Energy Consumption, CO_2 Emissions and Economic Development in the Caribbean: Are There Causal Links?

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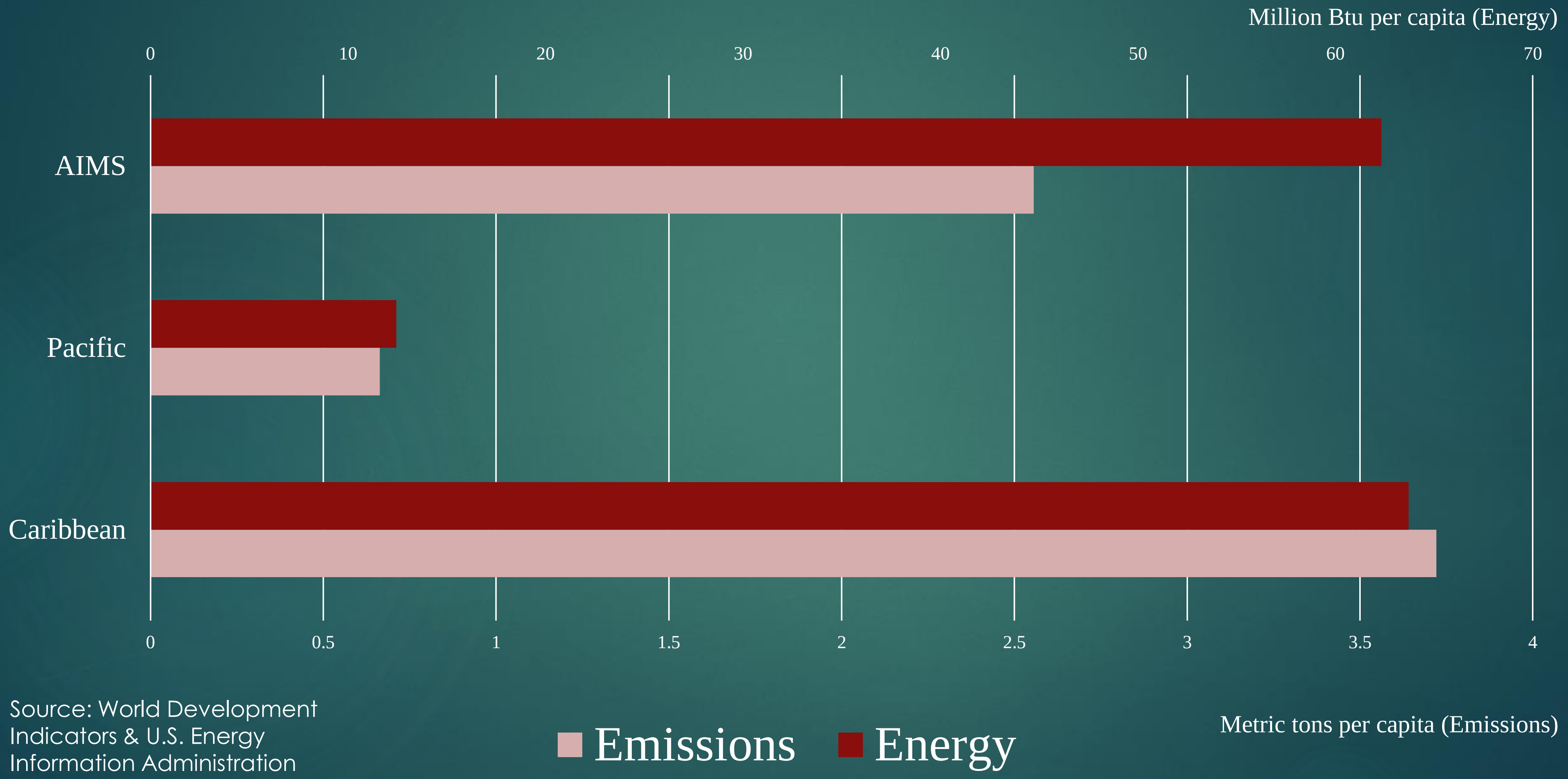
Motivation

- High cost to energy consumption in the Caribbean.
  - More than 90% of energy consumption comes from imported fossil fuels (UNEP 2014).
  - Fuel imports account for up to 20% of annual GDP (Walker-Leigh, 2012).
  - More than 30% of foreign exchange earnings is spent on fuel imports (UNEP 2014).

Motivation

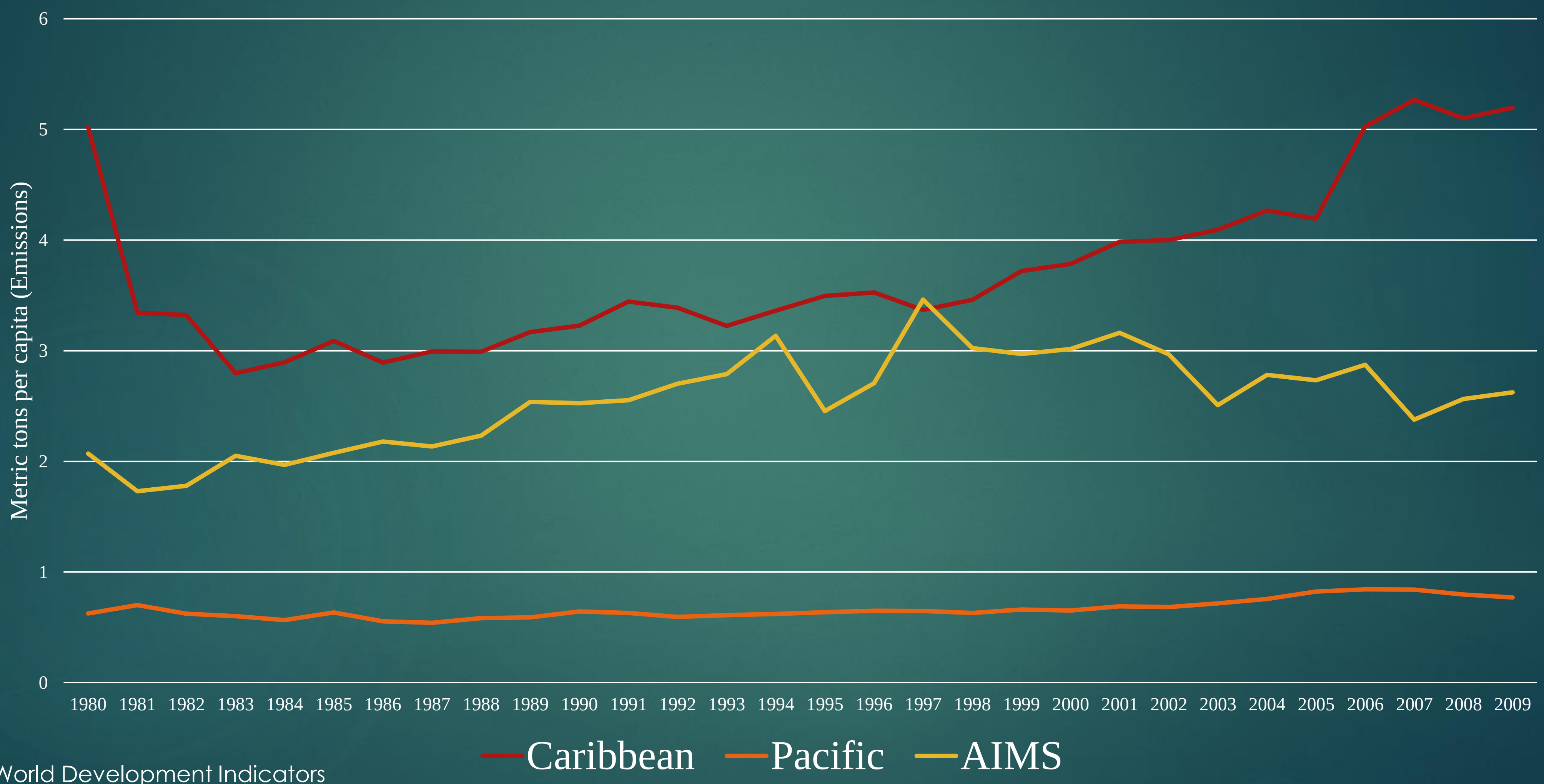
- High dependence on imported fuels comes with risk.
  - Many Caribbean islands involved in the PetroCaribe agreement.
  - Disruptions to this agreement have implications for regional energy security.
- High energy consumption may be associated with negative environmental impacts.
  - Current policy focus - Renewable energy
  - Limited financing, low technological capacity and political constraints (UNEP 2014).
- Conservation measures in the region?

Energy Consumption & CO_2 Emissions Across SIDS



Source: World Development Indicators & U.S. Energy Information Administration

CO_2 Emissions Over Time for SIDS



Source: World Development Indicators

Motivation – Main Questions

- Can conservation measures be implemented in the CARICOM member countries without harming development?

- If so, can conservation measures alone mitigate emissions?

Previous Work

- Studies specific to the Caribbean are sparse and span only a few countries.
  - Ramcharran (1990): Jamaica. Conservation not conducive to growth.
  - Francis et al. (2007): Haiti, Jamaica, Trinidad & Tobago. Conservation possible in long run for Haiti & Jamaica but not T&T.
  - Lorde et al. (2010): Barbados. Conservation not conducive to growth.
- Previous studies focus on first question – little attention to the role of environmental emissions
  - Omitted variable bias
  - Cannot address second question – Can conservation measures alone mitigate emissions?

Innovations of this Paper

- We address omitted variable bias by including environmental emissions as an endogenous variable. Emissions can affect the energy-development link.
- we include fourteen Caribbean islands to make results more generalizable to the SIDS group.
- We use a country-specific approach to allow for heterogeneity.
- Use the TY (1995) Granger non-causality approach
  - Accommodates different integration and cointegration properties of the data – more flexible
  - Does not require testing for cointegration prior to causality testing – avoids pre-test bias
  - Variables enter model in levels – no loss of long-run information from differencing

Economic Model

Energy-Development Link (Energy dependence literature)

Hypothesis	Relationship	Implication
Growth	Energy → Development	Conservation may reduce growth.
Feedback	Energy ↔ Development	Conservation may reduce growth.
Conservation	Development → Energy	Growth unaffected by conservation.
Neutrality	Energy -/-> Development	Growth unaffected by conservation.

Emissions-Development-Energy Links (EKC Hypothesis)

Hypothesis	Relationship	Environmental Implication
Energy consumption raises emissions	Energy → Emissions	Conservation likely to have a positive impact.
Development increases emissions	Development → Emissions	Form of development associated with higher emissions

Estimation and Testing

- Step I – Construct VAR in levels and determine optimal lag length, k, using SBC; diagnostic tests to ensure VAR(k) well-specified.

- Step II – Determine maximum order of integration, m, from stationarity properties of data for each country.

- Step III – Augment optimal VAR(k) with d additional lags. Estimate VAR(k+d):

  - $ED_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} ED_{t-i} + \sum_{i=1}^{k} \alpha_{2i} EC_{t-i} + \sum_{i=1}^{k} \alpha_{3i} EE_{t-i} + \sum_{i=k+1}^{k+d} \alpha_{4i} ED_{t-i} + \sum_{i=k+1}^{k+d} \alpha_{5i} EC_{t-i} + \sum_{i=k+1}^{k+d} \alpha_{6i} EE_{t-i} + \varepsilon_{1t}$ (1)

  - $EC_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} ED_{t-i} + \sum_{i=1}^{k} \beta_{2i} EC_{t-i} + \sum_{i=1}^{k} \beta_{3i} EE_{t-i} + \sum_{i=k+1}^{k+d} \beta_{4i} ED_{t-i} + \sum_{i=k+1}^{k+d} \beta_{5i} EC_{t-i} + \sum_{i=k+1}^{k+d} \beta_{6i} EE_{t-i} + \varepsilon_{2t}$ (2)

  - $EE_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} ED_{t-i} + \sum_{i=1}^{k} \gamma_{2i} EC_{t-i} + \sum_{i=1}^{k} \gamma_{3i} EE_{t-i} + \sum_{i=k+1}^{k+d} \gamma_{4i} ED_{t-i} + \sum_{i=k+1}^{k+d} \gamma_{5i} EC_{t-i} + \sum_{i=k+1}^{k+d} \gamma_{6i} EE_{t-i} + \varepsilon_{3t}$ (3)

- ED – real GDP (WDI); EC – energy consumption (US Energy Info Admin); EE - CO_2 emissions (WDI); ε - N(0,1) error terms.

Estimation and Testing

- To assess Granger causality - block exogenous Wald test.
- In determining causality from energy consumption to development:
  - H_0: $\alpha_{21} = \alpha_{22} = \ldots = \alpha_{2k} = 0$
- In determining causality from energy consumption to emissions:
  - H_0: $\gamma_{11} = \gamma_{12} = \ldots = \gamma_{1k} = 0$
- Modified Wald Statistic – asymptotic χ^2 distribution with k degrees of freedom (TY, 1995).

Results

Country	Energy-Development Link	Hypothesis	Energy → Emissions	Development → Emissions
Antigua & Barbuda	Energy → Development	Growth	No	No
Haiti	Energy → Development	Growth	Yes	No
Trinidad & Tobago	Energy ↔ Development	Feedback	No	Yes
St. Kitts & Nevis	Development → Energy	Conservation	No	No
Bahamas	Energy -/-> Development	Neutrality	No	No
Belize	Energy -/-> Development	Neutrality	No	Yes
Barbados	Energy -/-> Development	Neutrality	No	Yes
Dominica	Energy -/-> Development	Neutrality	Yes	No
Grenada	Energy -/-> Development	Neutrality	No	No
Guyana	Energy -/-> Development	Neutrality	No	No
Jamaica	Energy -/-> Development	Neutrality	Yes	No
St. Lucia	Energy -/-> Development	Neutrality	No	Yes
St. Vincent & the Grenadines	Energy -/-> Development	Neutrality	No	No
Suriname	Energy -/-> Development	Neutrality	No	No

Policy Recommendations

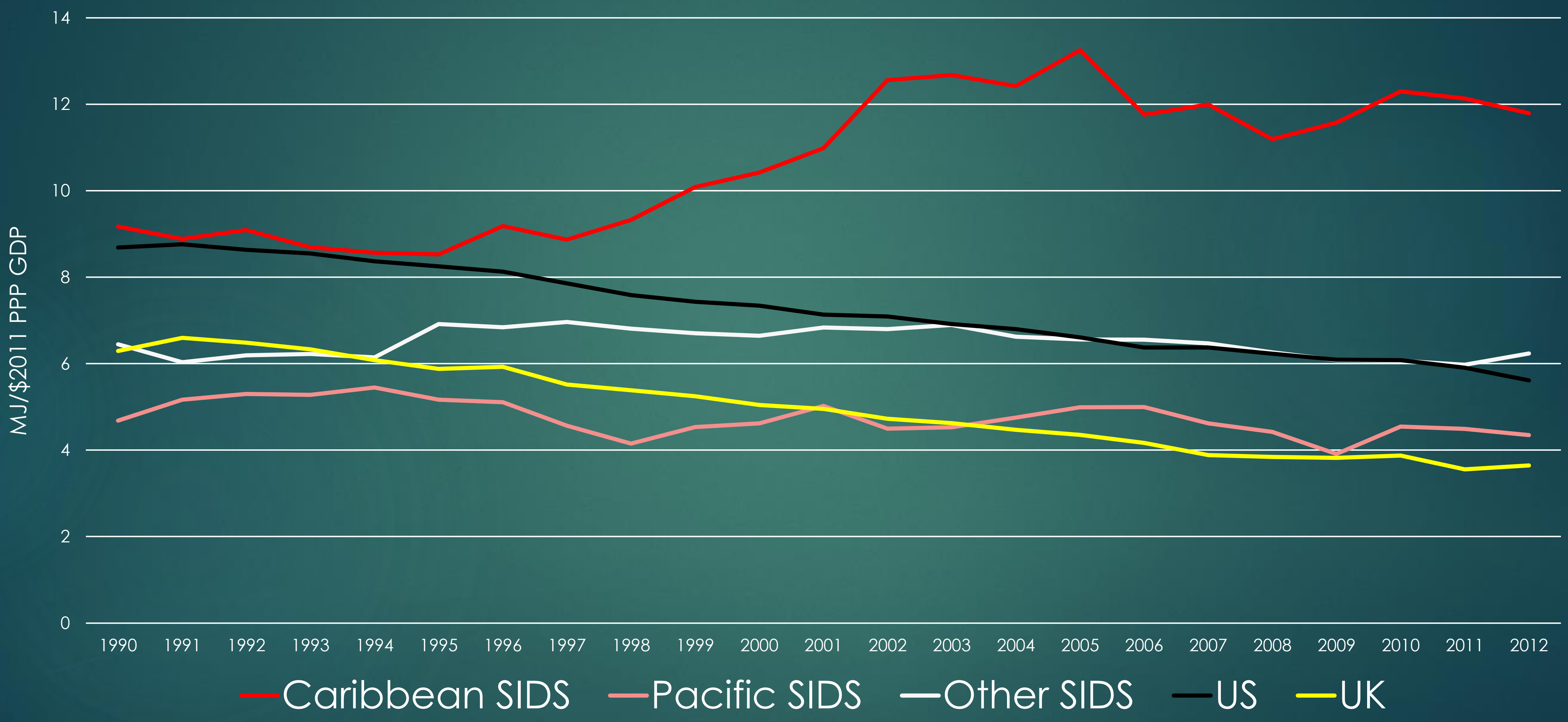
- Energy policies aimed at reducing energy consumption in the 3 energy dependent countries are likely to negatively impact economic growth (Ant & Bar, Haiti, T&T).
  - More focus on energy intensity policies.
- Such policies may be possible to implement in the 11 non-energy dependent countries without harming economic development
  - Conservation measures may reduce energy costs
- However, among the non-energy dependent countries, conservation measures may mitigate emissions in 2 countries (Dom, Jam).
- Among 11 non-energy dependent countries, ED main driver of emissions in 3 countries (Bel, Bar, St. Luc).
- Other factors likely driving emissions in remaining 6 non-energy dependent countries – need for further research.

Policy Recommendations

- T&T - Feedback hypothesis holds
  - Conservation measures may negatively affect economic development
    - Not advisable in reducing energy costs
    - More focus on energy intensity policies.
  - But EC not main driver of emissions – ED is!
    - More attention to linking ED and environmental policies

- Perhaps role for private sector, in conjunction with gov't policies
  - Providing solutions to facilitate energy conservation and lower energy intensity

Final Thought – Energy Intensity Over Time



Source: World Development Indicators

Appendix – PP & ADF Unit Root Test Results

Country	Development	Energy Consumption	Emissions
Antigua & Barbuda	I(1)/I(1)	I(0)/I(0)	I(0)/I(0)
Bahamas	I(1)/I(1)	I(1)/I(1)	I(0)/I(0)
Belize	I(2)/I(2)	I(1)/I(1)	I(1)/I(1)
Barbados	I(1)/I(0)	I(0)/I(0)	I(1)/I(1)
Dominica	I(1)/I(1)	I(0)/I(0)	I(0)/I(0)
Grenada	I(1)/I(1)	I(1)/I(1)	I(1)/I(1)
Guyana	I(1)/I(0)	I(1)/I(1)	I(1)/I(1)
Haiti	I(1)/I(1)	I(1)/I(1)	I(1)/I(1)
Jamaica	I(1)/I(1)	I(1)/I(1)	I(1)/I(1)
St. Kitts & Nevis	I(1)/I(1)	I(1)/I(1)	I(1)/I(1)
St. Lucia	I(1)/I(1)	I(0)/I(0)	I(1)/I(1)
St. Vincent & the Grenadines	I(1)/I(1)	I(1)/I(1)	I(1)/I(1)
Suriname	I(1)/I(1)	I(1)/I(1)	I(0)/I(0)
Trinidad & Tobago	I(2)/I(2)	I(1)/I(1)	I(1)/I(1)