GROWTH AND TRADE DIVERSION
DUE TO CHINA'S BELT AND ROAD INITIATIVE

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Abstract

China's Belt and Road Initiative is a series of bilateral arrangements that facilitate infrastructure investments and promote trade between China and participating countries. The Initiative can increase the GDP of a participating country by providing financing for infrastructure investments, but it might also slow growth if it leads to problems with corruption and debt burden. The Initiative can reduce trade costs between a participating country and China by improving transportation infrastructure and connectivity, liberalizing barriers to trade, or enhancing the bilateral relationships in other ways. In this paper, we use a pair of econometric models to estimate the immediate and delayed effects of participating in the Initiative on a country's GDP and its costs of trading with China. Then we use a structural gravity model to simulate the combined impact of these two effects on the bilateral trade flows of the United States, China, and Central Asian nations. For example, we estimate that participating in the BRI increased Kazakhstan's total exports by 10.69%, its total imports by 15.40%, and its GDP by 11.06% in 2022. On the other hand, the BRI increased U.S. total exports by only 0.3% and reduced U.S. total imports by 0.09%. The BRI increased exports from China to Kazakhstan by 29.05% but only increased exports from the United States to Kazakhstan by 6.75%, while reducing U.S. exports to China by 5.29%.

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1 Introduction

There is an ongoing and sometimes intense debate about the economic impact of China's Belt and Road Initiative (BRI) on the trade and growth of countries that participate, like the Central Asian nations, and those that do not participate, like the United States. Overall, there is a general consensus in the economics literature that the BRI has reduced trade costs, expanded trade, and accelerated growth and international investment, though published studies vary significantly in their empirical methodologies, the economic outcomes that they quantify, and the BRI countries that they examine.

We contribute to this literature by estimating a set of econometric models of the immediate and delayed effects of participating in the BRI on a country's GDP and then separately on the country's bilateral trade costs. Then we combine these two effects in a single structural gravity model simulation of the impact of the BRI on the trade flows of China, Central Asian nations along the Old Silk Road, and the United States. We estimate that participating in the BRI increased Kazakhstan's total exports by 10.69%, its total imports by 15.40%, and its GDP by 11.06% in 2022. On the other hand, the BRI increased U.S. total exports by only 0.3% and reduced U.S. total imports by 0.09%. The BRI increased exports from China to Kazakhstan by 29.05% but only increased exports from the United States to Kazakhstan by 6.75%, while reducing U.S. exports to China by 5.29%.

The rest of the paper is organized in six parts. Section 2 provides an overview of the BRI. Section 3 reviews the literature that models the economic effects of the Initiative. Section 4 presents an econometric model of the effects of participating in the BRI on the growth of each country's GDP. Section 5 presents a separate econometric model of the effects of participating in the BRI on a country's costs of trading with China and other trade partners. Section 6 reports a simulation of the combined impact on trade of these growth and trade cost effects. Section 7 offers conclusions and caveats. We include two Appendices that provide additional details.

2 Overview of the Belt and Road Initiative

Chinese President Xi Jinping first introduced the concept of the Silk Road Economic Belt during his visit to Kazakhstan in September 2013.[1] Xi suggested that China and the Central Asian nations jointly build an economic belt along the Silk Road. Stressing a unique opportunity to expand foreign trade, Xi stated that the proposed economic belt — inhabited by close to three billion people — represents "the biggest market in the world with unparalleled potential."[2] Although not a free trade agreement, the proposed new Initiative aimed to facilitate trade and investment, reduce trade and investment costs, increase the speed and quality of regional economic flows, and achieve mutual progress in the region, according to official statements.[3]

Then China branded the proposed engagement as the One Belt, One Road Initiative. "One Belt" refers to the Silk Road Economic Belt, an overland trans-continental connection from China through Central Asia to Europe, while "One Road" refers to China's concept of a Maritime Silk Road that connects China to Southeast Asia, South Asia, the Middle East, Eastern Africa, and Europe via the South China Sea and Indian Ocean. In 2015, China's leaders changed the English name to the Belt and Road Initiative.[4] The Initiative envisioned the development of six major economic corridors: China-Mongolia-Russia, New Eurasian Land Bridge, China-Central Asia-West Asia, China-Indochina Peninsula, China-Pakistan, and Bangladesh-China-India-Myanmar.[5]

Central Asia, defined as the nations of Kazakhstan, the Kyrgyz Republic, Tajikistan,

[1]The State Council of the People's Republic of China (2015b).
[2]Witte (2013).
[3]Witte (2013).
[4]Congressional Research Service (2023), Nedopil (2023b).
[5]The State Council Information Office of the People's Republic of China (2020).

Turkmenistan, and Uzbekistan, has emerged as a region of strategic importance for the BRI. The fact that the Initiative was launched in Kazakhstan highlights the critical role of the country and the wider Central Asia region in establishing better trade routes to Europe.

In March 2015, China announced a BRI Action Plan, which was jointly released by China's National Development and Reform Commission, Ministry of Foreign Affairs, and Ministry of Commerce.[6] This document sets out priorities for international cooperation, such as developing infrastructure networks connecting all sub-regions in Asia and connecting Asia to Europe and Africa. According to the Action Plan, the Initiative "is open to all countries, and international and regional organizations for engagement."[7] The BRI initially included less than a dozen countries across Europe and Asia. In the decade since its launch, BRI's country coverage has expanded significantly, reaching 151 by December 2023.[8] The BRI is often described as one of the most ambitious infrastructure projects ever conceived by a single country and as a massive endeavor that is bigger than the Marshall Plan.[9] The Initiative aims to improve the regional integration of China's trading partners by developing their infrastructure — including transport, energy, and telecommunications — to further China's own economic interests.[10]

Many country analysts see the Initiative as a key to China's expanding geopolitical influence.[11] Whether the economic benefits of the BRI outweigh its costs to participating countries remains an open question. Proponents highlight BRI's potential to improve infrastructure, regional connectivity, foreign trade flows, growth, and poverty reduction, by providing funding for infrastructure investment in low-income or emerging countries. On the other hand, critics voice concerns about debt sustainability, opaque project assessment

[6]The State Council of the People's Republic of China (2015a).
[7]The State Council of the People's Republic of China (2015a).
[8]Nedopil (2023a).
[9]McBride, J. et al. (2023), Knowledge at Wharton Staff. (2017).
[10]Knowledge at Wharton Staff. (2017).
[11]Cordell (2020), MERICS (2018), McBride, J. et al. (2023).

practices, negative environmental impacts of some of the massive projects, and the increase in China's geopolitical influence.[12]

According to an official report in November 2023, the BRI has implemented more than 2,000 projects in over 120 BRI countries, "mobilizing nearly US$1 trillion in investment and helping nearly 40 million people escape poverty."[13] Unfortunately, there is not an official repository of BRI projects and outcomes that provides comprehensive documentation on the financial commitments and disbursements under the BRI across time and participating countries.[14] According to the *China Global Investment Tracker* dataset compiled by the American Enterprise Institute and the Heritage Foundation, the value of China's BRI-related overseas investment and construction projects across 126 countries amounted to $971.5 billion between 2013 and 2023 (Figure 1). Implementation of the BRI could extend to 2049, according to some reports, to coincide with 100th anniversary of the People's Republic of China and Xi's target date for establishing China as "fully developed, rich, and powerful."[15]

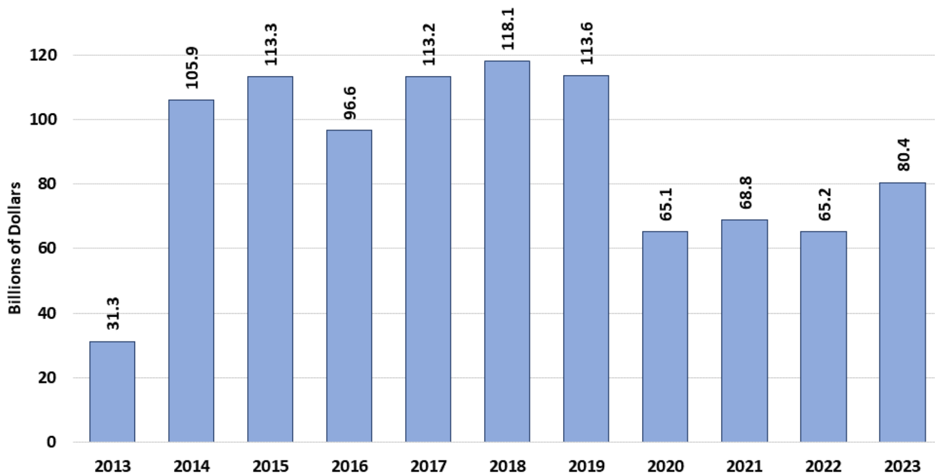
[12] Gokkon (2018), Hillman (2020), McBride, J. et al. (2023), World Bank (2018), Cordell (2020).

[13] The State Council Information Office of the People's Republic of China (2023).

[14] Green Finance and Development Center (Shanghai) provides an overview of a number of databases relevant for the BRI, stating there is no "master" database. For further information, see https://greenfdc.org/databases-for-the-belt-and-road-initiative-bri/

[15] Hillman (2018).

Figure 1: BRI Investment and Construction Projects, in Billion Dollars



Source for Figure 1: Authors' calculations are based on The American Enterprise Institute and the Heritage Foundation (2023).

3 Related Economics Literature

There is a diverse and very informative literature that analyzes how the BRI influences economic outcomes such as trade costs, trade flows, foreign investment, GDP, and economic welfare.

3.1 Estimates of the Effects on Trade Costs

De Soyres, Mulabdic, Murray, Rocha and Ruta (2019) estimate the effects of the BRI on trade costs. They estimate that shipping times for BRI countries are reduced by 1.7 to 3.2 percent, while trade costs are reduced by 1.5 to 2.8 percent.

3.2 Estimates of the Effects on Trade Flows

Baniya, Rocha and Ruta (2020) estimate the changes in trade flows resulting from BRI reductions in time to trade using a gravity model and detailed geographical information system analysis. They estimate that the BRI increased trade flows between participating countries by up to 4.1%. The largest trade gains were in time-sensitive inputs to global supply chains.

OECD (2018) stresses that the BRI can be expected to ultimately generate "connectivity dividends" from China's infrastructure investment by facilitating trade. The report provides evidence based on a gravity model of bilateral trade that attempts to capture the effect of free trade zones for BRI- and OECD-origin exports. The dependent variable is bilateral exports; the sample is based on an unbalanced panel dataset of 52 origin economies and 141 destination economies over the period 1997 to 2014. The OECD's sample is split into two parts: (i) exports that originate from countries that are linked to the BRI, and (ii) exports originating from OECD countries. The independent variables set includes relative size (a similarity index based on GDP), bilateral exchange rates, relative factor endowments, presence of a common language, investment openness, physical distance between the trade partners, presence of common borders, presence of political instability, and whether the partner was a former colony. The model also considers the influence of membership in trading blocs (including, ASEAN, EU, and USMCA). The OECD's modeling results suggest that trade creation is definitely present for exports that originate in OECD countries and less so for exports that originate in BRI countries, given infrastructure connectivity weaknesses in the BRI countries at the time of assessment. A separate but similar analysis in Pan and Chong (2023) finds that the BRI has had a positive impact on trade through investment that has increased over time.

Kohl (2019) estimates the effects of infrastructure projects and trade agreements on bilateral Trade in Value Added prior to the BRI. He uses these econometric estimates to simulate the effects of the BRI under alternative assumptions about how much the BRI reduces bilateral distance between countries. He concludes that the BRI benefits China more than trade agreements like the Regional Comprehensive Economic Partnership.

Taking a more sector-specific approach, Ho, Chan, Yip and Tsang (2020) develop an extended gravity model that predicts U.S. apparel imports from China and 14 Asian countries that are participating in the BRI, using panel data regression and artificial neural network techniques and data from 1998 to 2018. They predict trade patterns in 2019 and show a positive effect of the BRI on the apparel exports of some Asian developing countries to the United States. The authors note more research is needed to examine the balance between economic growth and the social and environmental sustainability of developing countries.

3.3 Estimates of the Effects on Cross-Border Investment

Chen and Lin (2020) estimate that extending transportation networks has the potential to increase cross-border investment by three percent in participating countries. They note that it could also increase cross-border investment in non-participating countries due to network spillovers.

3.4 Estimates of the Effects on GDP Growth

Iqbal, Rahman and Sami (2019) estimate the impact on GDP, using a random effects panel regression model. They find "a significant impact of BRI on the economic growth of Asian economies" in the early years of the BRI. A case study on Kazakhstan in World Bank (2020) states that lower shipment time generates higher FDI and exports, which in turn improves productivity and raises GDP. They find that lower shipment times can reduce prices of imported inputs and production costs and thus raise productivity growth. Using the model in De Soyres, Mulabdic and Ruta (2020), the Kazakhstan case study reports that improved infrastructure increases the country's GDP by approximately 6.5 percent.

3.5 Estimates of the Effects on Economic Welfare

Jackson and Shepotylo (2021) use a structural general equilibrium model to simulate the impact of the BRI on economic welfare through reductions in trade costs. They conclude that the BRI could result in significant welfare gains if combined with other policy measures that facilitate trade.

Mukawaya and Mold (2018) simulate reductions in transport costs for imports and exports using a GTAP CGE model. They evaluate the impact of the BRI on trade and welfare in Eastern Africa. They find that "the total exports of countries could increase by $192 million and welfare by about $1 billion. The BRI would result in a particularly pronounced increase in intra-regional trade."

World Bank (2019) uses data on the impact of the BRI on shipment times and trade costs as inputs into three modeling approaches: computable general equilibrium, structural general equilibrium, and gravity models. They find that BRI transport corridors have the potential to substantially improve trade, foreign investment, and living conditions in participating countries. However, these results are conditional on China and the corridor economies adopting deeper policy reforms that improve transparency, expand trade, strengthen debt sustainability, and mitigate environmental, social, and corruption risks. The authors estimate that foreign trade could grow by 2.8 to 9.7 percent for the BRI corridor economies and by 1.7 to 6.2 percent worldwide. The biggest winners would be the countries with comparative advantage in time-sensitive sectors (e.g., fresh fruits and vegetables), or that require time-sensitive inputs (e.g., electronics). They also estimate that the low-income countries will see a substantial increase in FDI (7.6 percent) due to the new transport links. Real income gains could increase by up to 3.4 percent due to expanded trade and investment-induced growth.

3.6 Literature that Tracks the BRI Countries

For the modeling analysis in this working paper, we use a list countries that are participating in the BRI from Nedopil (2023a). The list identifies 150 countries that signed a BRI Memorandum of Understanding with China prior to December 2023. Based on our review of publicly available data regarding country participation in BRI, this source appears to contain the most updated information, though Nedopil (2023a) notes that "the availability of independent information is limited and partly contradictory." For four countries (Austria, Republic of Congo, Niger, and Russian Federation), the source file was missing likely dates when the countries started to participate in the BRI. Based on open source research, we identified these dates and added these four countries to the list.

4 Economic Model of the Effects of BRI on Growth

The first step in our own modeling analysis is to estimate the effects of participating in the BRI on a country's GDP growth using a reduced-form econometric model of growth, conditional on country effects and year effects. The reduced-form model quantifies the net effect of the BRI on growth; it combines the effects of increased infrastructure investments, improved links in energy supply, and any new development opportunities, as well as any adverse effects on development. Equation (1) is the econometric specification.

$$\Delta \ln y_{c,t} = \alpha \ln y_{c,t-1} + \beta_0 \ BRI_{c,t} + \beta_2 \ BRI_{c,t-2} + \beta_4 \ BRI_{c,t-4} + \gamma_c + \delta_t + \epsilon_{c,t} \tag{1}$$

$\ln y_{c,t}$ is the log of the GDP of country c in year t, and $\Delta \ln y_{c,t}$, the log difference of GDP, is approximately equal to the growth rate. $BRI_{c,t}$ is an indicator variable that is equal to one if country c participated in the BRI in year t.[16] The specification in equation (1) represents the effects of BRI participation as a step function. If $\beta_0 > 0$ and $\beta_2 = \beta_4 = 0$, there is an immediate, permanent effect on growth; on the other hand, if $\beta_0 = \beta_2 = 0$ and $\beta_4 > 0$, then the effect on growth occurs with a four-year lag. The specification also allows for convergence in countries' GDP growth rates ($\alpha < 0$). The data on GDP, in current dollars for each country and year, are from the World Bank's World Development Indicators.

Table 1 reports the parameter estimates for four versions of the econometric specification with different parameter restrictions. The estimated standard errors are reported in parentheses, and the p-values are reported in square brackets. The standard errors are clustered by country-year. All of the specifications include country fixed effects to condition on time-invariant or very slowly changing country characteristics (like institutions and culture of the countries) and year fixed effects to condition on factors that vary over time but not across countries (like global demand shocks). According to the model, the impact of BRI occurs with a lag of four years.

Version 1C is the best fit to the data, according to the Akaike Information Criterion (AIC).[17] In this version of the model, there is no effect on a country's growth until four years after first participatping, then a permanent step up in the country's growth rate. We use these parameter estimates ($\beta_4 = 0.030$ and $\alpha = -0.123$) to calculate a counterfactual GDP level in 2022 for each of the countries that participated in the BRI. In the fourth year, counterfactual GDP is β_4 log points less than actual GDP. In the fifth year it is $\beta_4\ (1\ +\ (1\ +\ \alpha))$ log points less, et cetera.

[16] The joining dates are from Nedopil (2023a).

[17] The AIC is a conventional diagnostic for selecting among alternative models based on relative statistical quality. It is a function of the maximized likelihood function of the estimator and the number of estimated parameters estimates, so it penalizes the inclusion of irrelevant explanatory variables. A lower value of the AIC indicates higher statistical quality.

Table 1: Econometric Estimates from GDP Growth Model

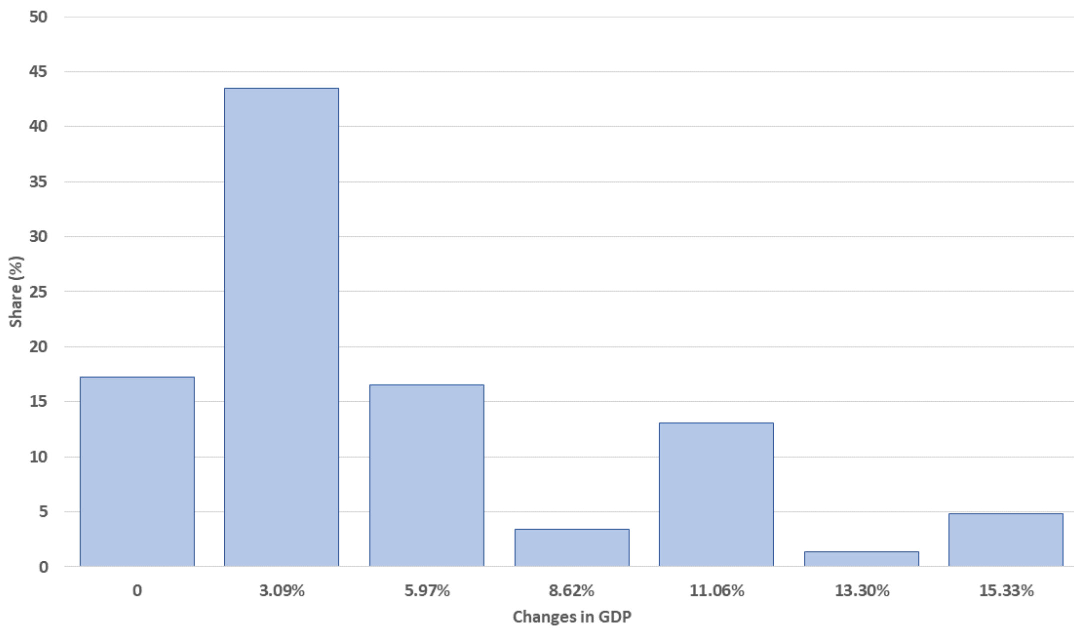
Estimated Parameter	Version 1A	Version 1B	Version 1C	Version 1D
α	-0.122	-0.123	-0.123	-0.121
	(0.012)	(0.012)	(0.012)	(0.012)
	[0.000]	[0.000]	[0.000]	[0.000]
β_0	-0.011			-0.011
	(0.009)			(0.009)
	[0.264]			[0.229]
β_2	0.012	0.006		0.023
	(0.011)	(0.009)		(0.010)
	[0.267]	[0.526]		[0.022]
β_4	0.027	0.027	0.030	
	(0.010)	(0.010)	(0.008)	
	[0.006]	[0.005]	[0.000]	
Number of Observations	4,163	4,163	4,163	4,163
AIC	-7,166.7	-7,167.1	-7,168.6	-7,161.9

Equation (2) compares the actual level ($y_{c,t}$) to the counterfactual level ($y'_{c,t}$).

$$\hat{y}_{c,t} = \left(\frac{y_{c,t} \;-\; y'_{c,t}}{y'_{c,t}} \right) \; 100 > 0 \tag{2}$$

Figure 2 reports the distribution of the percent change in the GDP in each of the countries that participated in the BRI ($\hat{y}_{c,t}$) in 2022.

Figure 2: Histogram of Increases in GDP of BRI Countries



The differences in these effects across the BRI countries mostly reflect how early each country started to participate, since the effects of the BRI on GDP compound over time in the model.[18] For countries that started to participate since 2018, there was not yet a significant impact on GDP in 2022. Table 2 reports the date when each of the Central Asian nations started to participate, as well as the percent increase in its GDP relative to the counterfactual in 2022.

[18]In addition, countries that were initially smaller experienced a greater increase in growth due to the convergence effect ($\alpha < 0$), though this effect was small.

Table 2: Estimated Effect on GDP in Central Asian Countries

Country	First Year in the BRI	Change in GDP in 2022 (%)
Kazakhstan	2015	11.06
Kyrgyz Republic	2013	15.33
Tajikistan	2018	3.09
Turkmenistan	2017	5.97
Uzbekistan	2015	11.06

5 Economic Model of the Effects of BRI on Trade Costs

The second step in our modeling analysis is to econometrically estimate the impact of the BRI on a country's trade costs with China and other trade partners. This is intended to capture the net effects of the BRI on trade costs due to improved transportation infrastructure, reductions in trade barriers, and other enhancements to bilateral relationships. The model estimates average treatment effects that combine all of these factors, like in Iqbal et al. (2019), rather than focusing more narrowly on reductions in shipping times, like in De Soyres et al. (2019) and De Soyres et al. (2020).

We use a structural gravity model and Poisson Pseudo Maximum Likelihood (PPML) with exporter-year, importer-year, and exporter-importer fixed effects to estimate the parameters of this second model, as described in Herman (2023) and the seminal contributions in Anderson and van Wincoop (2003) and Baier and Bergstrand (2007). Equation (3) is the high-dimensional fixed effects PPML specification.

$$
\begin{aligned}
X_{ij,t} = exp\ (\ \nu_{i,t}\ +\ \omega_{j,t}\ +\ \mu_{ij}\ +\ \phi_0\ BRIC_{ij,t}\ +\ \phi_2\ BRIC_{ij,t-2}\ +\ \phi_4\ BRIC_{ij,t-4}\ +& \\
\lambda_0\ BRIN_{ij,t}\ +\ \lambda_2\ BRIN_{ij,t-2}\ +\ \lambda_4\ BRIN_{ij,t-4}\ +& \\
\kappa_0\ RTA_{ij,t}\ +\ \kappa_2\ RTA_{ij,t-2}\ +\ \kappa_4\ RTA_{ij,t-4}\ )\ \eta_{ij,t}& \quad (3)
\end{aligned}
$$

$X_{ij,t}$ is the value of exports from country i to country j in year t. $BRIC_{ij,t}$ is an indicator variable that is equal to one if importing country j had started participating in the Initiative by year t and country i is China, or exporting country i had started by year t and country j is China. $BRIN_{ij,t}$ is an indicator variable that is equal to one if importing country j and exporting country i were both participating in the BRI by year t and neither of the countries is China. $RTA_{ij,t}$ is an indicator variable that is equal to one if countries i and j had entered into a regional trade agreement by year t. $\nu_{i,t}$ is an importer-year fixed effect, $\omega_{j,t}$ is an exporter-year fixed effect, μ_{ij} is an exporter-importer fixed effects, and $\eta_{ij,t}$ is the Poisson error term. The data on bilateral trade flows are from the CEPII BACI dataset for 2014-2022, aggregated across HS codes. Again, we use the dates when countries started participating in the BRI from Nedopil (2023a).

Table 3 reports parameter estimates for this model for three versions of the econometric specification. The estimated standard errors are reported in parentheses. They are clustered by country pair. All of the specifications include importer-year, exporter-year, and exporter-importer fixed effects. The immediate and lagged effects on trade costs on bilateral trade involving China are statistically significant, but the immediate and lagged effects on trade costs between BRI country pairs not including China are not statistically significant.[19] In other words, the estimates suggest that participating in the BRI only significantly increases trade with China, and it does not increase trade preferentially between BRI countries.[20] The estimates suggest that participating in the BRI does not increase trade preferentially between BRI countries. This is indicated by the Wald tests of coefficient restrictions.[21] All of the Wald tests reject the restrictions. The immediate effects of sharing a regional trade agreement are statistically significant ($\kappa_0 > 0$), but the lagged effects are not ($\kappa_2 = \kappa_4 = 0$). Version 3C is the specification with the best fit according to the AIC.

[19]Specifically, statistical significant means that the p-value of the point estimates are less than 5%.

[20]It may increase trade with all countries by increasing the trade infrastructure of the BRI country, but this would be absorbed in the country-year fixed effects.

[21]For Version 3A, the test is whether $\phi_0 = \lambda_0$; for Version 3B, the test is whether $\phi_0 = \lambda_0$ and $\phi_1 = \lambda_1$; for Version 3C, it is whether $\phi_0 = \lambda_0$ and $\phi_1 = \lambda_1$ and $\phi_2 = \lambda_2$.

Table 3: Econometric Estimates on Trade Costs

Estimated Parameter	Version 3A	Version 3B	Version 3C
ϕ_0	0.124	0.069	0.076
	(0.041)	(0.033)	(0.033)
	[0.003]	[0.040]	[0.022]
ϕ_2		0.098	0.064
		(0.029)	(0.027)
		[0.001]	[0.019]
ϕ_4			0.081
			(0.031)
			[0.009]
λ_0	-0.015	0.000	0.002
	(0.020)	(0.017)	(0.016)
	[0.447]	[0.989]	[0.920]
λ_2		-0.016	-0.005
		(0.016)	(0.014)
		[0.310]	[0.703]
λ_4			-0.024
			(0.021)
			[0.249]
κ_0	0.058	0.050	0.052
	(0.021)	(0.023)	(0.023)
	[0.006]	[0.031]	[0.026]
κ_2		0.023	0.010
		(0.022)	(0.024)
		[0.290]	[0.685]
κ_4			0.036
			(0.029)
			[0.217]
Number of Observations	257,316	257,316	257,316
Pseudo R^2	0.9945	0.9946	0.9946
AIC	5.96 e+09	5.95 e+09	5.94 e+09
Wald Test: p-value of χ^2 Statistic	0.0058	0.0107	0.0115

As a sensitivity analysis, we simplify the model by removing all terms that are not statistically significant in Table 3, so we impose the restrictions that $\lambda_0 = \lambda_2 = \lambda_4 = \kappa_2 = \kappa_4 = 0$. The point estimates for this restricted model as reported in Table 4. They are quite similar to the point estimates in Table 3.

Table 4: Econometric Estimates on Trade Costs

Estimated Parameter	Version 4A	Version 4B	Version 4C
ϕ_0	0.114	0.069	0.076
	(0.040)	(0.035)	(0.034)
	[0.004]	[0.048]	[0.027]
ϕ_2		0.087	0.060
		(0.025)	(0.025)
		[0.001]	[0.015]
ϕ_4			0.062
			(0.034)
			[0.065]
κ_0	0.059	0.059	0.059
	(0.021)	(0.021)	(0.021)
	[0.006]	[0.006]	[0.006]
Number of Observations	257,316	257,316	257,316
Pseudo R^2	0.9945	0.9946	0.9946
AIC	5.96 e+09	5.95 e+09	5.95 e+09

Using the econometric estimates from Version 3C ($\phi_0 = 0.076$, $\phi_2 = 0.064$, and $\phi_4 = 0.081$) and setting σ to five (a common value in the literature), we calculate counterfactual bilateral trade costs in 2022, absent the BRI, according to equation (4).

$$\ln \tau'_{ij,t} = \ln \tau_{ij,t} - \frac{\phi_0}{1 - \sigma} BRIC_{ij,t} - \frac{\phi_2}{1 - \sigma} BRIC_{ij,t-2} - \frac{\phi_4}{1 - \sigma} BRIC_{ij,t-4} \quad (4)$$

We calculate the percent change in bilateral trade costs due to the BRI according to equation (5).

$$\hat{\tau}_{ij} = \left(\frac{\tau_{ij} - \tau'_{ij}}{\tau'_{ij}} \right) 100 < 0 \quad (5)$$

Figure 3 reports the distribution of these percent changes, which are zero unless one of the countries in the pair joined the BRI by 2022 and the other is China.

Figure 3: Histogram of Changes in the Trade Costs of BRI Countries

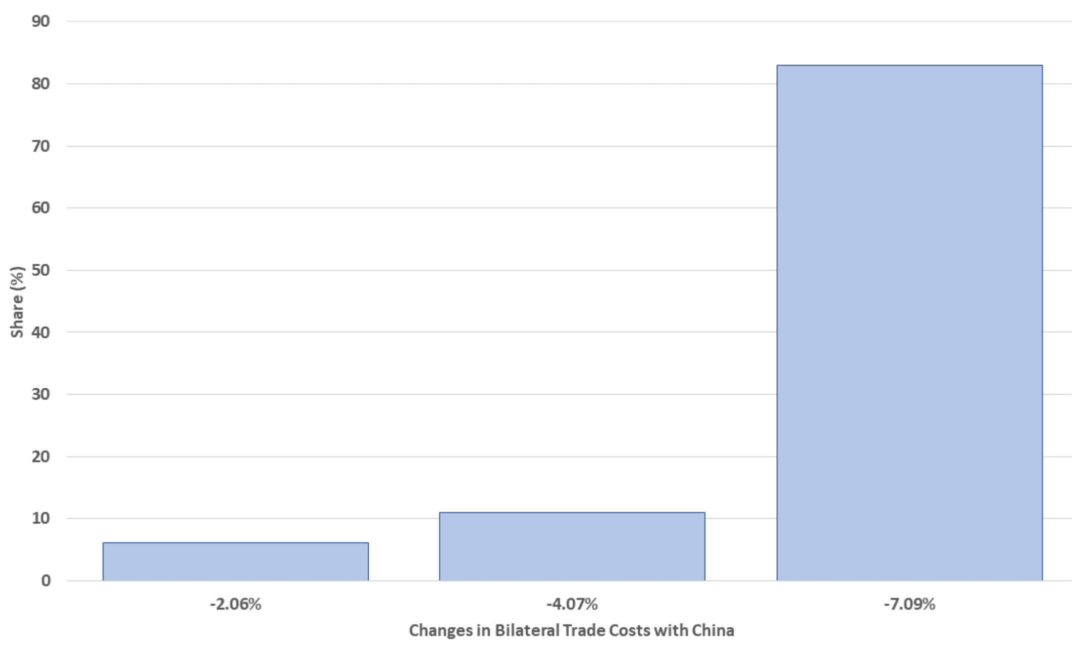


Table 5 reports the trade-weighted change in the average trade costs facing the exports and imports of the five Central Asian nations.

Table 5: Estimated Change in Average Trade Costs of Central Asian Countries

	Total Exports (%)	Total Imports (%)
Kazakhstan	-0.96	-1.98
Kyrgyz Republic	-0.25	-4.50
Tajikistan	-1.17	-2.34
Turkmenistan	-5.06	-1.35
Uzbekistan	-0.83	-1.74

6 Gravity Model Simulations

As explained in Herman (2023), the structural gravity model implies that the magnitude of trade flows between a pair of countries depends on two types of economic fundamentals, GDPs and bilateral trade costs. Equation (6) is this structural gravity equation.[22]

$$X_{ij} = \frac{Y_i\ Y_j}{\sum_k Y_k} \left(\frac{\tau_{ij}}{\Pi_i\ P_j} \right)^{1\ -\ \sigma} \tag{6}$$

X_{ij} is the value of trade between countries i and j in a particular year, Y_i and Y_j are the GDPs of countries i and j, τ_{ij} is a bilateral trade cost factor for trade between countries i and j, and the indices Π_j and P_j are defined in equations (7) and (8).

$$\Pi_i^{1\ -\ \sigma} = \sum_j \left(\frac{\tau_{ij}}{P_j} \right)^{1\ -\ \sigma} \frac{Y_j}{\sum_k Y_k} \tag{7}$$

$$P_j^{1\ -\ \sigma} = \sum_i \left(\frac{\tau_{ij}}{\Pi_j} \right)^{1\ -\ \sigma} \frac{Y_i}{\sum_k Y_k} \tag{8}$$

[22] This equation implicitly assumes that aggregate expenditure equal aggregate income in each country in each year. It can be modified to relax this restriction.

The econometric models in Sections 4 and 5 quantified the effects of the BRI on GDP and bilateral trade costs. In the next section, we use these econometric estimates and the model in equations (6), (7), and (8) to calculate the combined impact of BRI-related GDP growth and trade cost reductions on bilateral trade flows X_{ij}.

6.1 Counterfactual Trade Flows

We use a reduced-form log linear approximation of the structural gravity model with multilateral resistence terms that is based on the first-order Taylor series expansion in Baier and Bergstrand (2009).[23]

$$\hat{X}_{ij} = \hat{Y}_i + \hat{Y}_j - \sum_k \theta_k \hat{Y}_k + (1 - \sigma) \left(\hat{\tau}_{ij} - \sum_k \theta_k \left(\hat{\tau}_{ik} + \hat{\tau}_{kj} - \sum_m \theta_m \hat{\tau}_{km} \right) \right) \quad (9)$$

where $\theta_j = \frac{Y_j}{\sum_k Y_k}$. We do not need to assume (or estimate) a value of σ for these calculations, because the trade cost model in Section 5 already implicitly estimates the product of $(1 - \sigma)$ and $\hat{\tau}_{ij}$.

The estimated effects on trade can be decomposed into a part due to the effects of GDPs (setting the changes in trade costs equal to zero) and the effects on trade costs (setting the changes in GDPs equal to zero). In the tables below, we combine these two effects into a net effect on a country's exports and its imports. We calculate the change in total exports from country i and total imports into country j as trade-weighted averages of the percent changes in bilateral trade flows according to equations (10) and (11).

[23] Baier and Bergstrand (2009) demonstrate, via Monte Carlo simulations, that this reduced form provides a close approximation of the full non-linear model.

$$\hat{X}_i = \sum_k \left(\frac{X_{ik}}{\sum_{k'} X_{ik'}} \right) \hat{X}_{ik} \tag{10}$$

$$\hat{M}_j = \sum_k \left(\frac{X_{kj}}{\sum_{k'} X_{k'j}} \right) \hat{X}_{kj} \tag{11}$$

6.2 Impact on Total Trade of the Countries

Table 6 reports the simulated effects on the total exports and imports of the five Central Asian nations, China, and five advanced economies. The largest percent increases in total exports and imports are in the Central Asian nations (reflecting both GDP and trade cost effects) and China (reflecting only trade cost effects only). The other countries, except for Korea, only experience small positive, and sometimes negative, percent changes in their total exports and imports. For example, we estimate that participating in the BRI increased Kazakhstan's total exports by 10.69% and its total imports by 15.40%. On the other hand, the BRI increased U.S. total exports by only 0.3% and reduced U.S. total imports by 0.09%.

Table 6: Change in the Multilateral Trade of Each Country

Country	Total Exports (%)	Total Imports (%)
Kazakhstan	10.69	15.40
Kyrgyz Republic	16.65	26.64
Tajikistan	4.78	9.16
Turkmenistan	18.66	7.96
Uzbekistan	12.16	14.67
China	7.12	10.11
Japan	0.06	-0.27
Korea	4.31	4.28
France	0.67	0.67
Germany	1.15	1.28
United States	0.30	-0.09

6.3 Impact on Bilateral Trade Flows

Table 7 reports the simulated effects on the bilateral trade of the Central Asian nations, China, the United States, and Japan.

Table 7: Estimated Change in Bilateral Trade Flows

Importer	Exporter	Change in Value of Trade (%)
Kazakhstan	China	29.05
China	Kazakhstan	29.02
Kazakhstan	Turkmenistan	7.60
Turkmenistan	Kazakhstan	8.07
Kazakhstan	United States	6.75
United States	Kazakhstan	6.73
Kazakhstan	Japan	6.75
Japan	Kazakhstan	6.73
Japan	United States	0.79
United States	Japan	0.78
China	United States	-5.29
United States	China	-5.29

The BRI has a large positive effect on the bilateral trade of the Central Asian nations with China, due to both growth and trade cost effects. It has a moderate positive effect on trade between the Central Asian nations and between these nations and the advanced economies, due to growth effects in the Central Asian nations. There is a small positive effect on trade among other country pairs like the United States and Japan, due to trade effects in the multilateral resistance terms in the model. There is a negative impact on trade between the United States and China, due to trade effects in the multilateral resistance terms. The BRI increased exports from China to Kazakhstan by 29.05% but only increased exports from the United States to Kazakhstan by 6.75%, while reducing U.S. exports to China by 5.29%. Appendix A provides model-based estimates for the impact of the BRI on additional country pairs.

7 Conclusions

The estimated bilateral trade effects of the BRI meet our theoretical expectations: the increase in GDP growth creates more trade in both directions, and the preferential reduction in trade costs creates additional trade between some country pairs and diverts trade from others. The contribution of our model is that it provides estimates of the magnitudes of these effects on GDP, trade costs, and trade flows.

One limitation of our models is that they aggregate all commodities. The analysis could be extended by disaggregating the data and estimating sector-specific effects on growth and trade costs. For example, Nugent and Lu (2021) demonstrates that a sector-level emphasis is helpful for understanding the impact of BRI on China's FDI outflows.

Another limitation of our models is that they are estimating the average treatment effects of the BRI, though the effects may vary by country. It might be better to use measures of the intensity of infrastructure investment associated with the BRI. However, the ability to track financial information about the BRI is generally limited, and the level of infrastructure investment may be endogenously determined. In some cases, China does not disclose renegotiated terms of bilateral loans or may use onshore financing and special purpose investment vehicles, which complicate data tracking.[24] As a result, it is not clear how much investment has been realized from announced BRI commitments. China's reluctance to disclose detailed information about overseas development finance portfolio has made it difficult for countries to objectively weigh the costs and benefits of participating in the BRI.[25] Our preliminary review of data availability suggests there is no single, official, publicly-available database of BRI projects with financial information (including, for example, commitment and disbursement amounts across time, industries, and participating countries). This limits researchers' ability to derive a comprehensive measure of BRI intensity. China's official Belt

[24] Congressional Research Service (2023)

[25] Malik, Parks, Russell, Lin, Walsh, Solomon, Zhen, Elston and Goodman (2021)

and Road Portal contains sections for foreign investment and overseas direct investment, but the data were missing in both at the time of writing of this paper.[26] Various institutions have attempted to compile pertinent information to fill in the gap, even as such data would have limitations. Appendix B provides examples of potential data sources that might be useful for creating proxy measures of BRI intensity.

[26] China Economic Information Service and the State Information Center, Belt and Road Initiative Portal (Accessed March 14, 2024).

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Appendix A

Table 8: Additional Estimates of Changes in Bilateral Trade Flows

Importer	Exporter	Change in Value of Trade (%)
Kyrgyz Republic	China	33.35
China	Kyrgyz Republic	33.29
Kyrgyz Republic	United States	11.06
United States	Kyrgyz Republic	10.99
Tajikistan	China	21.12
China	Tajikistan	21.05
Tajikistan	United States	-1.17
United States	Tajikistan	-1.24
Turkmenistan	China	24.43
China	Turkmenistan	23.93
Turkmenistan	United States	2.13
United States	Turkmenistan	1.63
Uzbekistan	China	29.06
China	Uzbekistan	29.02
Uzbekistan	United States	6.76
United States	Uzbekistan	6.73

Appendix B

The *China's Overseas Development Finance Database* managed by the Boston University Global Development Policy Center states that it is "the global, harmonized, validated and geolocated record of Chinese overseas development finance." The database covers the years prior to and after launch of the BRI (2008-2021) and includes loans from China's two main development finance institutions (DFIs), the China Development Bank and Export-Import Bank of China, to governments, inter-governmental bodies, majority state-owned entities and minority state-owned entities with sovereign guarantees.[27] According to this database, the two DFIs provided nearly $0.5 trillion in development finance to foreign governments between 2008-2021. As of January 2023, the interactive database included 1,099 loans, detailing each project's country, borrower, lender, year, loan amount, and sector. The potential limitations of this database include absence of BRI flag in the database; lack of coverage after 2021; and lack of project status (e.g., active, cancelled or completed) information.

The *China Global Investment Tracker* dataset compiled by the American Enterprise Institute and the Heritage Foundation reports China's outbound investment and construction projects, providing details on country, investor, sector, and the value of transactions (as indicated by the companies engaged in the respective projects). The database tracks both BRI (2,079 records) and non-BRI transactions between 2005 and 2023 worldwide, and researchers can select the former for a more focused investigation. The potential limitations of this database include the lack of a flag for completed or ongoing projects and that exclusion of transactions that are under $100 million value. The grand total value of transactions between 2013 and 2023 across 126 countries with BRI flag ($971 billion) in this database appears to be close to the officially-stated estimate ($1 trillion) of BRI investment.[28]

[27] Boston University Global Development Policy Center. China's Overseas Development Finance Database (Accessed March 14, 2024).

[28] This dataset has been used in Nedopil (2023), "China Belt and Road Initiative (BRI) Investment Report

AidData's *Global Chinese Development Finance Dataset (Version 2.0)* includes 13,427 projects with commitment years from 2000 to 2017 across 145 countries supported by financial and in-kind transfers from official sector institutions in China. 10,849 of the 13,427 total records in the dataset are formally approved, active, and completed; they are collectively worth $843.1 billion. The potential limitations include the lack of a flag for the BRI and the lack of records after 2017.

2022," Griffith Asia Institute at Griffith University (Brisbane, Australia) and the Green Finance & Development Center of the Fanhai International School of Finance at Fudan University (Shanghai, China), p.9. The report indicates the data for 2013-2023 in charts derives from "AEI and others."