An Air Transport Connectivity Indicator and its Applications

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Outline

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2. ACI Results

3. Comparison with Other Indicators

4. ACI and Liberalization of Air Transport Policies

5. ACI and Economic Outcomes
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   - Integration into production networks
   - Export diversification

6. Summary
Why Connectivity Matters

- The trade facilitation agenda is currently expanding to focus more on the concept of connectivity, i.e. how a country is placed in global trade and transport networks
  - ASEAN Connectivity Master Plan
  - APEC’s follow up to the two Trade Facilitation Action Plans is the new Supply Chain Connectivity Framework

- Connectivity—network positioning—also matters for the broader export competitiveness agenda:
  - “Before-the-border” trade costs
  - Complements existing work on “at-the-border” and “behind-the-border” trade costs

- Importance of developing indicators to look at the logic from policy to connectivity to competitiveness
Why Connectivity Matters

- We focus on air connectivity, but the techniques can be applied elsewhere (e.g., maritime)

- Connectivity in air transport is particularly important for
  - Non-traditional exports (horticulture, etc.)
  - Export diversification
  - Data availability both on the input (policy) and output (economic variables) sides

- A natural experiment in lost air connectivity:
  - Iceland’s volcano eruption in April 2009 shut down air transport…
  - And cost Kenyan fresh food and flower exporters around $4m per day.
ACI Results

- Estimate a fixed effects gravity model using 2007 SRS data for 211 countries
  - Number of flights per week between the origin and destination
  - Includes passenger, cargo, and mixed flights
  - Most comprehensive data source in the industry BUT does not capture true origin – true destination
  - Cf. gross shipments versus value added in gravity models of trade.

\[ (36) \quad \hat{X}_{ij} = A_i B_j \exp(-\beta f(d_{ij})) \]

\[ (37) \quad f(d') = a \ast \left[ \log(a + d) - \log(a) \right] \]
ACI Results

- Estimation using Poisson PML

- Grid search over feasible values of the distance shift parameter so as to maximize the log-likelihood
  - Maximum at 3,900km, or roughly the threshold between medium- and long-haul flights.

- Manipulate the estimated fixed effects and total inward and outward flights to calculate the ACI:

\[
\tilde{C}_i = \sqrt{\frac{X_i/A_i + B_i}{\sum_j B_j}} \times \sqrt{\frac{X_i/B_i + A_i}{\sum_j A_j}}
\]
ACI Results
ACI Results

- Shifted distance coefficient is negative and 1% statistically significant
  - Implied elasticity of substitution of 5.5, which is on the low end of what is usually found for goods trade
  - At the mean, a 1% increase in distance is associated with a 3% decrease in the number of direct flights
  - Stronger distance effect than for most goods trade models

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>No. of Flights per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>3900 * [Log(3900 + distance) − Log(3900)]</td>
<td>-0.001***</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
</tr>
<tr>
<td>Observations</td>
<td>44,313</td>
</tr>
<tr>
<td>R2</td>
<td>0.854</td>
</tr>
</tbody>
</table>
ACI Results

- The distribution of ACI scores roughly lines up with what previous descriptive work has highlighted about the air transport network:
  - A small number of very well connected hubs
  - A large number of poorly connected spokes
  - IE, the distribution of scores follows a power law

- US and European countries score highly

- Asian and Middle Eastern hubs have lower scores because they are relatively distant
  - But this result is sensitive to the value of the distance shift

- African and Pacific countries score poorly
ACI Results
ACI Results

![Graph showing ACI results over rank]

ACI

Rank

0 5 10 15 20 25

0 50 100 150 200

0 5 10 15 20 25

0 50 100 150 200
## ACI Results

<table>
<thead>
<tr>
<th>Country</th>
<th>ACI 2007</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>22.78%</td>
<td>1</td>
</tr>
<tr>
<td>Canada</td>
<td>13.44%</td>
<td>2</td>
</tr>
<tr>
<td>Germany</td>
<td>12.11%</td>
<td>3</td>
</tr>
<tr>
<td>Belgium</td>
<td>12.03%</td>
<td>4</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>11.74%</td>
<td>5</td>
</tr>
<tr>
<td>Netherlands</td>
<td>11.73%</td>
<td>6</td>
</tr>
<tr>
<td>France</td>
<td>11.64%</td>
<td>7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>11.55%</td>
<td>8</td>
</tr>
<tr>
<td>Switzerland</td>
<td>10.76%</td>
<td>9</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>9.87%</td>
<td>10</td>
</tr>
</tbody>
</table>
## ACI Results

<table>
<thead>
<tr>
<th>Country</th>
<th>ACI 2007</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>5.70%</td>
<td>46</td>
</tr>
<tr>
<td>Japan</td>
<td>5.28%</td>
<td>48</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>4.88%</td>
<td>53</td>
</tr>
<tr>
<td>South Korea</td>
<td>4.79%</td>
<td>55</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>4.77%</td>
<td>57</td>
</tr>
<tr>
<td>Qatar</td>
<td>4.50%</td>
<td>64</td>
</tr>
<tr>
<td>Singapore</td>
<td>4.09%</td>
<td>74</td>
</tr>
<tr>
<td>Thailand</td>
<td>4.06%</td>
<td>75</td>
</tr>
<tr>
<td>Malaysia</td>
<td>3.91%</td>
<td>83</td>
</tr>
<tr>
<td>Country</td>
<td>ACI 2007</td>
<td>Rank</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------</td>
<td>------</td>
</tr>
<tr>
<td>Cook Islands</td>
<td>0.54%</td>
<td>211</td>
</tr>
<tr>
<td>French Polynesia</td>
<td>0.54%</td>
<td>210</td>
</tr>
<tr>
<td>Niue</td>
<td>0.62%</td>
<td>209</td>
</tr>
<tr>
<td>Kiribati</td>
<td>0.63%</td>
<td>208</td>
</tr>
<tr>
<td>Marshall Islands</td>
<td>0.64%</td>
<td>207</td>
</tr>
<tr>
<td>Tuvalu</td>
<td>0.65%</td>
<td>206</td>
</tr>
<tr>
<td>Wallis and Futuna</td>
<td>0.67%</td>
<td>205</td>
</tr>
<tr>
<td>Islands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nauru</td>
<td>0.71%</td>
<td>204</td>
</tr>
<tr>
<td>Falkland Islands</td>
<td>0.72%</td>
<td>203</td>
</tr>
<tr>
<td>Tonga</td>
<td>0.78%</td>
<td>202</td>
</tr>
</tbody>
</table>
Comparison with Other Indicators

- The ACI generally correlates strongly with alternative measures of connectivity/centrality

- It represents an improvement over other indicators such as:
  - Counting the number of direct destinations (France wins)
  - Share of global traffic: the USA, Germany, and the UK have very close scores at the top
  - Clustering coefficients produce non-intuitive results because they focus on local, not global, connectivity
  - Theil and Kulback-Leibler only capture dispersion, producing some non-intuitive results
  - Closeness has countries bunched together, and does not follow a power law
## Comparison with Other Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Spearman’s Rho</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Share</td>
<td>0.7590</td>
</tr>
<tr>
<td>No. of Direct Links</td>
<td>0.6704</td>
</tr>
<tr>
<td>Clustering Coefficient</td>
<td>-0.0831</td>
</tr>
<tr>
<td>Weighted Clustering Coefficient</td>
<td>0.2476</td>
</tr>
<tr>
<td>Theil Index</td>
<td>0.5537</td>
</tr>
<tr>
<td>Kullback-Leibler Distance</td>
<td>-0.8400</td>
</tr>
<tr>
<td>Closeness Centrality</td>
<td>0.7295</td>
</tr>
</tbody>
</table>
ACI and Liberalization of Air Transport Policies

- Policy should be an important input into connectivity

- Recent work by David Hummels shows that signing more Bilateral Air Services Agreements (BASAs) is associated with growth in passenger services
  - Intensive margin (more flights per destination)
  - Extensive margin (more destinations)

- We find a strong correlation between the ACI and the WTO’s Air Liberalization Index (ALI), based on the QUASAR database of BASA provisions

- The association is particularly strong for countries moving from highly restrictive BASAs to moderately liberal ones
ACI and Liberalization of Air Transport Policies

![Graph showing the relationship between Mean ALI and ACI, with fitted values indicated.](image-url)
ACI and Liberalization of Air Transport Policies

Lowess smoother

bandwidth = .8
ACI and Economic Outcomes

- Air transport performance has traditionally been considered as part of “broad” trade facilitation (e.g., Wilson Mann Otsuki 2005)

- “New age” trade facilitation is explicitly moving towards the concept of connectivity
  - ASEAN connectivity
  - APEC supply chain connectivity initiative

- We therefore expect to see significant associations between the ACI and important economic outcome variables
  - Trade openness
  - Production networking
  - Export diversification
ACI and Economic Outcomes

![Graph showing ACI and Economic Outcomes](image-url)
ACI and Economic Outcomes

![Graph showing the relationship between ACI and parts and components in total exports. The graph includes a scatter plot with fitted values indicated by a dashed line.](image)
ACI and Economic Outcomes

Lowess smoother

bandwidth = .8
ACI and Economic Outcomes

Lowess smoother

bandwidth = .8
Summary

- Connectivity is a new buzz word in trade facilitation circles, but...

- Measuring connectivity can be extremely challenging
  - Mathematics of network analysis
  - Data availability
  - Need to account for global interactions, not just bilateral

- The ACI makes a methodological contribution that can be replicated in other policy-relevant areas:
  - Maritime transport
  - Potentially road transport (using GIS data)
  - Analyzing country positioning in global production networks
Summary

- The ACI correlates with other possible measures of connectivity/centrality from the literature, but adds something to them:
  - Intuitive relationship between score and rank (power law), reflecting the hub and spoke nature of the network
  - Captures global interactions

- Main question mark going forward is the sensitivity of results to the distance shift parameter
  - Solid empirical basis for using the current value
  - But results in Asian and Middle Eastern hubs scoring lower than expected
The ACI appears to have strong external validity, as evidenced by its association with important input and output indicators:

- A more liberal policy environment is strongly associated with better connectivity, especially during the transition from highly restrictive to moderately liberal regimes.
- Overall trade openness is only weakly associated with the ACI, reflecting the fact that most goods still travel by sea...
- But trade in parts and components is very strongly associated with the ACI—air connectivity is vital for production networking.
- Air connectivity also matters for export diversification, in particular in terms of markets.
Conclusion

A number of possible policy applications going forward:

- Produce the index regularly?
- Detailed models to examine the links between:
  - ACI and air transport policies
  - ACI and participation in global production networks
  - ACI and export diversification, including exports of non-traditional products (horticultural goods, cut flowers, etc.)
- Applications to other transport modes, and analysis of the ways in which connectivity affects modal choice