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

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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.
  $\Rightarrow$ Comparative advantages can be re-allocated across countries.
- Gains are not aligned with investments.

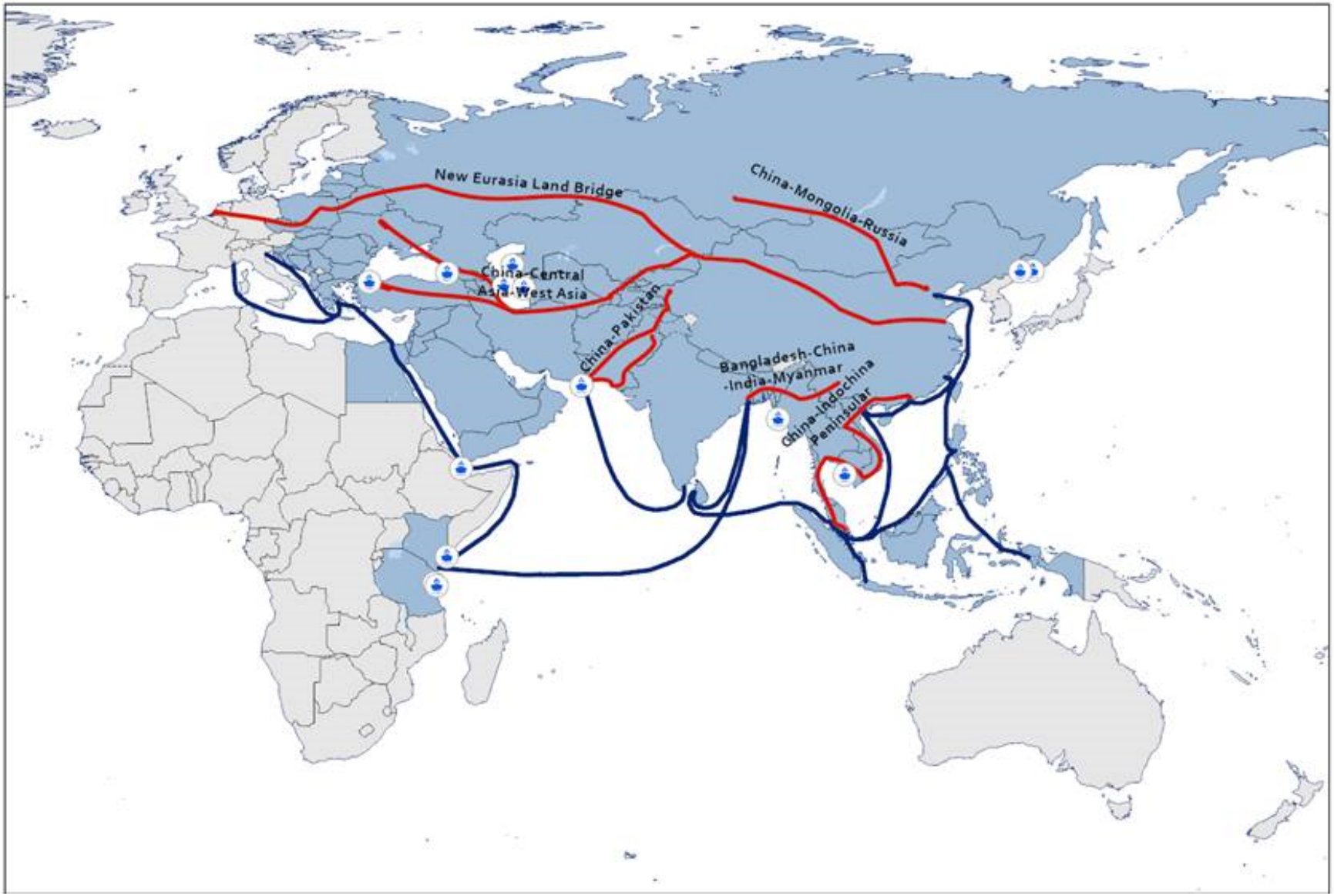
Road map

1. Estimate reduction in trade cost for all country-pairs-sectors in the world.
2. Use a structural model to simulate counterfactuals.
   - Based on Caliendo Parro (2015) extended for infrastructure investment.
3. Analyze the results and perform other counterfactuals.

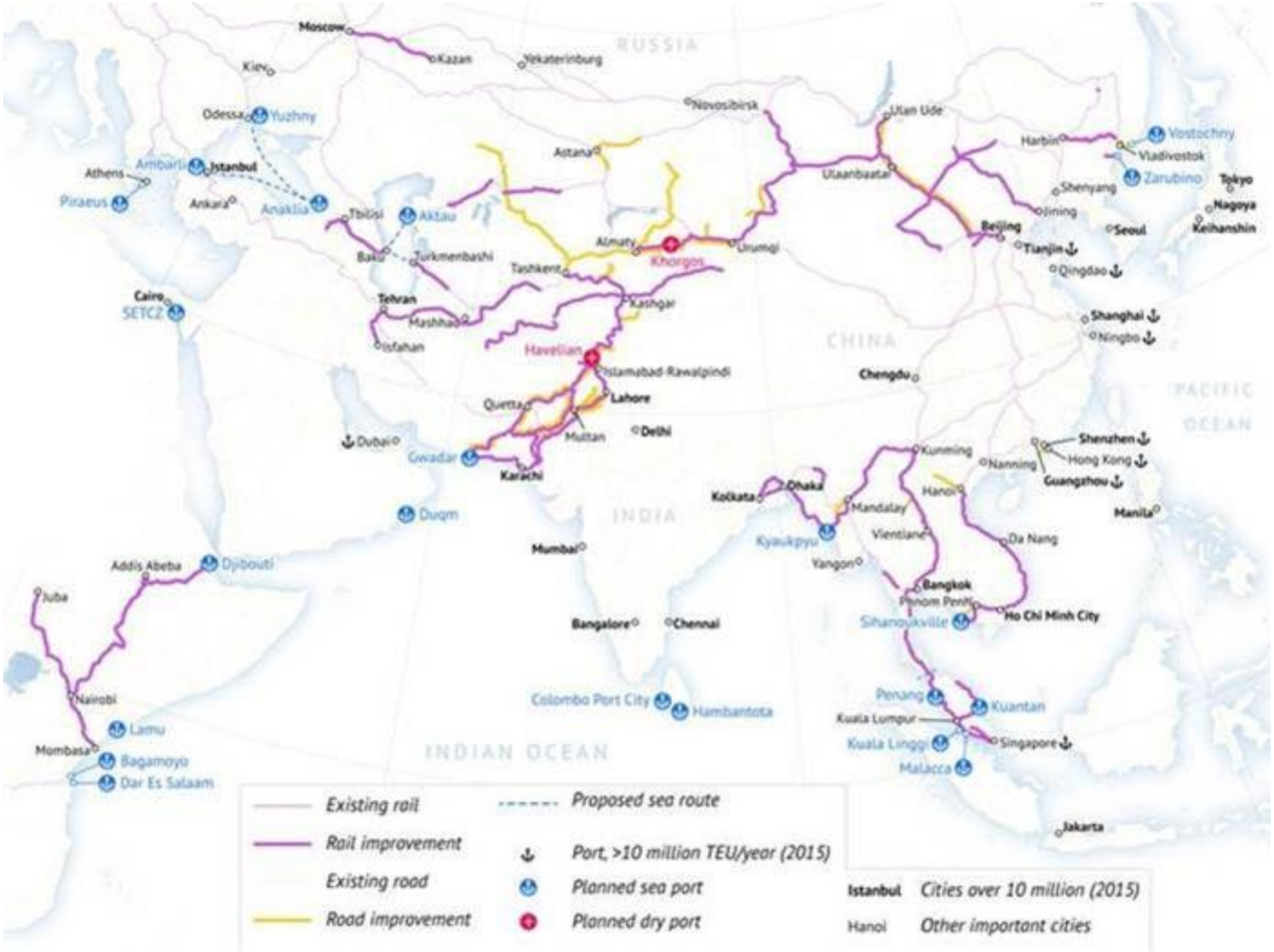
Related literature

- Quantitative Trade models with Input/Output linkages
  - Eaton and Kortum (2002), Caliendo and Parro (2015), Caliendo, Dvorkin and Parro (2017)
- Impact of infrastructure, trade costs and time to trade on trade flows
  - Donaldson (2012), Duranton, Morrow and Turner (2013), Deardorff (2014), Alder (2015), Djankov, Freund and Pham (2010), Hummels and Shauer (2013), Baniya (2017)
- Trade / spatial effects of infrastructure using GIS analysis
  - Roberts, Deichmann, Fingleton and Shi (2010), Volpe Martincus, Carballo and Cusolito (2016), de Soyres, Mulabdic, Murray, Rocha and Ruta (2018)
- Trade effects of the Belt and Road initiative
  - Villafuerte, Corong and Zhuang (2016), Baniya, Murray, Rocha and Ruta (2018) El-Hifnawi, Lall and Lebrand (2018), Maliszewska, van der Mensbrugghe and Osorio-Rodarte (2018)

BRI: Broad Overview



BRI: All projects

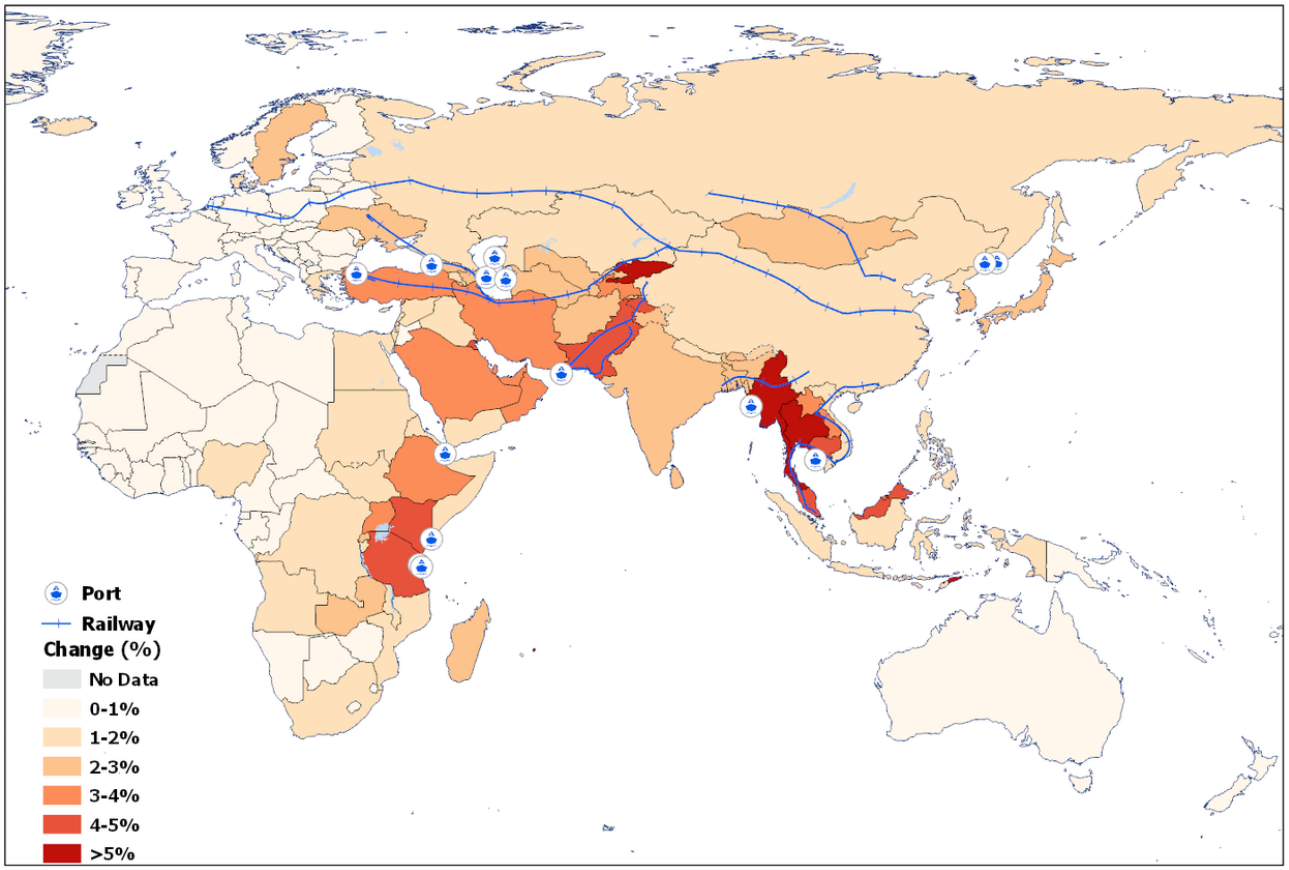


Shipping Time: a Network Analysis

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

(% decrease)	**Min**	**Max**	**Mean**	**Std Dev**
Lower Bound (%)	0.00	61.52	1.05	2.43
Upper Bound (%)	0.00	65.16	2.19	3.40

Model – Basics

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.

Model – Production 1/2

Production function:

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

$$q_n^j(z_n^j) = z_n^j \left[A_n^j h_n^j(z_n^j)^{\beta_n} \ell_n^j(z_n^j)^{(1-\beta_n)} \right]^{\gamma_n^j} \prod_{k=1}^{J} M_n^{jk}(z_n^j)^{\gamma_n^{jk}}.$$

- $M_n^{jk}(z_n^j)$ is the "composite intermediate" from k used in production.
  $\Rightarrow$ CES aggregate of all varieties z with elasticity σ^j.
- Input-Output linkages governed by γ_n^{jk}.

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

$$x_n^j = B_n^j \left[{r_n}^{\beta_n} {w_n}^{(1-\beta_n)} \right]^{\gamma_n^j} \prod_{k=1}^{J} \left(P_n^k \right)^{\gamma_n^{jk}}$$

- P_n^k is the price of the composite from sector k.
- Cost in (n, j) depends on the price of all other sectors.

Model – Production 2/2

Firms "shop around the world" for the cheapest version of variety z

- All prices in the economy must be jointly solved:

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

- κ_{ni}^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 τ_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.

Model – Equilibrium and calibration

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.

Total costs per country

Build *bottom-up* estimates of infrastructure investments:

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

Static model with long-time investments

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 ($r = 2.5\%$):

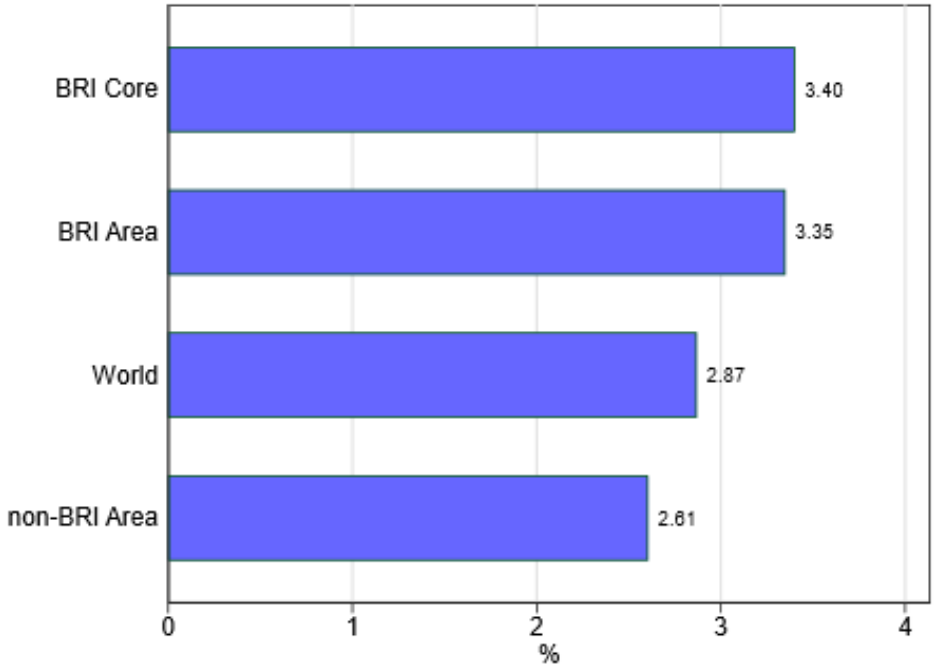
$$\text{Total Cost}_n = \sum_{k=1}^{+\infty} \frac{\text{Annuity}_n}{(1+r)^k} \quad \Rightarrow \quad \text{Annuity}_n = r \times \text{Total Cost}_n$$

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

Global GDP Gains



Top 10 countries

Country	GDP Change
Lao PDR	13.19%
Kyrgyzstan	9.04%
Turkmst + Uzbekst	7.96%
Cambodia	7.01%
Vietnam	6.52%
Kazakhstan	6.47%
Pakistan	6.43%
Qatar	6.21%
Iran	6.18%
Azerbaijan	6.01%

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.

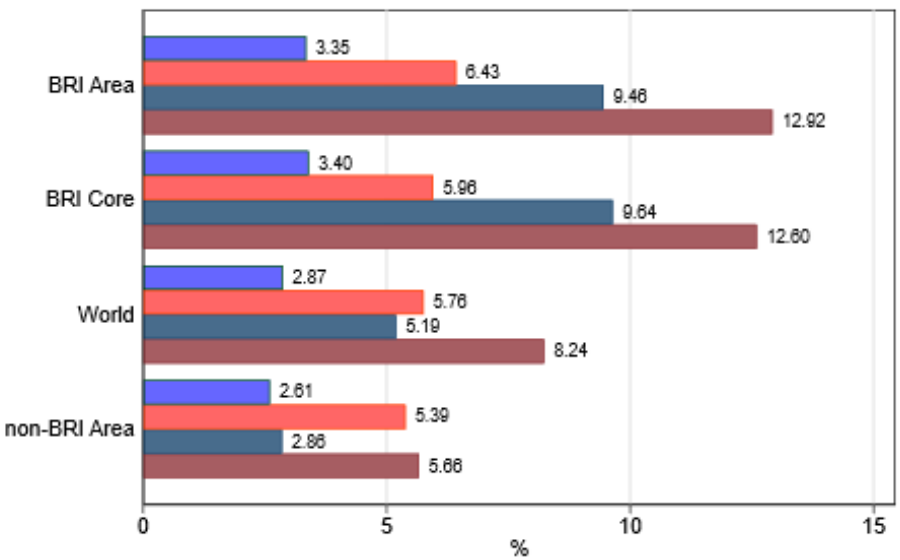
Country	Welfare Change
Kuwait	5.84%
Iran	5.34%
Saudi Arabia	5.22%
Pakistan	5.18%
Qatar	5.00%
Vietnam	4.86%
Kazakhstan	4.77%
Lao PDR	4.73%
.....	
Turkmst + Uzbekst	0.49%
Mongolia	-1.95%
Azerbaijan	-4.06%

Magnified gains with complementary policies

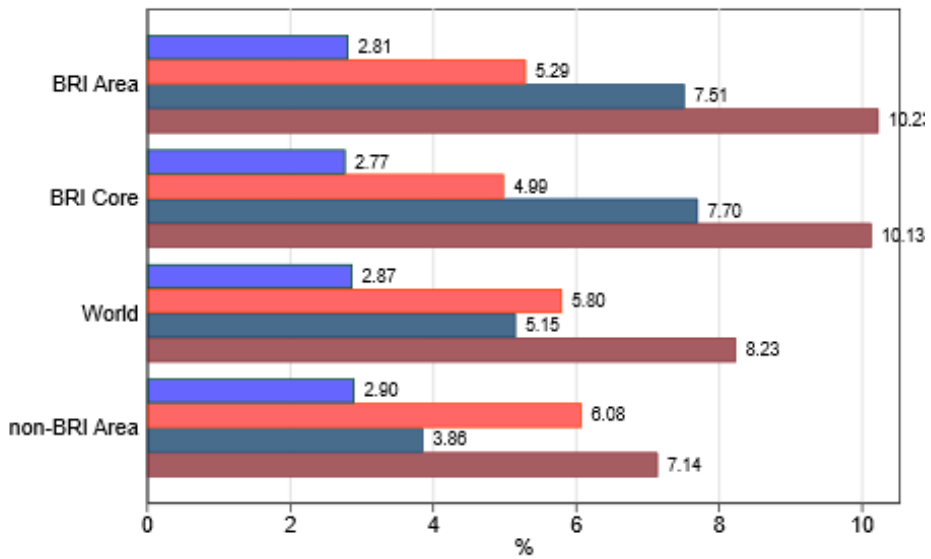
Potential Gains of complementing BRI with other policies are very large:

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

GDP Gains



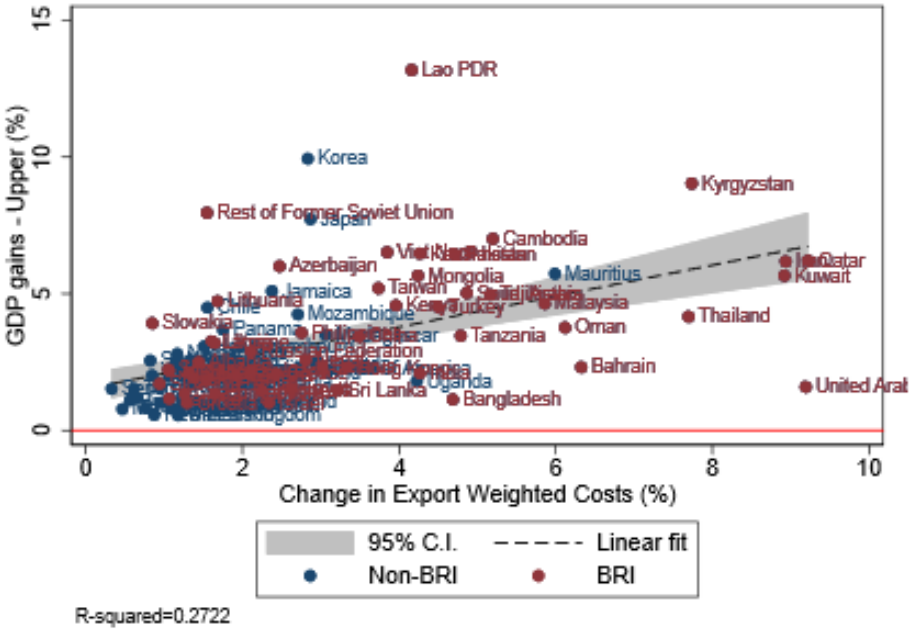
Welfare Gains

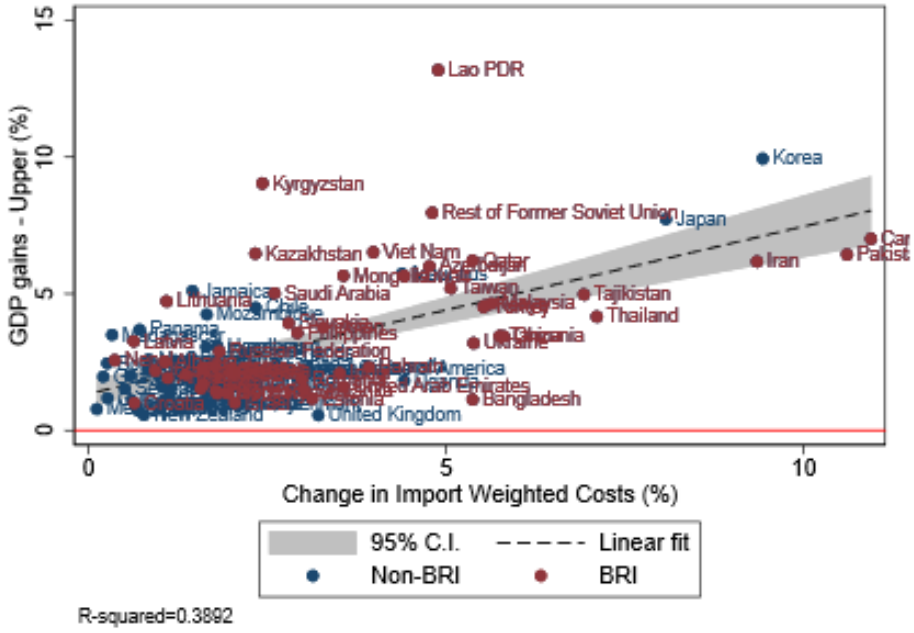


GDP Gains vs. decrease in Imports / Export cost

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).

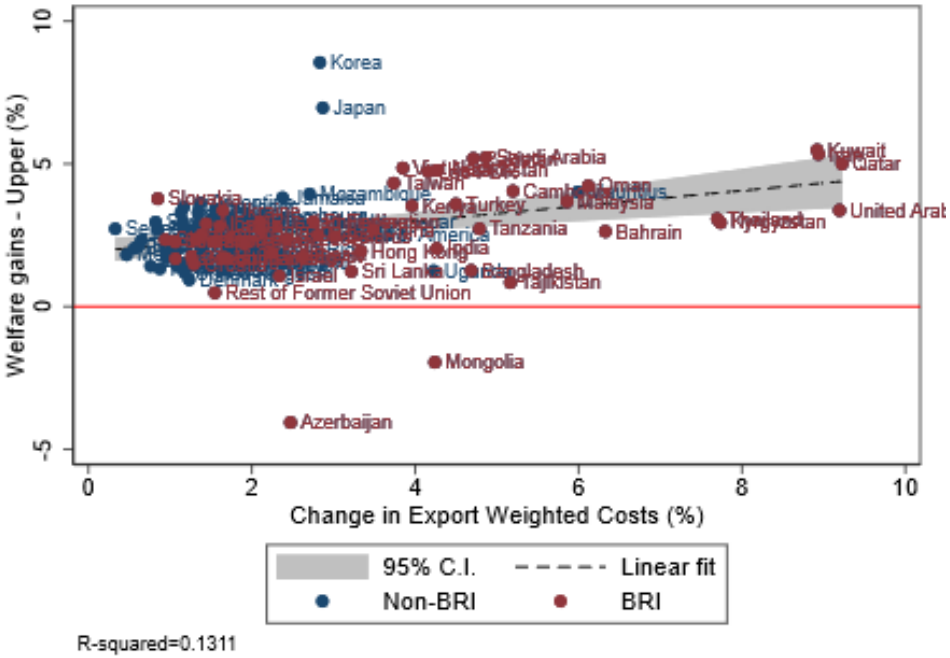


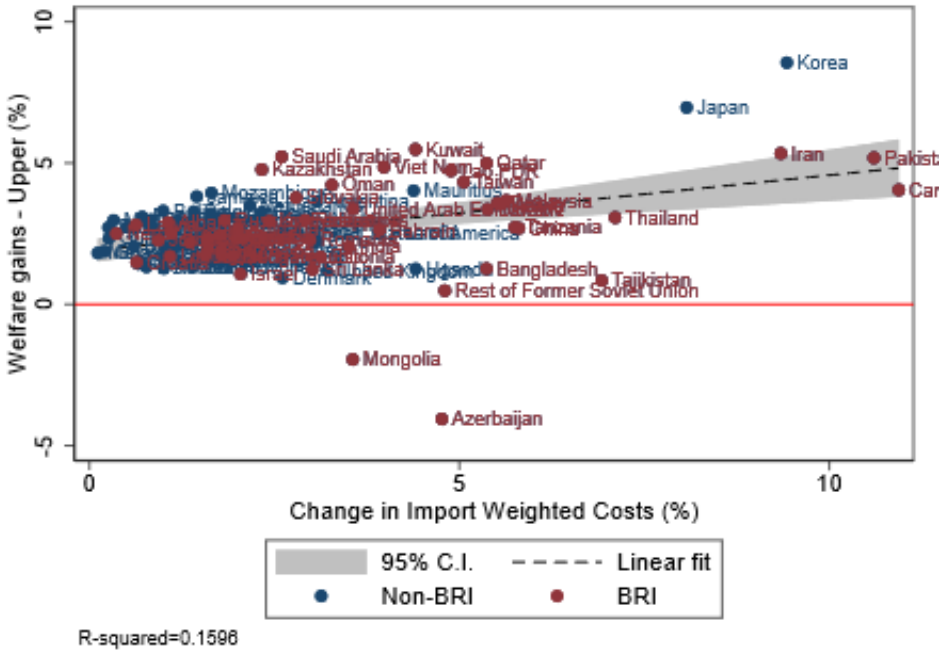


Welfare Gains vs. decrease in Imports / Export cost

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

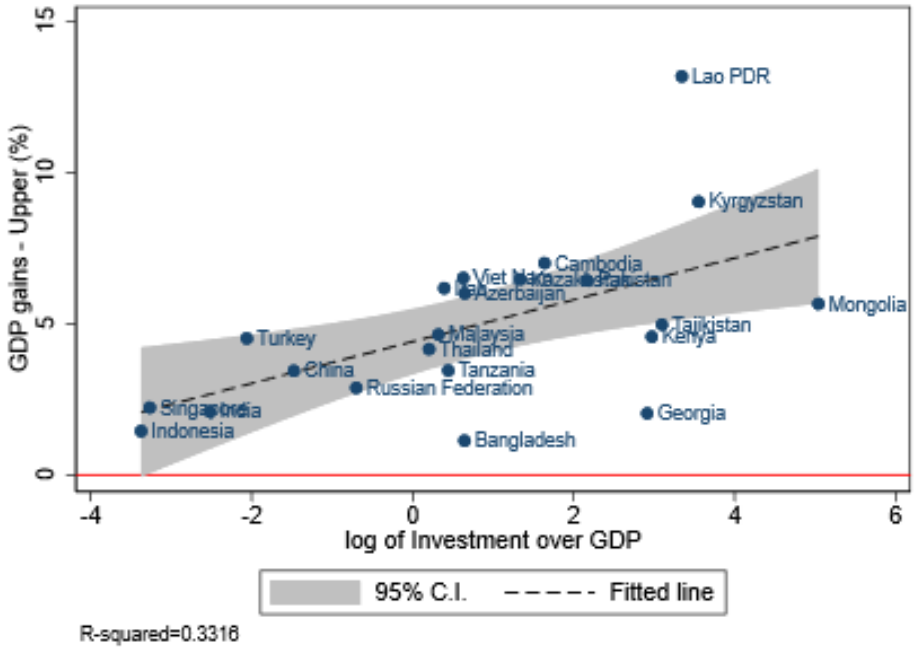
- Welfare gains are on average lower than GDP gains (because of investments)
- Some countries experiencing net losses (more so in Lower Bound).

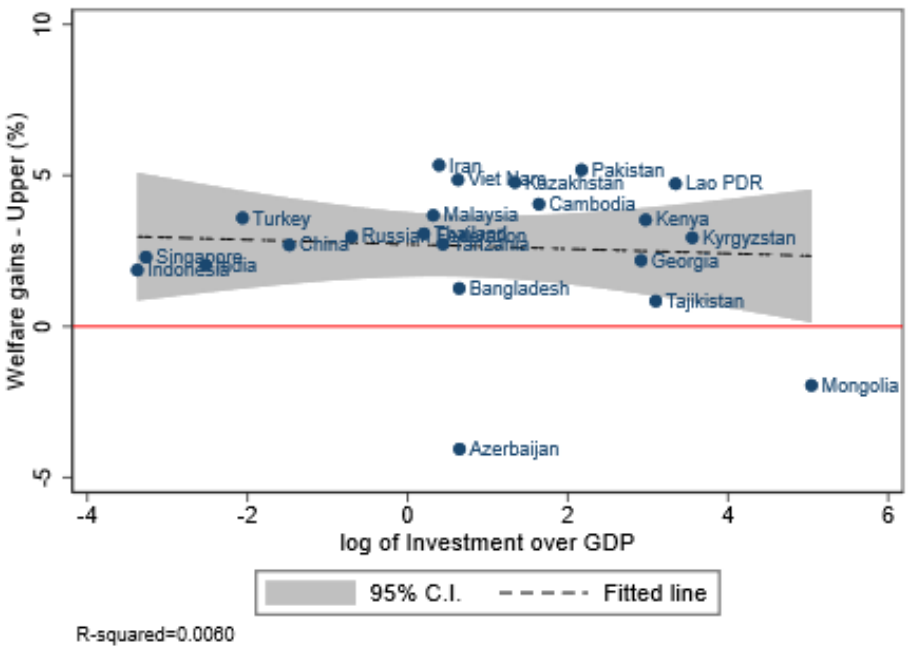




Gains vs. BRI Investment

- **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%.

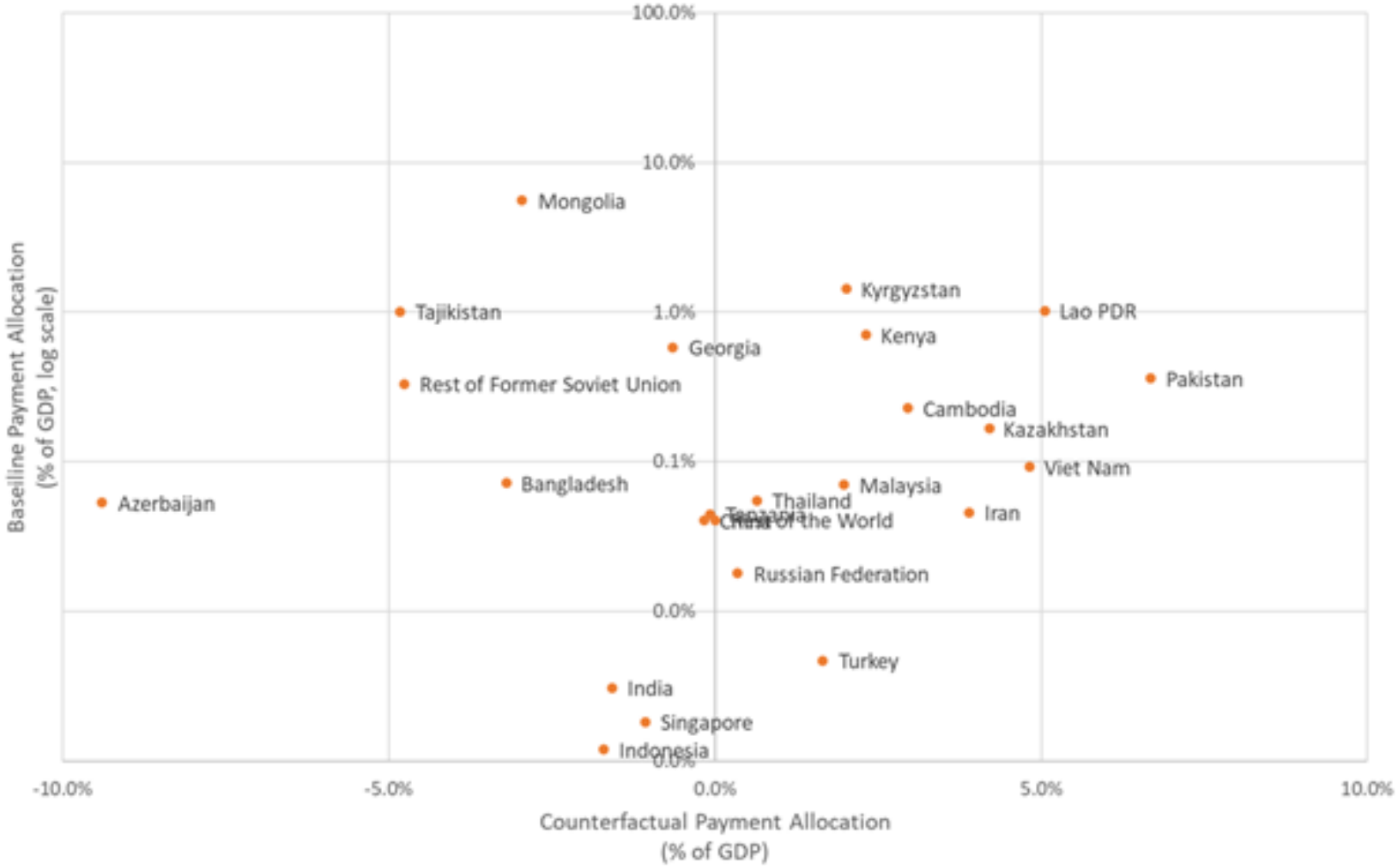
$\Rightarrow$ **Why such a strong impact on world's GDP and welfare?**

1. Size of the "BRI shock"
   - *All* countries experience a decrease in trade costs with some partners.
     $\Rightarrow$ 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**.



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.