Simple Models for the Complex Problem of Measuring and Improving Sustainable Development

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Outline

- The problem
- Rationale for selecting certain solutions for today
- Solution from Humboltd State University
- Solution from Zhejiang University
- Other cool math
- Conclusions and Discussion

The Problem

The Problem (well first…)

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- Sustainable Development
    - What is it?
    - Why is it hard?
    - Who is thinking about this issue?
    - Why is it important?

The Problem

- Part 1:
  - Develop a way to compare/rank the sustainable development of a nation
  - Validate the methodology
- Part 2:
  - Select one of nations of the UN's list of 40 least developed nations
  - Develop a specific targeted action plan to advance that nation's level of sustainable development

Commonly used data

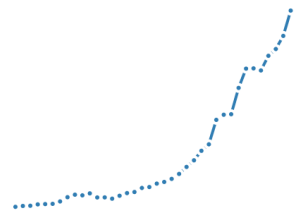- World Bank

Commonly used data

- World Bank

How did I pick the solutions we will discuss?

From Humboldt State University

- Methodology overview:
  - Identified six domains
    - Economics, Risk, Social, Environmental, Political, Institutional
  - Identified country-specific data to create a metric score for each domain
  - So far – this was a common approach, so why was this paper outstanding?

From Humboldt State University

- Strengths:
  - Clear rationale for selection of choices
  - Excellent link between mathematical choices and real world – clear and convincing discussion!
  - Did *NOT* try to collapse these six domains into a single integrated metric (which was a common approach)
    - So, what did they do instead?

From Humboldt State University

- Radar Plot
  - Used a radar plot visualization
  - Allowed more targeted suggestions for the country-specific 20-year plan (Bhutan)
  - Allowed a better way to show the outcome of implementing the 20-year plan
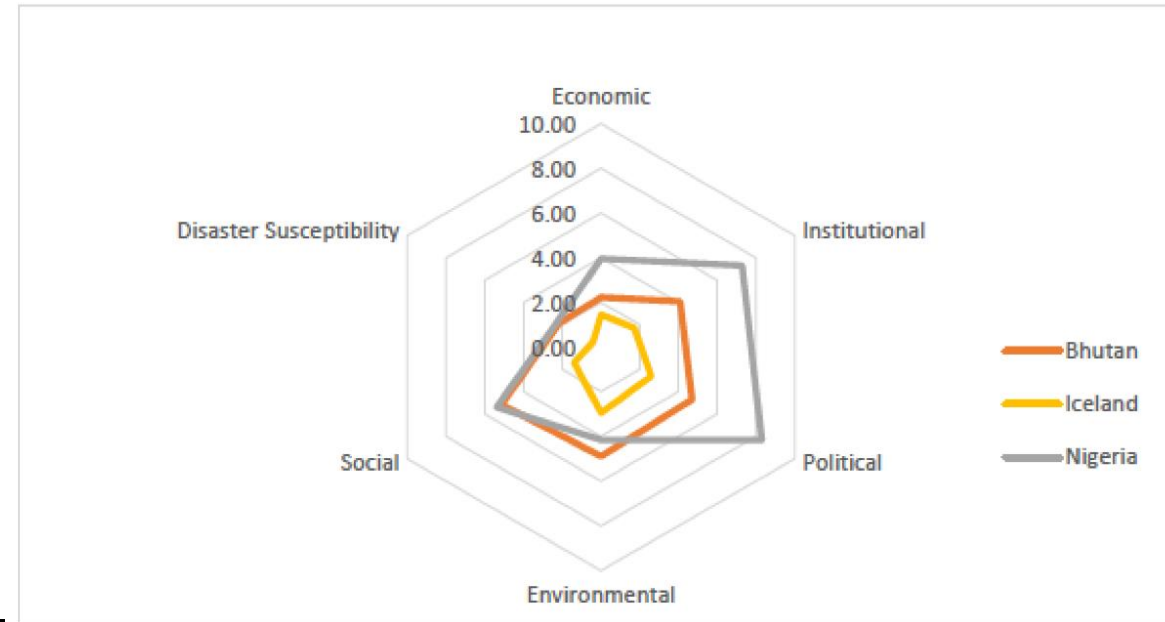
From Humboldt State University
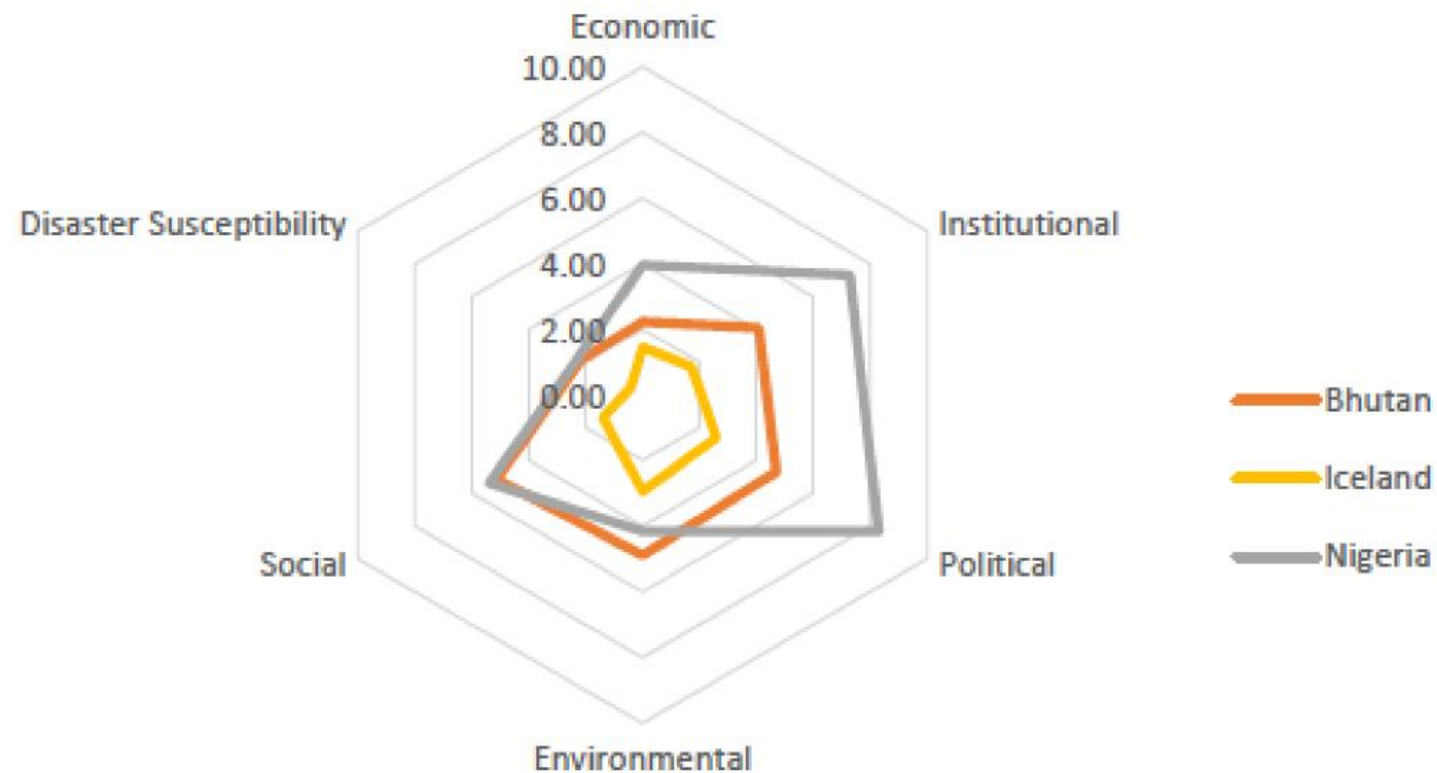
What level of math was needed?

- For each domain, they made and justified a linear weighted metric involving factors that they noted as relevant

- They made a radar plot – more about creativity than "math knowledge"

- The beauty of this solution is the simplicity – any national leader could understand their logic, their methodology, and their findings.

From Zhejiang University

- Methodology Overview
  - As with many teams, this Outstanding paper distilled country data into two indices: socio-economic and environmental
  - They used many of the same approaches as other teams to make their indices (PCA and entropy-based weighting scheme)
  - So, why is this solution special?

From Zhejiang University

- Strength
  - Development of an angle-based measure!
  - Goal was to be balanced between the two indices, so living along a y=x line
    - "Harmonious development measure" defined as the magnitude of the intersection angel between the ideal development direction and the actual development direction of a nation through regression analysis
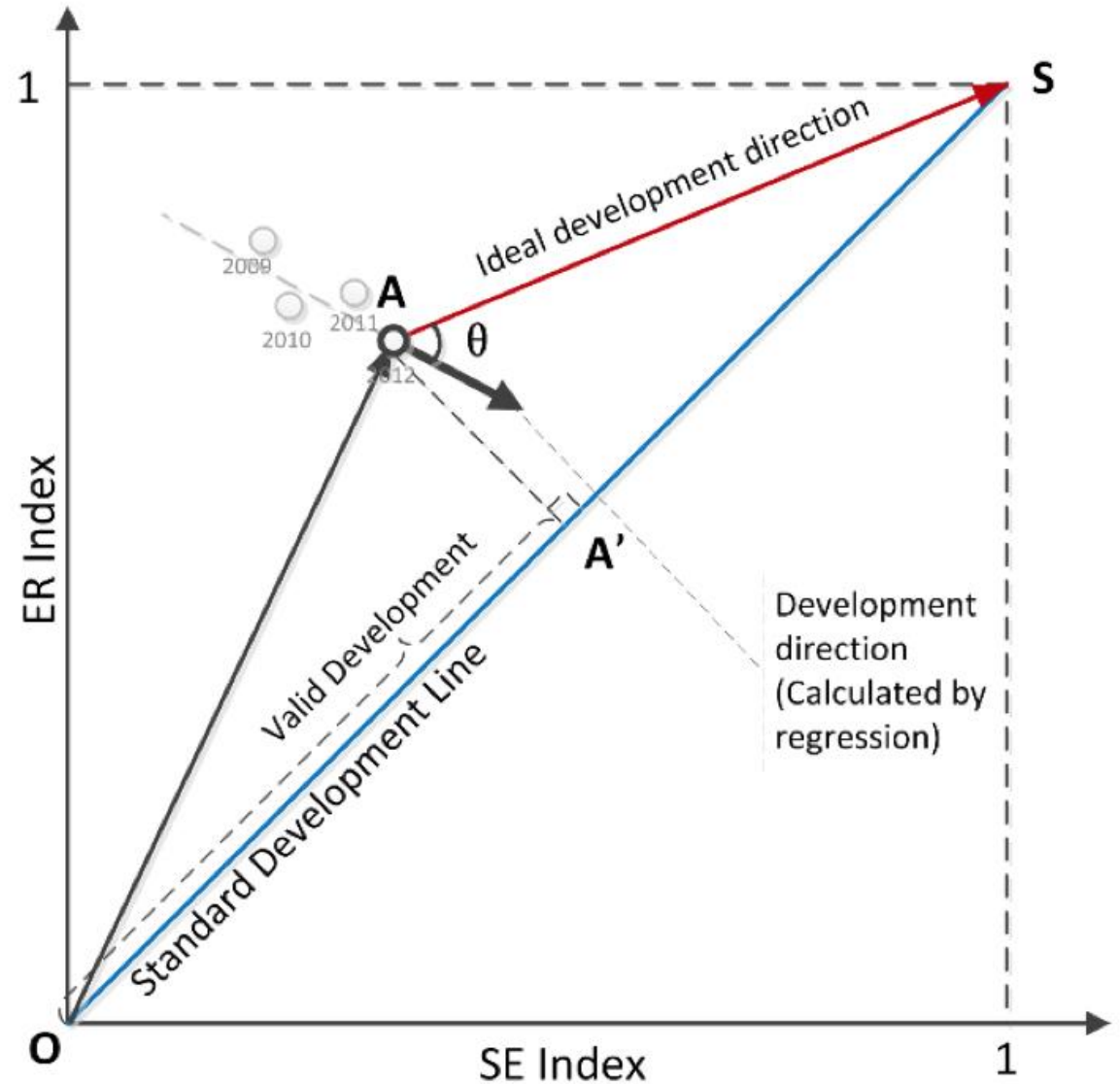
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- Wait! This sounds confusing! How is that good…?
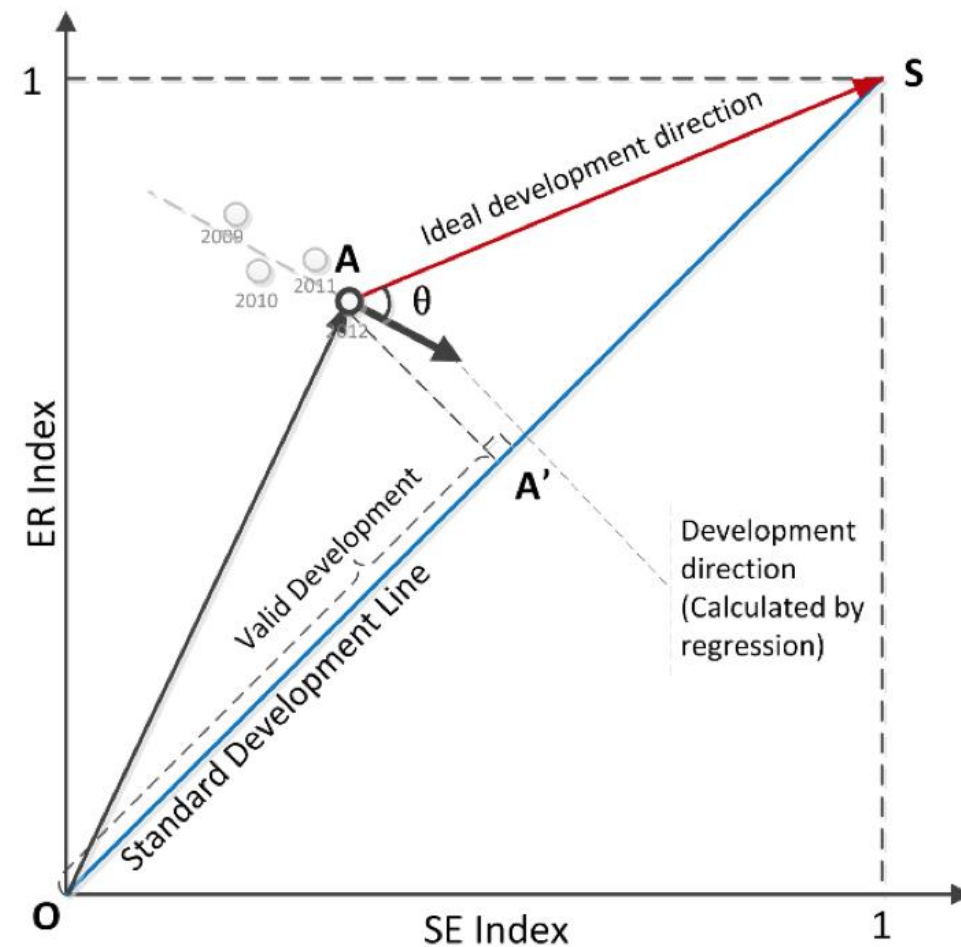
From Zhejiang University

- Harmonious Development Measure
  - The magnitude of the intersection angel between the ideal development direction and the actual development direction of a nation through regression analysis
- Single metric as a result which allows easy relative ranking of nations
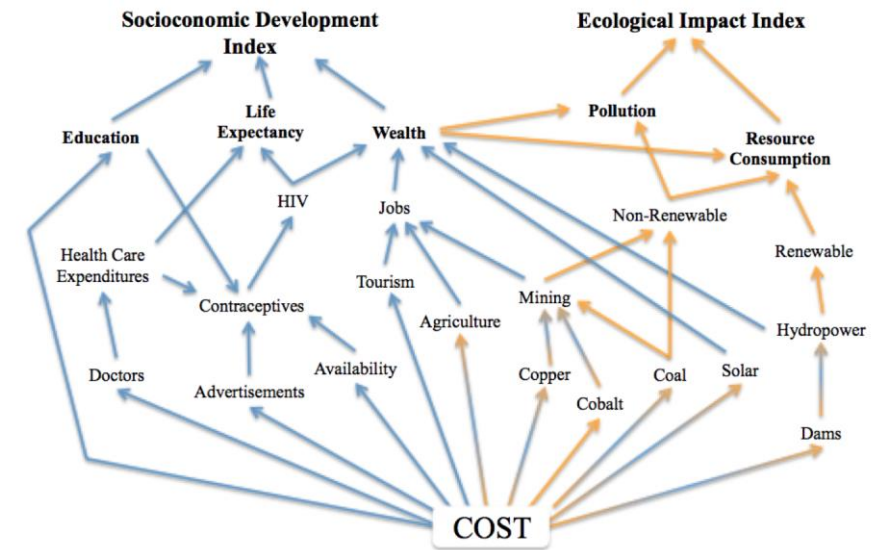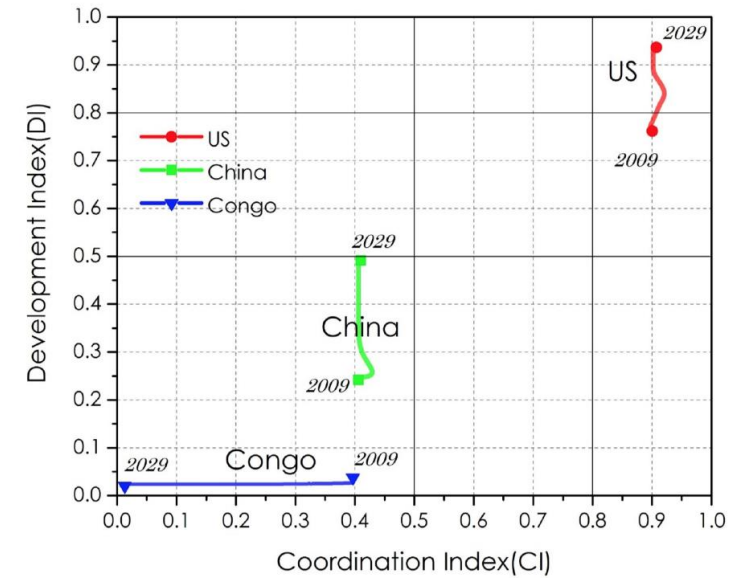
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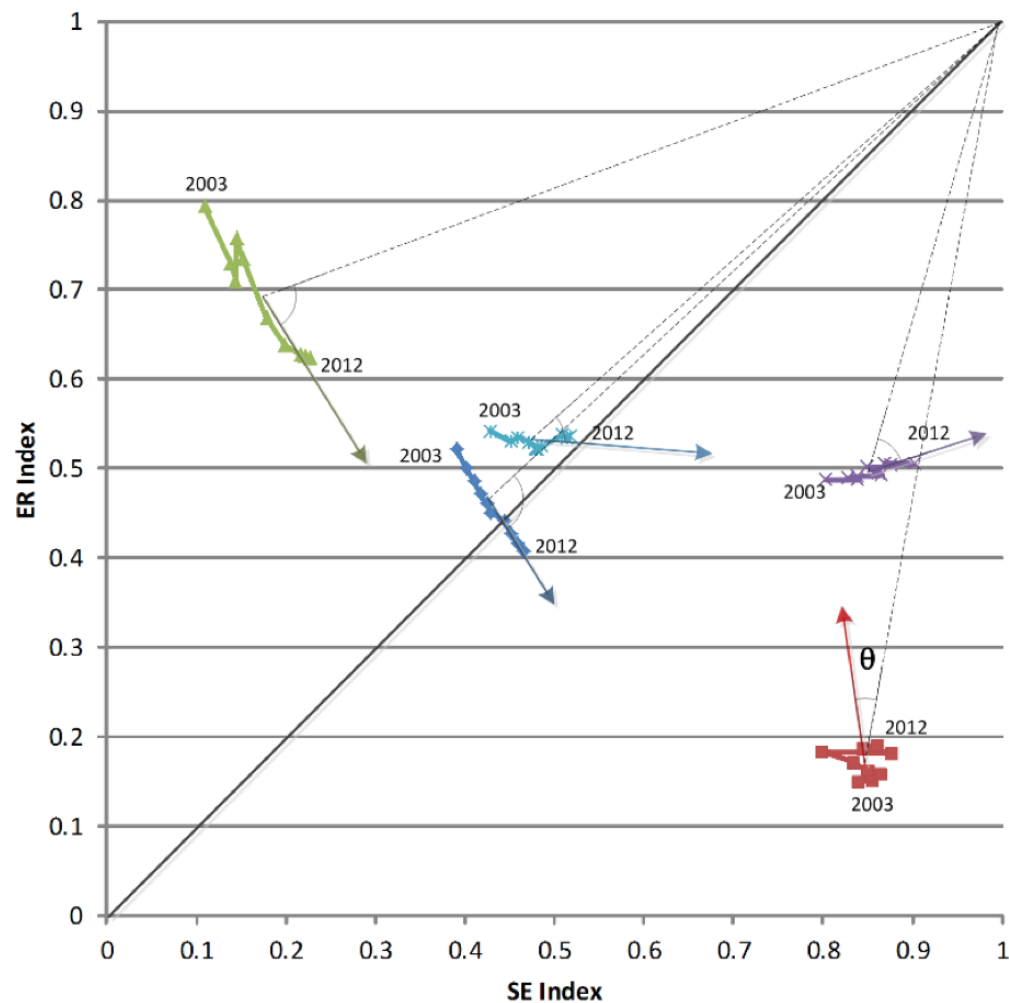
What level of math was needed?

- For each index, they used linear algebra (PCA)

- They used linear trendlines to determine a pattern

- They used trigonometry to define their angle

Some other cool mathematics used!

- Particle Swarm Optimization

- Lanchester Equations

- Trajectory Tracking

- Principle Component Analysis

Conclusions and Discussion

- In these contests, students use a wide range of mathematics
  - Some is advanced and surprising for undergraduates
  - Some is simple and elegant and accessible
  - Good explanations are critical
  - Good visualizations are powerful
- Questions?
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