population lacks access to electricity or doesn't use it.
- ❑ Social Context: The disparity between rural and urban areas is a significant highlight. The Gini index tends to be higher in rural areas.

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