Hydrodynamic Entropy of Income Distributions

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Abstract

This study analyzes global income inequality using **Hydrodynamic Entropy (HDE)**. Income data (2023) for 10 deciles per country were sourced from the *World Inequality Database*. Eight regional categories were studied to identify global inequality patterns. Results highlight entropy variations across income levels, governance types, and regions.

1 Data and Method

Each country's income distribution was represented by decile shares (P_k) summing to unity. The Shannon entropy formula is used:

$$H = -\sum_{k=1}^{10} P_k \log_2 P_k$$

Maximum entropy ($H_{max} = 3.322$) occurs when income is perfectly equal, while $H = 0$ indicates total inequality. Countries were grouped as:

- **Nordic:** Iceland, Denmark
- **Balkan:** Croatia, Slovenia
- **OPEC:** UAE, Saudi Arabia, Kuwait, Iraq
- **OECD:** USA, Canada, UK, Germany, France, Belgium
- **Communist:** China, Cuba, Vietnam, North Korea
- **African:** Nigeria, Egypt, Ethiopia, Kenya
- **Asian:** India, Bangladesh, Sri Lanka, Singapore, S. Korea
- **S. America:** Brazil, Chile, Peru, Colombia

1.1 Bar Plot of Income Distribution

The bar plot (Figure 1) illustrates the share of total national income held by each decile group for one representative country from each category. A uniform bar height indicates a more equitable distribution, while steeply increasing bars toward higher deciles signify strong income concentration among the wealthiest.

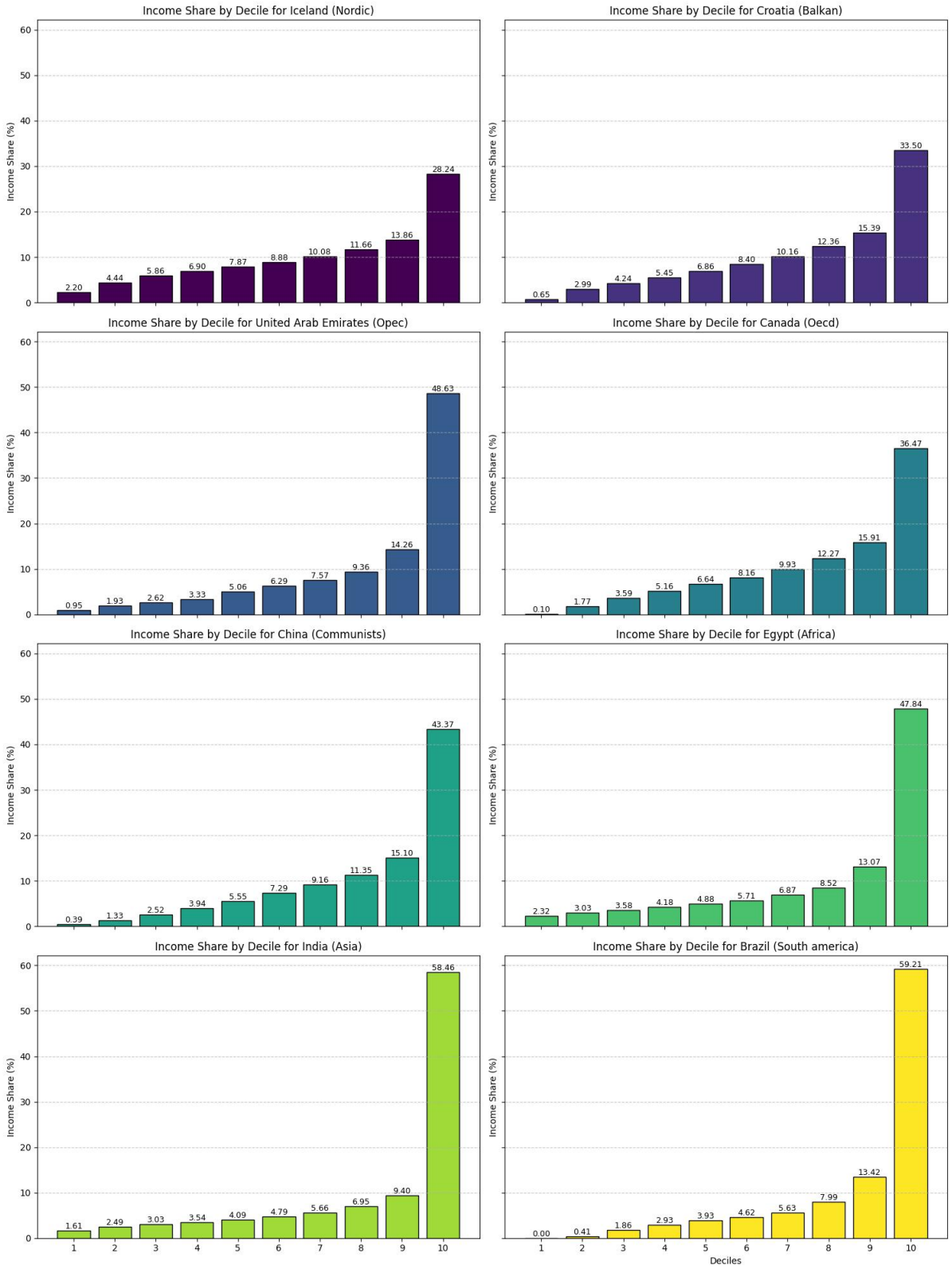

Figure 1: Bar plot of Income distribution across deciles for representative countries in each group.

1.2 Income Distribution

Each country shows varying skewness between richest and poorest deciles. Nordic nations have smoother curves, while OPEC and African regions show sharp income concentration.

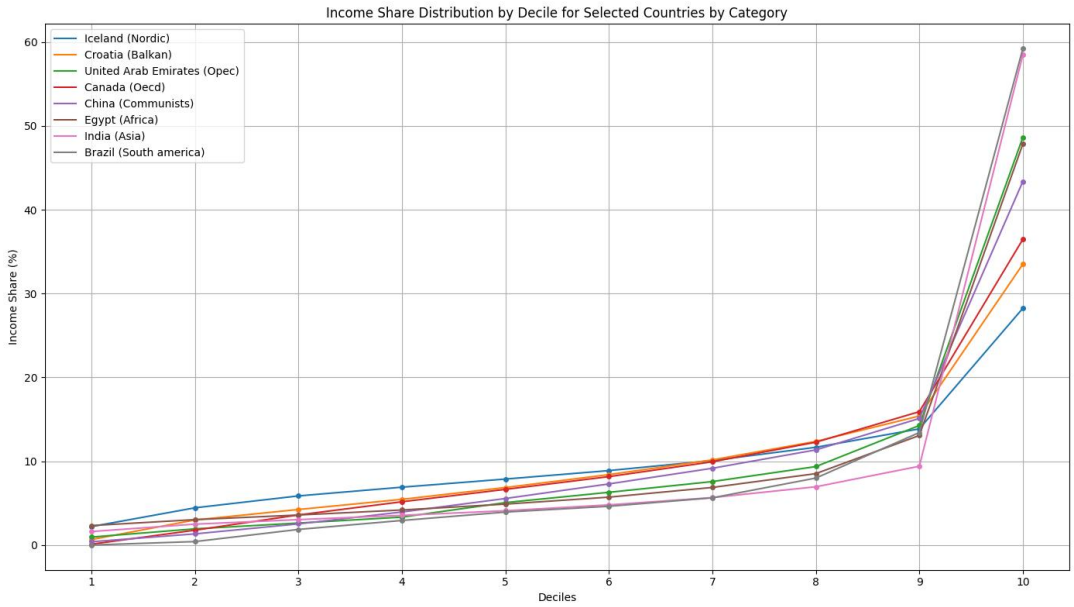

Figure 2: Income share distribution across deciles for representative countries in each group.

2 Results

2.1 Hydrodynamic Entropy Values of countries

Table 1: Individual Country Shannon Entropy (HDE) by Category

Category	Country	HDE	Category	Country	HDE
Nordic	Iceland	3.0311	**Balkan**	Croatia	2.8382
	Denmark	2.9051		Slovenia	2.9628
OPEC	United Arab Emirates	2.4519	**Communist**	China	2.5454
	Saudi Arabia	2.2670		Cuba	2.4952
	Iraq	2.5608		Vietnam	2.5922
	Kuwait	2.6485		North Korea	2.5711
OECD	Canada	2.7157	**Asia**	India	2.2258
	USA	2.4733		Bangladesh	2.6984
	France	2.8172		Sri Lanka	2.4695
	Germany	2.7881		Nepal	2.7021
	UK	2.7727		South Korea	2.7915
	Belgium	2.8798		Singapore	2.6230
S. America	Brazil	2.0386	**Africa**	Egypt	2.5514
	Peru	2.0808		Nigeria	2.6417
	Chile	2.0705		Kenya	2.4715
	Colombia	1.9048		Ethiopia	2.5931

2.2 Average Entropy by Category

Average entropy quantifies income uniformity across regions. Nordic countries exhibit the highest entropy (3.2), and South American the lowest (2.0) as shown in Figure 3.

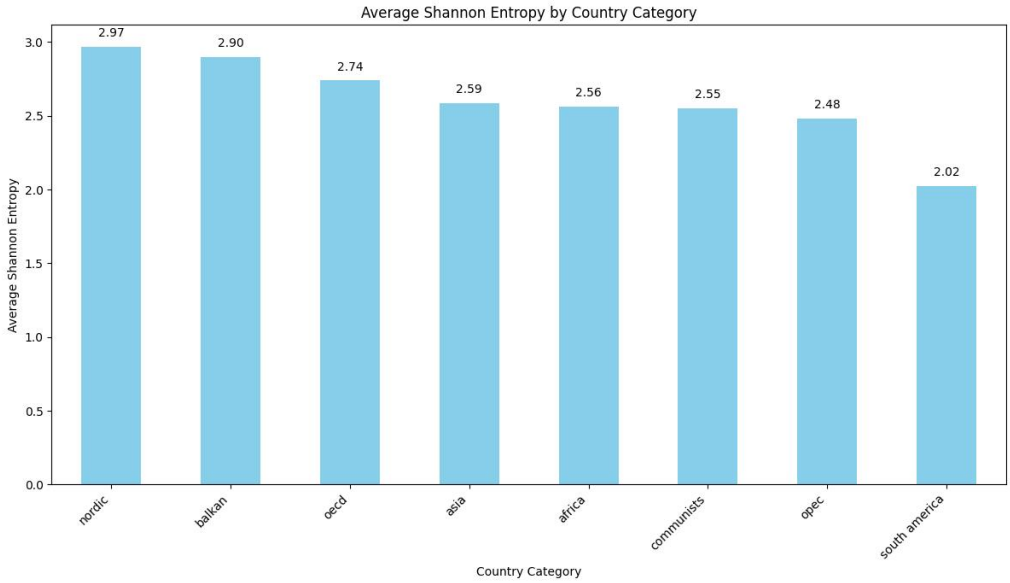

Figure 3: Average Hydrodynamic Entropy by regional category.

2.3 Temporal Trends

Entropy values were tracked across available years to reveal inequality dynamics. OECD countries remained stable, while developing nations showed gradual increase due to growth-led redistribution.

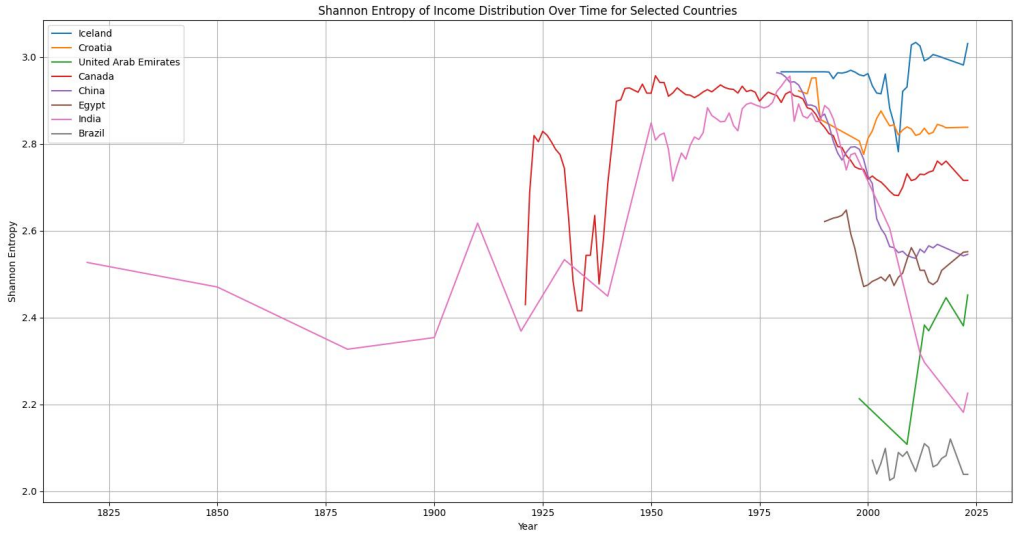

Figure 4: Temporal variation of Shannon entropy for one representative country per category.

3 Conclusion

Entropy-based analysis effectively visualizes global inequality structure. High-entropy (equal) societies align with welfare-oriented economies, while low-entropy (unequal) regions often coincide with resource-based or transitional economies.