Common Transport Infrastructure: 
A Quantitative Model and Estimates from the Belt and 
Road Initiative 

F. de Soyres, A. Mulabdic and M. Ruta

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reflect those of the World Bank.

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Introduction

The Belt and Road Initiative (BRI)

- Development strategy proposed by China that focuses on connectivity and cooperation between Eurasian countries and East Africa.
- Creates economic corridors with the goal of boosting trade and stimulating economic growth across Asia and beyond.
- Embraces many different types of projects: transport, energy production and distribution, ICT, water management, SEZ etc...

This paper

- Focuses on transport infrastructure and studies the consequences of a decrease in shipment time.
- Combines precisely geo-localized information on BRI transport projects with a structural model
  - Builds on dataset from de Soyres, Mulabdic, Murray, Rocha and Ruta (2018)
This paper

**BRI expected to have large and complex impact on all countries in the world**

- Trade cost reduction for all countries in the world (but not all *pairs*)
- Reductions in trade costs propagate through input-output linkages.
  ⇒ Comparative advantages can be re-allocated across countries.
- Gains are not aligned with investments.

**Road map**

1. Estimate reduction in trade cost for all country-pairs-sectors in the world.
2. Use a structural model to simulate counterfactuals.
3. Analyze the results and perform other counterfactuals.
Related literature

- Quantitative Trade models with Input/Output linkages

- Impact of infrastructure, trade costs and time to trade on trade flows

- Trade / spatial effects of infrastructure using GIS analysis

- Trade effects of the Belt and Road initiative
BRI: Broad Overview
BRI: All projects
Shipping Time: a Network Analysis

Goal: estimate decrease in trade barrier once all BRI projects are realized

⇒ from de Soyres, Mulabdic, Murray, Rocha and Ruta (2018)

1. Define a set of 1,000 cities in more than 180 countries.

2. Use current infrastructure network to compute “ex-ante” shipping time.

3. Use Geo-referenced data on BRI projects and run an “ex-post” scenario.
   - Lower and Upper Bound depending on mode change

4. Transform changes in shipping time into changes in trade barrier
   - Trade barriers = Tariffs + Transport + Time
   - Value of Time from Hummels and Schaur (2013) for each sector.
Proportional decrease in Trade Costs

Upper Bound, bilateral trade cost are import weighted

<table>
<thead>
<tr>
<th>(%) decrease</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Bound (%)</td>
<td>0.00</td>
<td>61.52</td>
<td>1.05</td>
<td>2.43</td>
</tr>
<tr>
<td>Upper Bound (%)</td>
<td>0.00</td>
<td>65.16</td>
<td>2.19</td>
<td>3.40</td>
</tr>
</tbody>
</table>
Caliendo and Parro (2015)

- Ricardian model of trade with many countries and I/O linkages.
  - Trade driven by comparative advantage, trade costs and consumer tastes.
- Initially used for NAFTA, widely used in other contexts since.
  - Here: infrastructure investment lowering trade costs.
  - Contrary to simple policy reforms, this has budget implications.

Advantages

- Solved in “relative difference” (Hat Algebra):
  - Counterfactuals reduce to a small system of equations.
  - No need of prior knowledge of fundamentals such as TFP or employment.
  - We will have a total of $N=107$ countries and $J=31$ sectors.
- Takes into account the world’s complexity in a rather simple way.
Production function:

In sector $j$ and country $n$, continuum of varieties indexed by $z \in [0, 1]$:

$$q^j_n(z^i_n) = z^i_n \left[ A^j_n h^j_n(z^i_n)^{\beta_n} \ell^j_n(z^i_n)^{(1-\beta_n)} \right] \gamma^j_n \prod_{k=1}^{J} M^j_k(z^i_n)^{\gamma^j_k}.$$ 

- $M^j_k(z^i_n)$ is the “composite intermediate” from $k$ used in production.  
  \Rightarrow CES aggregate of all varieties $z$ with elasticity $\sigma^j$.  
- Input-Output linkages governed by $\gamma^j_n$.

Cost of the input bundle in $(n, j)$:

$$x^j_n = B^j_n \left[ r_n^{\beta_n} w_n^{(1-\beta_n)} \right] \gamma^j_n \prod_{k=1}^{J} \left( P^k_n \right)^{\gamma^j_k}.$$ 

- $P^k_n$ is the price of the composite from sector $k$.  
- Cost in $(n, j)$ depends on the price of all other sectors.
Firms “shop around the world” for the cheapest version of variety $z$

- All prices in the economy must be jointly solved:

$$p_n^j(z^j) = \min_i \left\{ \frac{x_i^j \kappa_n^j}{z_{ij}} \left( A_i^j \right)^{-\gamma_i^j} \right\} \quad \forall j, n$$

- $\kappa_n^j$ is total trade costs from $i$ to $n$ in sector $j$.

**Standard (Eaton-Kortum) distributional assumption:**

- Variety-specific productivities $z^j$ are distributed according to Frechet.
  - $\Rightarrow$ The minimum of $n$ draws also follows a Frechet distribution.
- Solve for the *share* of varieties produced in each country.
**Model – Consumers and Production**

**Consumers’ utility** in country $n$:

$$v_n = \max \prod_{j=1}^{J} \left( c_n^j \right)^{\alpha_n^j}$$

Budget constraint accounts for lump sum $\tau_n$ to finance BRI investment:

$$\sum_{j=1}^{J} p_n^j c_n^j = w_n L_n + \iota_n \chi + T_n - \tau_n \equiv I_n$$

**Welfare** is defined by:

$$U_n = \frac{I_n}{P_n} = \frac{w_n L_n + \iota_n \chi + T_n}{P_n} - \frac{\tau_n}{P_n}$$

with $P_n = \prod_{j=1}^{J} \left( P_n^j / \alpha_n^j \right)^{\alpha_n^j}$ the price index in country $n$. 
Equilibrium
For each country, we have $4 \times J + 1$ equations:

- Cost of inputs in each sector
- Equilibrium prices in each sector
- Resulting trade shares in each sector
- Good market clearing in each sector
- Trade balance (or labor market equilibrium)

Equilibrium can then be expressed in **relative changes**, which dramatically reduces the number of fundamental values needed for counterfactuals.

Calibration
107 countries and 31 sectors using GTAP 10 and CP’s estimates of sectoral trade elasticities.
Build *bottom-up* estimates of infrastructure investments:

<table>
<thead>
<tr>
<th>Country</th>
<th>Country Cost</th>
<th>Country</th>
<th>Country Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>12,252</td>
<td>Malaysia</td>
<td>12,998</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>2,262</td>
<td>Mongolia</td>
<td>35,516</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>6,880</td>
<td>Myanmar</td>
<td>26,398</td>
</tr>
<tr>
<td>Cambodia</td>
<td>2,039</td>
<td>Pakistan</td>
<td>49,302</td>
</tr>
<tr>
<td>China</td>
<td>63,706</td>
<td>Russian Federation</td>
<td>18,065</td>
</tr>
<tr>
<td>Georgia</td>
<td>5,146</td>
<td>Singapore</td>
<td>304</td>
</tr>
<tr>
<td>Greece</td>
<td>–</td>
<td>Tajikistan</td>
<td>3,480</td>
</tr>
<tr>
<td>India</td>
<td>3,400</td>
<td>Thailand</td>
<td>11,798</td>
</tr>
<tr>
<td>Iran, Islamic Rep.</td>
<td>10,621</td>
<td>Turkey</td>
<td>1,947</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>21,305</td>
<td>Turkmenistan</td>
<td>15,155</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>5,391</td>
<td>Uzbekistan</td>
<td>5,780</td>
</tr>
<tr>
<td>Laos</td>
<td>6,528</td>
<td>Vietnam</td>
<td>8,587</td>
</tr>
<tr>
<td>Djibouti</td>
<td>580</td>
<td>Ethiopia</td>
<td>9,131</td>
</tr>
<tr>
<td>Indonesia</td>
<td>583</td>
<td>Kenya</td>
<td>23,598</td>
</tr>
<tr>
<td>Sudan</td>
<td>4,311</td>
<td>Tanzania</td>
<td>1,100</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td><strong>368,168</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How to incorporate costs in the budget constraint?

- Model is calibrated using annual data (trade flows, value-added, etc...).
- One time investment, gains every year over a longer horizon. 
  *Equivalently*, investment paid over multiple years.

Compute annualized equivalent assuming perpetuity \((r = 2.5\%)\):

\[
\text{Total Cost}_n = \sum_{k=1}^{+\infty} \frac{\text{Annuity}_n}{(1 + r)^k} \quad \Rightarrow \quad \text{Annuity}_n = r \times \text{Total Cost}_n
\]
Results – GDP change once all projects are implemented

- Transport infra. improvements lead to efficiency gains and higher GDP.
- Heterogeneity reflects different connectivity and import/export structure.

Overall Effect in the Upper Bound Scenario

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lao PDR</td>
<td>13.19%</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>9.04%</td>
</tr>
<tr>
<td>Turkmen + Uzbekst</td>
<td>7.96%</td>
</tr>
<tr>
<td>Cambodia</td>
<td>7.01%</td>
</tr>
<tr>
<td>Vietnam</td>
<td>6.52%</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>6.47%</td>
</tr>
<tr>
<td>Pakistan</td>
<td>6.43%</td>
</tr>
<tr>
<td>Qatar</td>
<td>6.21%</td>
</tr>
<tr>
<td>Iran</td>
<td>6.18%</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>6.01%</td>
</tr>
</tbody>
</table>
Results – Welfare change once all projects are implemented

- Welfare includes cost of investment – matters only for BRI countries.
- **Gains are not commensurate with projected investments.**
  
  *Countries with large investment could experience welfare losses.*

<table>
<thead>
<tr>
<th>Country</th>
<th>Welfare Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuwait</td>
<td>5.84%</td>
</tr>
<tr>
<td>Iran</td>
<td>5.34%</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>5.22%</td>
</tr>
<tr>
<td>Pakistan</td>
<td>5.18%</td>
</tr>
<tr>
<td>Qatar</td>
<td>5.00%</td>
</tr>
<tr>
<td>Vietnam</td>
<td>4.86%</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>4.77%</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>4.73%</td>
</tr>
<tr>
<td>Turkmst + Uzbekst</td>
<td>0.49%</td>
</tr>
<tr>
<td>Mongolia</td>
<td>-1.95%</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>-4.06%</td>
</tr>
</tbody>
</table>
Magnified gains with complementary policies

Potential Gains of complementing BRI with other policies are very large:

1. **Trade Facilitation**: reduce border delays by 50%.
2. **Trade Policy**: 50% reduction in applied tariffs among BRI economies.

### GDP Gains

<table>
<thead>
<tr>
<th>Area</th>
<th>Infrastructure</th>
<th>Infrastructure and reduced preferential tariffs</th>
<th>Infrastructure and reduced border delays</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRI Area</td>
<td>3.35</td>
<td>6.43</td>
<td>9.46</td>
</tr>
<tr>
<td>BRI Core</td>
<td>3.40</td>
<td>5.96</td>
<td>8.64</td>
</tr>
<tr>
<td>World</td>
<td>2.87</td>
<td>5.78</td>
<td>8.24</td>
</tr>
<tr>
<td>non-BRI Area</td>
<td>2.88</td>
<td>5.39</td>
<td>5.60</td>
</tr>
</tbody>
</table>

### Welfare Gains

<table>
<thead>
<tr>
<th>Area</th>
<th>Infrastructure</th>
<th>Infrastructure and reduced preferential tariffs</th>
<th>Infrastructure and reduced border delays</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRI Area</td>
<td>2.81</td>
<td>5.29</td>
<td>7.51</td>
</tr>
<tr>
<td>BRI Core</td>
<td>2.77</td>
<td>4.99</td>
<td>7.70</td>
</tr>
<tr>
<td>World</td>
<td>2.87</td>
<td>5.15</td>
<td>5.80</td>
</tr>
<tr>
<td>non-BRI Area</td>
<td>2.90</td>
<td>3.86</td>
<td>6.08</td>
</tr>
</tbody>
</table>
GDP Gains vs. decrease in Imports / Export cost

Taken separately, reduction in export and import costs “explain” respectively 27% and 39% of GDP gains.

⇒ Gains also explained by I/O linkages, overall openness, and relative cost reduction compare to other countries (Comparative Advantage).
Welfare Gains vs. decrease in Imports / Export cost

Reduction in export & import costs “explain” 18% and 19% of Welfare gains.

- Welfare gains are on average lower than GDP gains (because of investments)
- Some countries experiencing net losses (more so in Lower Bound).
Gains vs. BRI Investment

- Again, gains are not commensurate to investments.
- Large transport infrastructure investments have a systemic impact. ⇒ Many countries will gain without investing anything.
- The value of any project depends on all other projects in the network.
Should we be surprised by the size of the effect?

Worldwide Welfare gains of 2.87%.

⇒ Why such a strong impact on world’s GDP and welfare?

1. Size of the “BRI shock”
   - All countries experience a decrease in trade costs with some partners.
     ⇒ Average decrease across all country-pairs is 2.19% (Upper Bound)
   - How much of those infrastructure would be implemented even without the BRI is an open question...

2. Large Input-Output linkages across countries in the “BRI region”.
   - Propagation/amplification through I-O linkages are stronger than in previous studies such as NAFTA.

3. BRI also involves large within countries improvements
Counterfactual Allocation of Payment

Counterfactual Experiment

- How to allocate payment so that *all BRI countries* have same welfare gain?
- Results involve significant transfer across countries.

![Graph showing counterfactual allocation of payment across countries.](image)
Conclusion

- **BRI will potentially have a very large effect on trade, GDP and Welfare for many countries.**
  - All countries in the world experience a decrease in trade costs.
  - GVC play an important role in both amplification and distribution of gains and losses.
  - Not all sectors/countries will gain but aggregate effect is largely positive... if factor re-allocation is achieved.

- **Changes in the geography of production can potentially be disruptive and needs to be monitored.**
  - Both workers and capital will need to change sectors.
  - Human capital / training will need to be adapted.
  - Country-specific focus will be needed.