Strategic Trade Infrastructure: Understanding China's Belt and Road Initiative

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Abstract

Since 2000, through it's Belt and Road Initiative (BRI), China has invested $320.1 billion in transportation infrastructure across 143 countries. Are these investments economically justified for China? What are trade and welfare impacts for host and third countries? How should major economies respond? First, we examine the economic and geopolitical drivers of Chinese overseas infrastructure investments and estimate their impacts on trade. Second, we derive theoretical predictions for strategic trade infrastructure investments among competing countries. Surprisingly, we find that a foreign country has stronger incentives to invest in a transportation hub than private investors and the host country and that private investors, which in may be fully crowded out. The equilibrium trade infrastructure may be efficient for the world; when it is not, a host country would like to restrict foreign investment. Third, we embed these forces in a multi-country framework with a transport network over land, sea, and air featuring congestion in transport hubs. We back out political weights that rationalize the observed BRI investments and compute the optimal economic investments that China would have implemented absent those weights. Computationally, we tackle high-dimensionality and complex non-linearities using piecewise linear approximations that allow us to apply standard optimal-transport methods. Our preliminary results suggest positive net economic returns for China and gains for most of the world including the U.S., even though China's political weights appear biased against the U.S.

JEL Classification: F0, F2, H5

1 Introduction

Starting in the early 2000's, China launched the Belt and Road Initiative (BRI), a sweeping program of infrastructure investments across the world. The initiative focuses on transportation infrastructure designed to facilitate international trade in low- and middle-income countries, including seaports across South Asia, the Middle East, and West Africa and rail and road corridors through Central Asia. China has also pursued similar investments in some high-income countries throughout the world. While the BRI also encompasses investments in other sectors such as energy, pipelines, and telecommunications, its transportation component alone represents an unprecedented effort by a single country to reshape the global trade network. In terms of sheer value, these transportation investments amount to approximately $320.1 billion, roughly twice the present value of the U.S. Marshall Plan.

The motivations behind these investments can be both economic and geopolitical. Much of the narrative spoused by China and host countries for BRI centers on the economic benefits. In this view, the investments will facilitate China's access to both import sources and exports markets, promoting economic development in host countries and fostering deeper integration via future trade and investment agreements. An alternative critical view posits that the economic impacts are small or negative and that the BRI serves as a vehicle for China to exert political influence. The goal in this paper is to understand the relative importance of these motivations, as well as the economic consequences of the BRI investments for China, host countries, and third countries. Specifically, we ask three questions. First, are China's BRI investments economically profitable for China, and how are host and third countries affected? Second, what trade infrastructure investments would be economically optimal from China's perspective, and how important are non-economic motives in driving the observed investments? Third, how should other major developers of international trade infrastructure, such as the United States and international organizations, respond to these investments, if at all?

To answer these questions, we proceed in three steps. First, using detailed data on BRI investments and trade, our reduced-form empirical evidence examines the economic and geopolitical drivers of Chinese overseas infrastructure investments, as well as their impacts on trade in the affected ports. Second, we characterize a baseline theory of strategic trade infrastructure investments among two competing countries. The model demonstrates the conditions under which a foreign country benefits from investing in another country's international trade infrastructure. Third, we extend the theory to a multi-country framework with a transport network over land, sea, and air featuring congestion in transport hubs. Using the framework, we quantify the impacts of actual BRI investments and back out China's political weights across countries that rationalize these investments. We compute China's optimal investments under alternative political weights –for example, placing more value on the U.S.– and how other major investors in the world should optimally respond.

Section 2 introduces the data. We combine several datasets to obtain a comprehensive picture of global transportation networks and BRI investments. Our BRI investment data primarily come

from AidData's Global Chinese Development Finance Dataset, which (after our cleaning procedure) tracks 1,694 transportation loans worth $320.1 billion across 143 countries since 2000, including important information for our analysis such as interest rates on China's loans and ownership structures. In turn, we identify infrastructure locations (seaports, airports, rail terminals, and road terminals) using the United Nations Code for Trade and Transport Locations (locode), which gives geocoded locations on more than 116,000 sites across 250 countries. To match the BRI investments to these locodes, we aggregate across projects in AidData and match based on information about the project. To construct the network of global trade, we measure sea routes and port activity using port-to-port container shipment data from Containerized Trade Statistics (CTS) and vessel routes from the Maritime Data Systems and Technology (MDST) database. (Our work in progress further includes bulk and gas ships). To assess port infrastructure (such as harbor size, berths, and cranes) we draw on the World Port Index (WPI) and on Lloyd's Ports of the World. We combine this information with cargo air routes and international land crossings to construct a global network of trade over land, sea, and air.

Section 3 presents descriptive evidence on where China invests in infrastructure, as well as correlates of these investments that give a sense of the possible determinants. We compare China's portfolio with those of other major global investors, including the U.S. Development Finance Corporation (DFC), the Japan International Cooperation Agency (JICA), the World Bank (IBRD, IDA), and the International Finance Corporation (IFC). The results suggest China is more likely to invest in countries trading more with China prior to investment. Similar trade-driven motivations for investments are less visible for the other investors. We also find China tends to invest more in countries with greater endowments of metals and minerals, but less in countries with endowments of coal, and in poorer countries, suggesting relative abundance of natural resources is also a driver. However, China's investments do not correlate with conventional measures of political alignment, such as UN voting patterns. We also find that China tends to invest in ports with characteristics, such as their harbor size, that are strongly correlated with international trade activity, suggesting that economic fundamentals play an important role in shaping China's decisions. In work in progress, we demonstrate that Chinese investments in the AidData drive improvements in infrastructure measured by external sources, such as the World Port's Index, and we explore their port-level impacts on shipments.

To study our questions it is essential to understand why China may reap economic benefits from the BRI. The answer is not obvious. A recent literature in spatial economics, including among others Fajgelbaum and Schaal (2020), Allen and Arkolakis (2022), and Bordeu (2023), quantifies optimal investments in transport infrastructure but lacks three crucial ingredients to answer this question theoretically. First, in these papers, the investment decision affects price wedges in receiving links but does not generate economic returns. However, in reality, investing in a transportation hub is itself an activity that generates economic returns, in addition to reducing price wedges. For example, investing in the port of an origin country for its imports allows China to enjoy *both* lower import prices and an endogenous economic return on its capital. These returns are sizable in the

data and play an important role in the theoretical characterization. Second, in these models, no agent besides a planner can invest in transport infrastructure; however, in reality, private investors can also finance infrastructure projects. Theoretically, it is ex-ante unclear why a country may benefit from distorting investment decisions made by the private sector. Third, these models only quantify planners investing within their own economy, whereas the BRI improves nodes and links that lie either partially or fully outside China's jurisdiction. When any of these three forces – economic returns from investing in transport infrastructure, private financing of infrastructure, and investments outside a planner's jurisdiction– are active, it is unclear whether foreign trade infrastructure investments are desirable from an economic perspective, barring obvious asymmetries across countries and private developers such as technological superiority building ports or cheaper access to financing.

Section 4 develops and characterizes a baseline framework that incorporates these ingredients and Section 5 expands the model to a quantitative setup. In our baseline model, two countries trade a differentiated product and an outside good through a single transport hub operated by a local transport authority. Infrastructure –such as berths and cranes in a port– is demanded by the transport hub, which supplies services to shipping companies. Better infrastructure lowers both the cost per shipment and the congestion caused by extra shipments. Both governments and the private sector can finance infrastructure, with these investments earning an economic return, and governments may tax or subsidize private developers and international trade. To isolate strategic incentives to invest in infrastructure, we assume in the baseline that all governments and private agents have access to the same technologies. The key asymmetry between countries is whether a country hosts the transportation hub, supplying shipping services and demanding infrastructure, or is a potential foreign investor demanding shipping services and supplying infrastructure. In this context, the incentives to invest boil down to strategic manipulation of terms of trade.

In this model, as we could expect, better infrastructure leads in equilibrium to more trade and lower user fees at the port for shipping companies. However, it also creates opposing terms-of-trade effects between the host country and the foreign investor. The host country owns the rents of the transport hub; therefore, it benefits from a greater global supply of infrastructure through reduced infrastructure costs, but it loses from the price effects on traded goods. In other words, for the host country, more infrastructure is similar to promoting trade in goods (with negative terms-of-trade effects) but also to substituting away imports for domestic supply of an intermediate input (with positive terms-of trade effects). For the foreign investor, these terms-of-trade effects are flipped.

This logic implies that a foreign country may benefit from investing. Furthermore, in equilibrium, the foreign country has stronger incentives to invest than the host country: foreign investment always occurs, and in some cases the host country may be completely crowded. To see why foreign investment must arise as a result of strategic competition, consider an initial situation without foreign investment. Around that point, the terms-of-trade effects from investing on the returns to infrastructure are zero, but they are positive or negative (depending on the country) on traded goods. In particular, the foreign country benefits from investing because it enjoys positive terms-

of-trade effects (cheaper access to host-country goods if they are imported, or higher export prices to the host country if they are exported) but suffers no terms-of-trade loss from reduced returns on transport infrastructure. Therefore, around a point of no foreign investment both the host and foreign countries have incentives to distort infrastructure investments, but in opposite directions: the host country would like to tax private investors and the foreign country would like to invest more than private investors or subsidize them. As a result, foreign investment always occurs in a Nash equilibrium, and in some cases the host country may be completely crowded from investments. Depending on how countries set trade policy, there may be too much or too little global investment compared to what a world planner. However, host countries would generally prefer to limit foreign investment.

Section 5 generalizes these forces to a quantitative, multi-country setting used for counterfactual analysis. We build an Armington-style trade model with many countries, each producing a differentiated good, connected through a global transport network that encompasses both land and sea routes (our work in progress incorporates the air network as well). Each country is represented by a set of nodes linked together in the network, with each node representing a trade hub such as a port, airport, rail junction, or land crossing. Trade costs on link depend on congestion at the nodes it connects, which in turn depends on the volume of all shipments passing through and the level of infrastructure. China allocates investment across foreign locations to maximize a weighted combination of its own welfare and that of host countries, with the weights allowing for possible geopolitical motivations.

Solving this model is challenging due to the non-linearities arising from congestion at nodes and the scale of the problem. These features make it unfeasible to use existing solution methods incorporating optimal transport in general equilibrium such as Fajgelbaum and Schaal (2020). The key difference here is that investments happen at nodes rather than links, and the scale of the problem is considerably larger given the number of differentiated products and the size of the global network. To make the model computationally tractable, we adapt an approach from operations research on intermodal transportation relying on approximations with piecewise linear methods (Crainic and Kim, 2007; Croxton et al., 2007). These approximations allows us to globally solve the investment problem using a standard optimal transport approach. After constructing the transport network using land borders and direct shipping connections, we calibrate the model to match data on bilateral trade flows, GDP, and container traffic for 160 countries. (Our work in progress defines the network at a more detailed geographic level than transport mode by country as we currently impose).

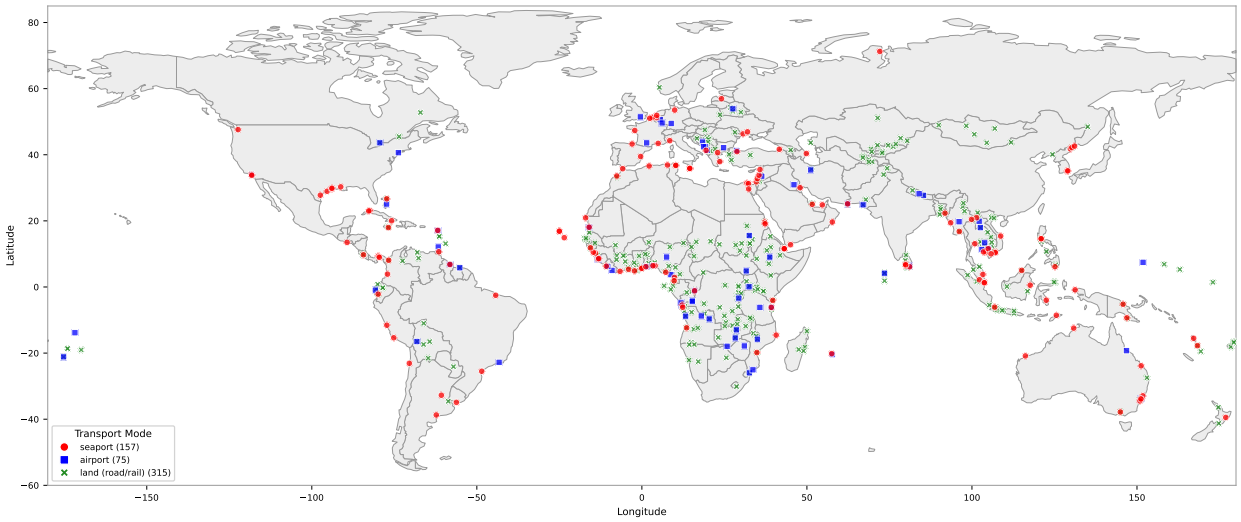
Section 6 presents the preliminary quantitative results. We first evaluate the global welfare effects of the observed BRI investments. Accounting for both their costs and economic returns, both direct through transport hub's payments and indirect through prices, we find BRI investments to be economically profitable for China. Most countries in the world also benefit, including the United States, Japan, and several European economies. However, echoing results from the baseline model, not every country necessarily gains from receiving investments, due to adverse terms of trade

effects. All countries enjoy improved consumer surplus from cheaper imports, but most experience declining production profits as domestic expenditures shift towards foreign goods. The impacts on port profits are heterogeneous: well-connected recipients like Russia gain while others like India suffer losses due to trade diversion. We then estimate the geopolitical weights implicit in China's investment choices by inverting the planner's first-order conditions. The recovered weights suggest that China favors developing economies in Africa, the Middle East, and Southeast Asia, while placing negative weight on the United States and Russia. Finally, we compute the economically optimal investment network that a Chinese planner without geopolitical motives would choose. We find that such a planner would direct more investment toward advanced trading partners, including the U.S., Japan, and Europe, and less toward the developing-country recipients that are a focus of the current BRI.

2 Data

Infrastructure Locations We use the United Nations Code for Trade and Transport Locations (locode) as the frame for infrastructure locations around the world. There are 116,011 official locodes in 250 countries. Each locode is assigned one or more function codes: seaport (1), rail terminal (2), road terminal (3), airport (4), postal exchange office (5), inland container depot or dry port (6), fixed transport function (7), and border crossing (B).

Figure 1: China's Overseas Infrastructure Investments, 2000-2025



Notes: Figure plots the locations of China's overseas investments in seaports, airports, and land infrastructure (roads and railways).

China's Overseas Investments We use AidData's China's Loans and Grants to the Global South dataset (CLG-Global 1.0) as the primary source for official Chinese-funded transportation

Table 1: China's Largest Overseas Infrastructure Investments, by Transport Mode

mode	country	locode	name	year	value ($b)
land	MYS	MYKBR	Kota Bharu	2017	20.0
seaport	RUS	RUSAB	Sabetta	2012	15.0
land	PAK	PKKHI	Karachi	2016	13.0
seaport	AUS	AUGLT	Gladstone	2009	11.0
land	NGA	NGKAD	Kaduna	2011	9.0
land	KEN	KEMBA	Mombasa	2014	8.0
land	BGD	BDDAC	Dhaka	2018	8.0
land	NGA	NGLOS	Lagos	2017	7.0
land	ARG	ARBUE	Buenos Aires	2013	6.0
land	LAO	LAVTE	Vientiane	2008	5.0

Notes: Table reports the 10 largest overseas investments by China in the AidData.

projects Parks et al. (2025) between 2,000 and 2,023. Since 2013, the research teams across 10 institutions have established the Tracking Unreported Financial Flows (TUFF) method to track China's investments through project-level information reported around the world by governments, multilateral agencies, NGOs, and newspapers. Tracking these investments poses several challenges, including cases where financing originates from Chinese state-owned institutions based outside mainland China or where the borrowing institution is legally incorporated in an offshore location. The TUFF method attempts to track these details attempts to track such details systematically, and to our knowledge, AidData is the most comprehensive database of China's official investments across years, destinations, and project types.

Since 2000, the dataset reports that Chinese state-owned institutions have committed an estimated 2.2 trillion in official financing through 33,593 commitments in 200 countries encompassing loans, grants, debt forgiveness, technical assistance, and in-kind transfers. The bulk of the financing are classified as Official Development Assistance (ODA) or Other Official Flows (OOF) and funded through 1,242 official agencies, ranging from Chinese government agencies, state commercial and policy banks, to state-owned enterprises. China's financing supports a range of activities across 25 sectors, such as agriculture, health, energy, education, and transport. AidData classifies flows as Official Development Assistance (ODA), Other Official Flows (OOF), or Vague (could be ODA or OOF); this classification relies on OECD criteria of the flow's intent (development or not), income classification of the receiving country, and the extent to which a flow is concessional. AidData also assigns the grant element of the loan, a score ranging from 0 to 100, where 1000 represents a full grant and 0 represents lending solely based on market terms, although this variable is often missing.

Since this paper focuses on China's overseas infrastructure investments, and we attempt to ensure we have the complete set of these investments. While the AidData is comprehensive for

debt financing, we also use the Council on Foreign Relations (CFR) datasets "Tracking China's Investment in Airports" (.–.in 42 countries) and "Tracking China's Control of Overseas Ports" (.–.in 74 countries) to supplement these two types of infrastructure investments. Restricting to cases of acquisition or construction investment, we isolate equity investments in transportation infrastructure made by Chinese companies in addition to the Chinese state-sponsored lending described in AIDdata.

Our final infrastructure dataset retains China's overseas investments across three infrastructure modes: seaports, airports, and land (roads and railways).[1] The final dataset contains investments at 486 locodes across 143 countries totaling $320.1 billion (in constant 2023 USD over the 2000-25 period). As a benchmark for this number, the World Bank's transportation portfolio is $34 billion and the Marshall Plan investments totaled $150 billion in today's dollars. Across transportation modes, the breakdown is: 157 seaports (84 countries totaling $107.1 billion), 77 airports (57 countries totaling $26.5 billion), and 320 rail/road terminals (100 countries totaling $186.5 billion). Figure 1 plots the locations of these investments. Table 1 reports the 10 largest investments in the dataset.

Figure 4 shows a timeline of China's overseas infrastructure investments, with grey denoting all modes and navy capturing seaports only. The Belt and Road Initiative was formally launched in 2013, and the mid 2010s was a period of large investment activity, but the ramp up predates the BRI launch. Since 2020, there has been a slow down in new infrastructure projects supported by China.

Ownership AIDData provides some information on the interest rate and ownership structure of China's investments. This information is an important piece of the theory and of the quantification. We have processed this information for seaports so far. We plan to incorporate this information in the quantification.

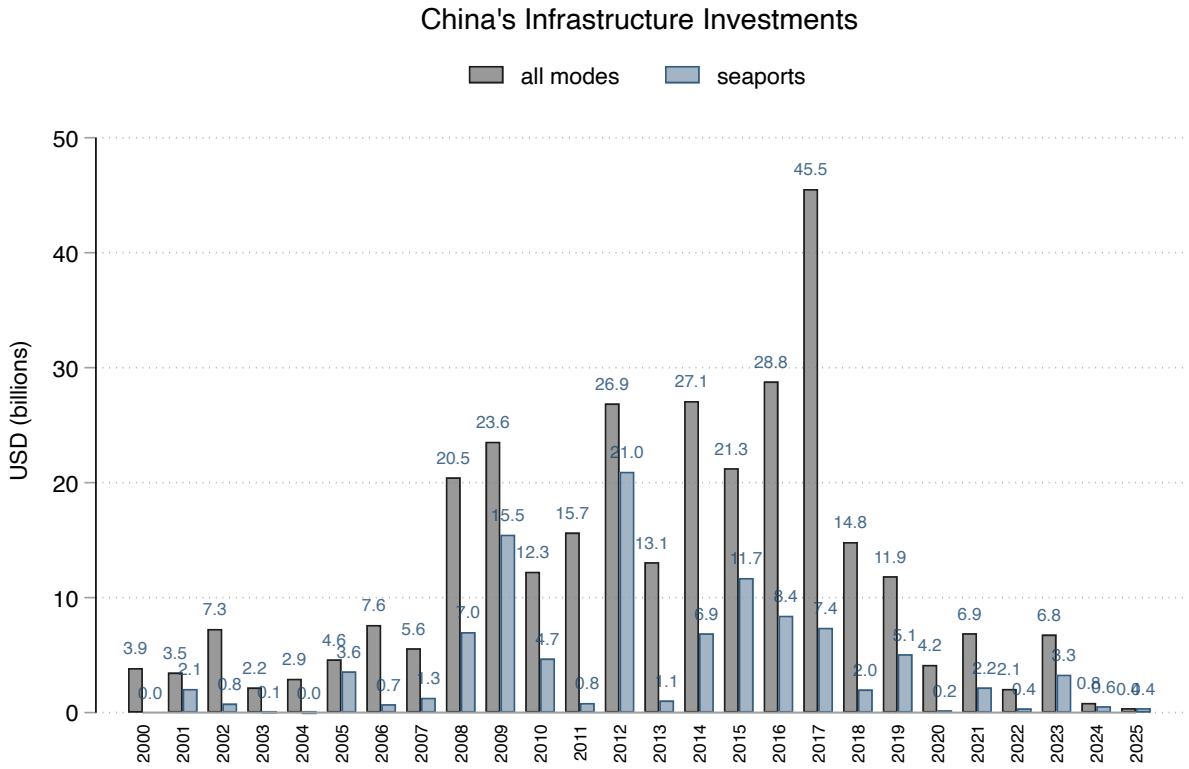
Of China's 157 seaport investments, we observe the interest rate of the loan at origination for about a third of the projects. Contractual terms may be a fixed rate or a variable rate relative a benchmark (e.g., LIBOR), and AID attempts to standardize and annualize the rate. This rate does not account for potential modifications of the borrowing terms at future dates (AIDData does capture some information on debt rescheduling which we have not yet processed). The average interest rate is 3.36%. The left panel of Figure 3 reports a histogram of the interest rate at origination.

The right panel reports the distribution of China's ownership shares. China has no ownership share in 91 of the 157 seaports it has invested in.[2]

[1] We drop projects that are committed but not yet implemented as of 2025. We have cleaned and processed the seaport and airport investments, and the processing of rail and road investments remains in progress.

[2] For 15 out of the 66 cases where China has non-zero ownership, we observe an interest rate. For 25 of these cases, we only observe equity investments. For the remainder, AIDdata was unable to collect all of the information on the terms of the loan.

Figure 2: Timeline of China's Overseas Investments, 2000-2025



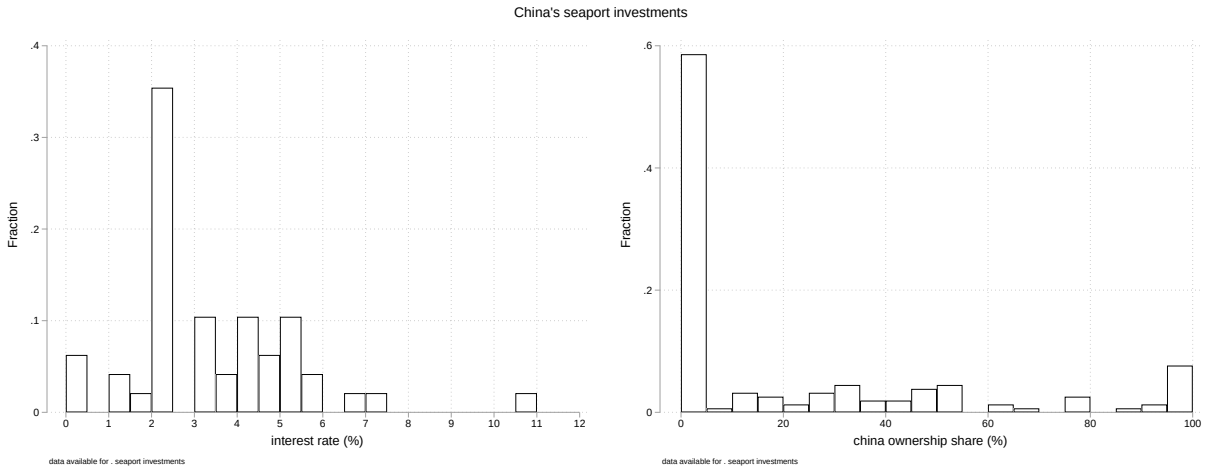
Notes: Figure plots a timeline of China's overseas infrastructure investments across all modes and seaports only.

Non-China Overseas Investments As a way to benchmark China's infrastructure investments, we also compile project-level investments by the World Bank, International Finance Corporation, the U.S. Development Finance Corporation (DFC), and Japan International Cooperation Agency (JICA). Future versions of this project will also compile infrastructure investments by the regional development banks (Asian Development Bank, African Development Bank, Asian Infrastructure Development Bank), and country aid agencies beyond DFC and JICA (France, Germany, Korea, etc).

There are differences in the lending criteria and objectives across these agencies. For example, the World Bank projects through the International Bank for Reconstruction and Development (IRBD) and International Development Association (IDA) lend to governments at near-market rates or on concessional terms, respectively, while the IFC lends to private-sector firms. DFC operates similarly to the IFC for U.S. overseas investments. One goal of this project is to use the investment locations and values with the model to uncover how China's investment objectives compare to these different agencies beyond China.

Table 2 reports the final dataset for the investments across agencies.

Figure 3: Interest Rate and Ownership, China's Seaport Investments



Notes: Figure plots the distribution of interest rate at origination and China's ownership shares across seaport investments.

Table 2: Overseas Infrastructure Investments Dataset

	seaports			airports			land		
source	locodes	countries	value ($bn)	locodes	countries	value ($bn)	locodes	countries	value ($bn)
China	157	84	107.1	77	57	26.5	320	100	186.5
IBRD/IDA	52	33	9.0	28	26	5.1	—	—	—
IFC	79	38	8.3	21	19	2.4	—	—	—
JICA	21	17	12.3	15	12	8.8	—	—	—
DFC	6	6	1.9	—	—	—	—	—	—

Notes: This table reports the locode-level investments across transport modes and sources.

Infrastructure Characteristics The model requires some information on the characteristics of the infrastructure projects. We obtain characteristics for seaports from two sources: the World Port Index (periodically between 2000 and 2023) and Lloyd's Ports of the World (2011). The World Port Index contains a mix of qualitative information, such as a port's harbor size (very small, small, medium, large) and maximum vessel size (below/above 500 feet in length), and some quantitative characteristics such as channel depth and tidal range. Lloyd's Ports of the World contains information on ports' berths and berth length and number of cranes.

Future versions of this project will collect more years of data from both sources. We will also obtain characteristics for airports, such as length of runways and number of gates.

Port Trade Data We obtain two types of port-to-port container shipping data. The first is from Container Trade Statistics which captures port-to-port movements of containers in 2011, 2012, 2023, 2024 for the month of May. The vendor claims to capture global trade in containers, with 80% of their data coming directly from the large global carriers and with the remaining 20% from other sources. We observe shipments across 564 seaports in 160 countries. In 2024, we observe the port-to-port routes of (annualized) 191 million twenty-foot equivalent unit (TEUs).

The second is from MDST which captures the sequence of port calls that a vessel rotates through on its regular schedule in May 2006, 2011, and 2024. For example, in 2006, Maersk Line TP5 rotated four vessels on a weekly basis between Los Angeles, Oakland, Shanghai, Ningbo, and returning to Los Angeles; the average capacity of each vessel was 4503 TEUs. Using this data, we can construct the total throughput across 1,156 seaports in 183 countries for these years.

We anticipate supplementing these data with additional years, and with port-to-port shipments in bulk cargo.

Trade Data We obtain country-to-country trade data from BACI. We exclude HS categories related to the sales of ships because these are often tracked by flags-of-covenience and do not reflect goods exchanged per se.

Country Characteristics We compile country characteristics from several sources: World Development Indicators, World Bank Changing Wealth of Nations (which measures values of natural resource stocks in constant USD), sovereign debt ratings from Bloomberg, geopolitical alignment from Bailey et al. (2017), and Polity (Marshall and Gurr 2020).

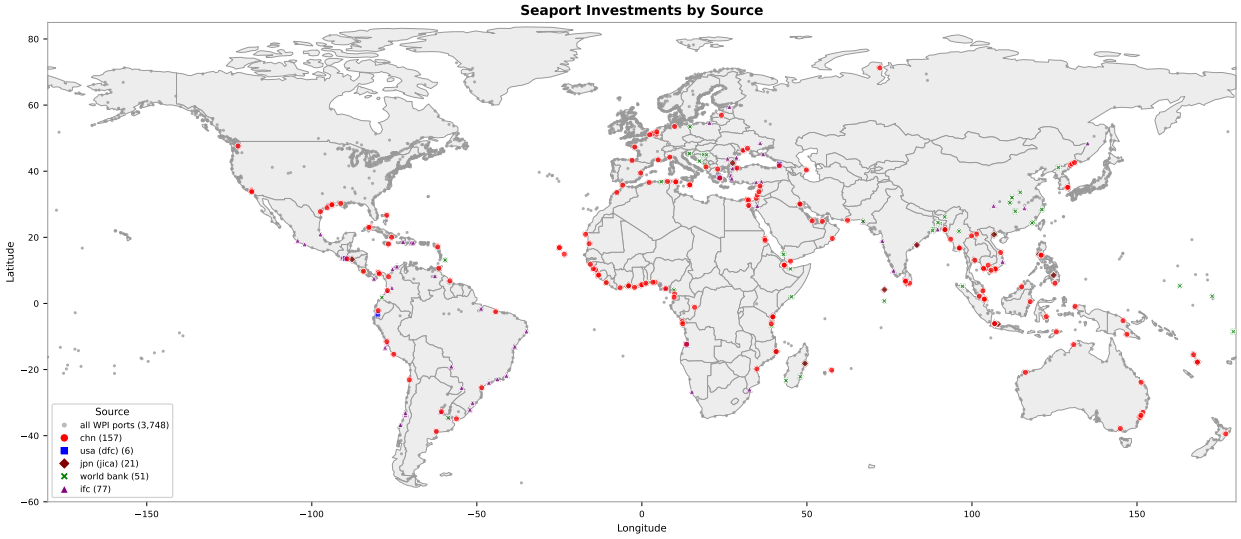
3 Summary Statistics

In this section, we provide summary statistics characterizing the destinations of China's investments, and how they compare with the U.S. (DFC), Japan (JICA), World Bank, and IFC. We have made the most progress collecting, processing and cleaning data on seaports, and so we focus for now only on these investments.

Figure 4 shows the location of 3,797 ports in the World Port Index, and overlays the ports receiving investments, by source, between 2000-25. China has directed investments across the globe, including in Western Africa, Western Europe, the U.S. and Southeast Asia, where the other sources have not invested in. On the other hand, China has not invested into any Indian ports, while the IFC, World Bank and Japan have. Four countries–Myanmar, Bangladesh, Vietnam, and Indonesia–have received investments from the sources excluding DFC (no country has received investments from all five sources). Japan and South Africa are two large countries that have received no investment from any of these sources.

We next analyze the correlates of China's seaport investments across countries. From Table 2, China has invested in nearly twice as many countries as the World Bank or IFC; and, on average, the receiving country is much richer than countries targeted by the other agencies. The average

Figure 4: Map of Overseas Seaport Investments by Investing Entity, 2000-2025



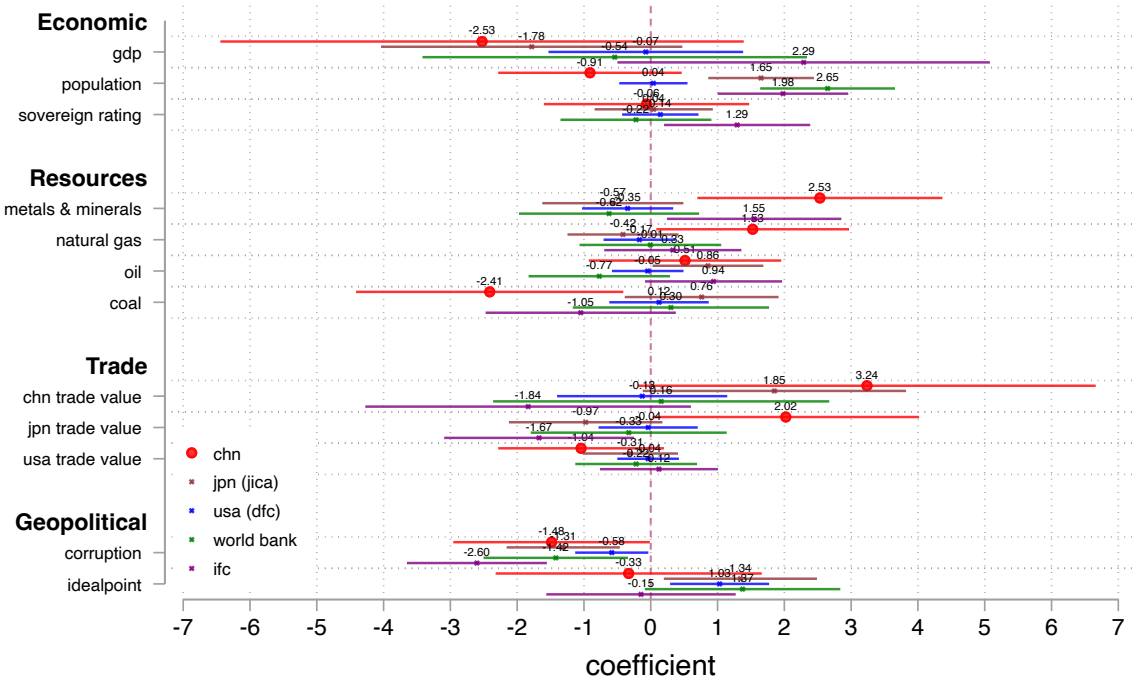
Notes: Figure plots a map of overseas seaports investments by source.

per capita income of countries receiving Chinese seaport investments is $6103, compared to $3090, $849, $1754, and $1943for the U.S., Japan, World Bank, and IFC, respectively.

We examine correlations of seaport investment values with country characteristics (averaged between 1995-2000). This is simply intended to understand the pattern of investment decisions across countries. We loosely group these characteristics into four categories: economic (GDP, area, population), value of natural resources (metals and minerals, natural gas, oil, coal), trade (number of seaports, import plus export shares with China, Japan, and U.S.), and geopolitics (corruption index, ideal point with higher values indicator closer alignment to the U.S.-led international world order). We standardize all variables, and if missing, impute a zero and include a missing value indicator. We regress the (inverse hyperbolic sine) value of seaport investments for China, Japan (JICA), World Bank, and IFC, against the correlates. The total number of observation for each regression is the number of countries, 217.

Figure 5 reveals some interesting patterns. The coefficients on first two variables–GDP and population–are consistent with China directing investments towards richer countries compared to other sources, holding all else equal. Only the IFC appears sensitive to the sovereign rating of the country, which makes sense given that its investments are typically syndicated with the private sector. The resource variables are the values of various natural stocks in constant dollars. There is a very strong correlation with metal and minerals with China's and IFC's investments. China's investments also target countries with high natural gas stocks, but not oil (whereas IFC appears to target slightly more oil-rich countries). China does not target countries with coal, consistent with it holding amongst the largest coal reserves in the world. Regarding trade variables, China's investments are directed more towards countries that are its relatively more important

Figure 5: Country-Level Correlates of Seaport Investments, 2000-2025

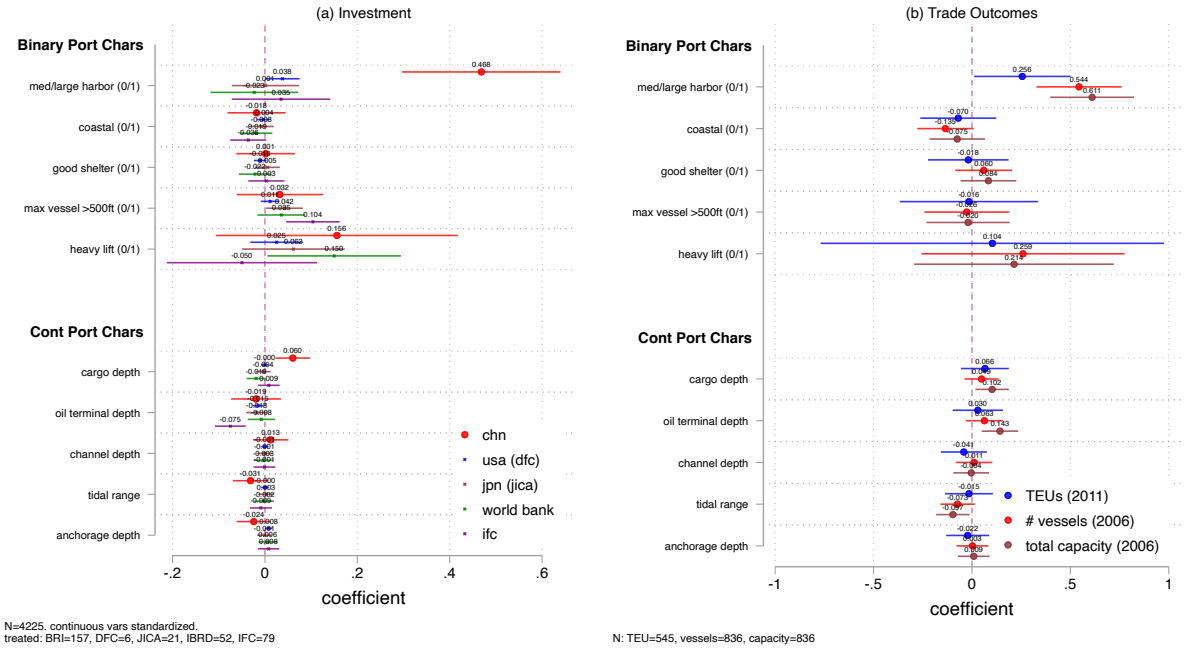


Notes: Figure plots regression coefficients of (inverse hyberbolic sine) seaport investment value on standardized country characteristics. If a characteristic is missing, it is set to zero with a missing value indicator switched on. 10%/90% error bars.

trade partners (pre-2000); it also directs investments towards countries that are relatively more important trade partners with Japan. The other agencies investments do not correlate with the host partner's trade is with these three countries. Interestingly, all four investing sources invest less in more corruption countries, with the IFC particularly sensitive to this metric. The final variable, countries' ideal point, reflects alignment to the U.S.-led international world order (a higher number indicates closer alignment with the U.S.). China and the IFC's investments are not correlated, either positively or negatively, with the measure, but the U.S., Japan's and the World Bank's investments positively covary.

We can also examine investment correlates at the locode-level by projecting investment decisions on characteristics of the seaports. The World Port Index contains several port attributes in 2000: the size of the harbor (=1 if large or very large), the harbor type (=1 if natural or breakwater coastal), shelter afforded (shelter afforded from wind, sea and swell; =1 if excellent or good), maximum vessel length (=1 if larger than 500 feet), lifting power available for cranes (=1 if more than 100 tons), cargo pier depth (the largest depth across piers), oil terminal depth (greatest depth

Figure 6: Port-Level Correlates of Seaport Investments, 2000-2025



Notes: Figure plots regression coefficients of investment location indicators on standardized port characteristics from the 2000 World Port Index. The right panel regresses standardizese port-level exports of TEUs (in 2011 from the CTS data) and port-level number of vessels and total capacity of vessels (in 2006 from the MDST data) on the same characteristics. If a characteristic is missing, it is set to zero with a missing value indicator switched on. 10%/90% error bars.

of the terminals for loading/unloading oil and refined petroleum), channel depth (controlling depth of the deepest channel), anchorage depth (the depth of the anchorage location), and the tidal range (vertical difference between high and low tide). Future versions of this project will add information on berths and cranes from earlier versions of Lloyd's Ports of the World data.

We regress indicators of investment locations, separately by source, on the port characteristics. We standardize the continuous variables (and set to zero if missing and include a missing-value indicator). The left panel of Figure 6 reports the coefficients. China appears to direct their investments towards seaports with large harbors and with deeper cargo piers. The other covariates do not statistically predict the location of China's investments. They also have no explanatory power for other agencies' port investments.

We can use the port-level container and vessels datasets to translate these port characteristics into potential volumes of trade. As noted above, we observe total TEU exports in 2011 for 564 seaports, and total vessels and capacity in 2006 for 1,156 seaports. We standardize these three trade outcomes and project them on the same characteristics; the results are in the right panel. We see that the same two characteristics–harbor size and cargo depth–are strongly correlated with

trade volumes. This suggests that China's selects ports that have the potential to handle large volumes of trade, whereas the location of the other 4 agencies does not suggest this potential.

4 Optimal Foreign Infrastructure Investments: Baseline Theory

4.1 Setup

Consumers and Producers We set up a simple model to study theoretically a country's incentives to invest in international transport infrastructure (this model is nested in the quantitative framework). We consider an economy with two countries, an importer (country M) and an exporter (country X). The exporter produces a differentiated commodity but does not consume it, and the importer consumes it but does not produce it. Both countries are endowed with, and consume, an outside good that is freely traded. Both countries may set trade taxes, a per unit import tax t_M in the importer and an export tax t_X in the exporter. Agents are competitive.

While the countries are indexed by M and X depending on who exports the differentiated good, as we show the key distinction for our results is what country owns the rents generated by transport hubs (Π_T defined below). We call the country owning the profits the "host" and the other country the potential "foreign investor".

Consumers in the importing country M have quasilinear preferences $U(Q) + C_M^O$, where $U(Q)$ is a concave utility function over the quantity imported of the differentiated good, and C_M^O is consumption of the outside good. Therefore, indirect utility in the importer is:

$$V_M = \max_Q U(Q) - p_M Q + \overline{O}_M + \mathcal{T}_M, \tag{1}$$

where p_M is the import price for Q, $\overline{O}_M$ is the endowment of the outside good, and $\mathcal{T}_M$ are additional sources of consumer income (government transfers and returns to the transport sector) defined below. Producers in the exporting country X have a convex cost function $\Psi(Q)$ in units of the outside good. As consumers in X only buy the numeraire good, their indirect utility equals their net income:

$$V_X = \max_Q p_X Q - \Psi(Q) + \overline{O}_X + \mathcal{T}_X, \tag{2}$$

where p_X is the producer price for Q, $\overline{O}_X$ is the endowment of the outside good, and $\mathcal{T}_X$ are the additional sources of income. Standard consumer and firm optimization gives the first order conditions:

$$p_M = G'(Q), \tag{3}$$

$$p_X = \Psi'(Q). \tag{4}$$

Shipping and Ports Competitive shipping companies buy the good from exporters in X, pay the (endogenous) user fees τ per unit shipped to operators transport infrastructure (ports), spend

their own (exogenous) shipping expenses $\overline{\tau}$, and sell to importers in M. Free entry into shipping give the no-arbitrage condition:[3]

$$p_M \leq p_X + \tau + \overline{\tau} + t, \quad = \text{ if } Q > 0, \tag{5}$$

where

$$t \equiv t_M + t_X \tag{6}$$

is the sum of of import and export taxes.

Shipping companies use services provided by transportation hubs such as ports, airports, or railway companies ("ports" in short). We assume there is a single port (the quantitative framework includes multiple ports). The port uses transport infrastructure I (physical infrastructure such as cranes or services such as dredging) and have a total cost $T(Q, I)$ (in units of the outside good) to process output Q. For example, it costs an $T(Q, I)$ dollars to process Q containers when the port has installed I cranes. Ports charge a fee τ per unit of Q and pay a user cost r per unit of I to maximize profits:

$$\Pi_T = \max_{Q,I} \tau Q - T(Q, I) - rI. \tag{7}$$

The first order conditions give the inverse supply of port services and inverse demand of infrastructure:

$$\tau = T_Q(Q, I), \tag{8}$$

$$r = -T_I(Q, I). \tag{9}$$

Throughout this section we make neoclassical assumptions on port technologies: T is increasing and convex in Q (increasing marginal cost due to port congestion) and decreasing and convex in I (decreasing returns to transport infrastructure). In addition, $T_{QI} < 0$ (infrastructure reduces the marginal cost of processing trade). We also impose $T(Q, I)$ is convex ($T_{QQ}T_{II} > T_{QI}^2$), ensuring an interior solution.

Infrastructure Supply Both national governments and private agents can invest to develop international transport infrastructure. Each country $j \in \{M, X\}$ can transform κ_j units of outside goods into one unit of infrastructure. A government of country j that chooses to invest $I_{G,j}$ charges a lump-sum tax $\kappa_j I_{G,j}$ to its residents to finance infrastructure and is paid a return $rI_{G,j}$ that is transferred back to its citizens. In turn, atomistic private firms in country j can use the same technology as the government to develop private infrastructure $I_{P,j}$. Private developers may also receive subsidy s_j from their government (a tax if negative). Hence for the private infrastructure developers in country j, profit maximization is

$$\Pi_{P,j} = I_{P,j}(r + s_j - \kappa_j) \leq 0 \tag{10}$$

[3]It does not matter who pays the taxes. We can equivalently assume t_M is paid by consumers in M and t_X by producers in X.

with equality if $I_{P,j} > 0$. Hence, letting $I_j = I_{G,j} + I_{P,j}$ be the total infrastructure developed by country j, the global supply of infrastructure to the transport hub is

$$I = I_X + I_M, \tag{11}$$

We interpret these investment as the actual shipment of resources or as financial transfers used to build infrastructure. Under the former interpretation, κ_j denotes country- and private-sector specific know-how to develop infrastructure. Under the latter, it captures the efficiency of financial markets.

We can now define the transfers $\mathcal{T}_j$ entering in (1) and (2). The net transfers to final consumers in country $j = M, X$ are:

$$\mathcal{T}_j = \underbrace{1_{(j \text{ is host})}\Pi_T}_{\text{Transport Profits}} + \underbrace{(r - \kappa_j) I_j}_{\text{Returns to infrastructure}} + \underbrace{t_j Q}_{\text{Trade tax}} \quad \text{for } j = X, M. \tag{12}$$

To define the transfers, an important distinction is which country owns the port profits, Π_T. The profits are owned by residents of the "host country". Being host does not necessarily indicate where the port is physically located.

Equilibrium Given Government Policies Given public transport infrastructure $\{I_{G,j}\}$, subsidies $\{s_j\}$, and trade policies $t \equiv t_X + t_M$, a market equilibrium consists of a quantity traded Q^*, a return to infrastructure r^*, a port fee τ^*, prices $\left\{p_j^*\right\}$, and private investments $\left\{I_{P,j}^*\right\}$ such that agents optimize according to (3), (4), (5), (8), (9), and (10). Combining these conditions we obtain Q^* given infrastructure and trade policies,

$$\underbrace{U'(Q^*)}_{=p_M^*} = \underbrace{\Psi'(Q^*)}_{=p_X^*} + \underbrace{T_Q(Q^*, I^*)}_{=\tau^*} + t + \overline{\tau}, \tag{13}$$

where $I^* = \sum_{j=M,X} I_{G,j} + I_{P,j}^*$ is determined by the free entry condition of private investors:

$$\underbrace{-T_I(Q^*, I^*)}_{=r^*} + s_j \leq \kappa_j \text{ for } j = X, M, \tag{14}$$

with equality if $I_{P,j}^* > 0$. (13) is a standard no-arbitrage condition: when there is trade in final goods, the price at the importer's port equals the price at the exporter's port plus marginal shipping costs and trade taxes. (14) is the free entry condition of private investors. Private investors in j are crowded out if public investments are so large that the subsidies s_j and returns r^* resulting from (13) are below the marginal cost κ_j.

4.2 Impacts of Infrastructure on Prices and Welfare

We first establish the scope for manipulation of global infrastructure. Each country j takes as given foreign public investment $I_{G,k}$ and subsidies s_k of the trade partner and chooses its own policies. Around an equilibrium, marginally shifting public investments only changes the global stock I^* if private investors are absent; otherwise, public capital crowds out private investments 1-1 without changing equilibrium outcomes. However a country can always subsidize its private investors, or undertake discrete rather than marginal investments, and raise the global stock.[4] Because a country cannot destroy the infrastructure of the foreign country or restrict entry of foreign private firms, there is a lower bound to the global infrastructure a country can choose. We formally state this result, and relegate its proof as well as all remaining proofs to the appendix.

Lemma 1. *Using public investment $I_{G,j}$ or subsidies s_j, country j can implement any level of infrastructure $I^* > \min\left\{I_{G,k}, \underline{I_{P,k}}\right\}$, where $\underline{I_{P,k}}$ is the level consistent with entry of private developers in country $k \neq j$.*

Consider next what happens when country j shifts the global infrastructure stock I^* one-to-one by changing its own (public and private) investment I_j via public investments or subsidies. Part (i) considers impacts on market outcomes, determined by (13). Parts (ii) and (iii) show effects on country-level welfare (V_M and V_X in (1) and (2)).

Proposition 1. *(Effects of infrastructure investments on prices and welfare). Suppose that, around an initial equilibrium, country j implements (via subsidies and public investment) an increase in equilibrium infrastructure $dI^* = dI_j$. Then,*

(i) trade grows ($\frac{dQ^*}{dI^*} > 0$), import prices fall ($\frac{dp_M^*}{dI^*} < 0$), export prices increase ($\frac{dp_X^*}{dI^*} > 0$), port fees fall ($\frac{d\tau^*}{dI^*} < 0$), and returns to infrastructure fall ($\frac{dr^*}{dI^*} < 0$);

(ii) letting h be the host country and f be the foreign investor, then

$$\frac{dV_h}{dI_h} = -\left|\frac{dp_f^*}{dI^*}\right| Q^* - I_f^* \frac{dr^*}{dI^*} + (r^* - \kappa_h) + t_h dQ^*, \tag{15}$$

and

$$\frac{dV_f}{dI_f} = \left|\frac{dp_f^*}{dI^*}\right| Q^* + I_f^* \frac{dr^*}{dI^*} + (r^* - \kappa_f) + t_f dQ^*; \text{ and} \tag{16}$$

(iii) if countries set trade taxes optimally, then

$$\frac{dV_h}{dI_h} = Q^* \frac{\partial \tau^*}{\partial I^*} - I_f \frac{\partial r^*}{\partial I^*} + (r - \kappa_h) \tag{17}$$

[4] Around an equilibrium with private investors from from their own country (such that $r_j + s_j = \kappa_j$) country j can either use subsidies s_j to grow the capital stock or grow public investments $I_{G,j}$ to the point that the private sector is crowded out. Similarly, around an equilibrium with private investors from the foreign country, a country can crowd out foreign investors by using subsidies or public investment, and from that point increase the capital stock further.

and

$$\frac{dV_f}{dI_f} = I_f \frac{\partial r^*}{\partial I^*} + (r - \kappa_f)\,. \tag{18}$$

Consider first the market outcomes in part (i). On impact, at an initial level of trade Q^*, congestion port fees τ^* fall ($T_{QI} < 0$). As a result, the price gap between importer and export shrinks; trade Q^* grows, p_M falls, and p_X grows. As trade increases congestion raises ($T_{QQ} > 0$) but not enough to offset the direct effect of infrastructure. The effect on returns r^* is more subtle. On impact, assuming decreasing returns to infrastructure ($T_{II} < 0$), the direct effect is to lower the returns r^*. However, because infrastructure reduces congestion ($T_{QI} < 0$), as the quantity traded the marginal returns to infrastructure grow (and therefore r^*) grow. This indirect effect resulting in higher r^* is dominated by the direct effect that lowers r^* if T is globally convex (a condition bounding the absolute value of T_{IQ}); we discuss below what would happen in the case when T is not globally convex.

Part (ii) shows the welfare impact from investment in each country. The relevant distinction for welfare impacts which country is host (owning the port profits Π_T) and which country is the potential foreign investor, rather than which country imports or exports.[5] The welfare impacts combine terms-of-trade effects on Q and I. The foreign investor gains from terms-of-trade on Q: the import price falls if the host is the importer, and it increases if the hots is the exporter. In contrast, the host country is worse of from terms-of-trade of Q. The reason is that the host country gains from changing the price at its port ($|dp_h^*/dI^*| > 0$) but also loses from sales of lower shipping services ($d\tau^*/dI^* < 0$), with a necessarily negative combined effect. [6] In turn, the foreign investors lose from investing as the returns to the infrastructure it exports fall ($dr^*/dI^* < 0$), while the host country gains from investing as the cost of the infrastructure it imports falls. In addition to these terms-of-trade effects, each country earns the return $r^* - \kappa$ on the investment and potentially a change in tariff revenue stemming due to changes in trade flows.

A natural question is whether these effects survive when countries manipulate the terms of trade with trade policies. Part (iii) shows that, in that case case, infrastructure still impacts prices directly by changing the transport technology $T(Q, I)$.[7] The host country loses from terms-of-trade on Q, now solely through lower shipping costs ($\partial\tau^*/\partial I^* < 0$). As before, through r^*, the host gains from investing and the foreign investor loses.

A key takeaway from Proposition 1 is that, by investing in infrastructure, host countries of trade hubs lose from lower from terms-of-trade on goods but gain from terms-of-trade of the infrastructure capital, while foreign investors gain from better terms-of-trade on goods and lose from terms-of-trade on infrastructure. We move on to characterize equilibrium investments with this result in mind.

[5] Note in the proposition we may have $h = X$ or $h = M$ depending on which of the two countries owns the transport profits. We let f be the other country.

[6] I.e., $|dp_h^*/dI^*| + d\tau^*/dI^* = -\left|dp_f^*/dI^*\right|$. More precisely, if the host country is the exporter, the first term in (15) is $\frac{dp_X^* + d\tau^*}{dI^*} = \frac{dp_M^*}{dI^*} < 0$. If it is the importer, it is $\frac{-dp_M^* + d\tau^*}{dI^*} = -\frac{dp_X^*}{dI^*} < 0$.

[7] I.e. no part (ii), $\frac{dr^*}{dI} = \frac{\partial r^*}{\partial I} dI + \frac{\partial r^*}{\partial Q} dQ$ and $\frac{d\tau^*}{dI} = \frac{\partial \tau^*}{\partial I} dI + \frac{\partial \tau^*}{\partial Q} dQ$ where $\tau^*$and r^* come from (8) and (9). In part (iii), only partial derivatives with respect to infrastructure enter in the welfare impacts.

4.3 Equilibrium Infrastructure Investments

first insight is that, absent foreign investment in infrastructure, host country under-invest compared to its private sector. This result follows from (15) and (17). Assuming an initial equilibrium without foreign investment, $I_f = 0$, then:

$$\frac{dV_h}{dI_h} = \begin{cases} -\left|\frac{dp_f^*}{dI^*}\right| Q^* + (r^* - \kappa_h) & \text{if } t_f = 0, \\ \frac{\partial \tau^*}{\partial I^*} Q^* + (r^* - \kappa_h) & \text{if } t_f = t_f^*. \end{cases} \tag{19}$$

Because more infrastructure worsens its terms of trade on goods, the host country distorts the market allocation to build smaller ports than would otherwise be constructed with free and undistorted entry of private investors. To see why, let r^{*a} be the equilibrium return to infrastructure consistent with host-country optimization under no international investment. Setting $dV_h/dI_h = 0$ in (19) we obtain $r^{*a} > \kappa_h$, while private investors would choose an investment such that $r^* = \kappa_h$. From Proposition (1), r^* falls with infrastructure. Therefore, the host country taxes the private sector.

A second insight is that, around the infrastructure chosen by the host country in the absence of foreign investment, the foreign country will invest unless in cases where it is too inefficient compared to the host country. This result follows from (15) and (17). Assuming an initial equilibrium without foreign investment, $I_f = 0$, and with a return to infrastructure r^{*a} consistent with the host-country investments,

$$\frac{dV_f}{dI_f} = \begin{cases} \left|\frac{dp_f^*}{dI^*}\right| Q^* + (r^{*a} - \kappa_f) & \text{if } t_h = 0, \\ r^{*a} - \kappa_f & \text{if } t_h = t_h^*. \end{cases} \tag{20}$$

For the foreign country, investing around this point is profitable as long as its marginal cost $\kappa_f \leq \overline{\kappa}$, for some $\overline{\kappa} > \kappa_h$. Therefore, the investment is profitable if the foreign country has same or better technologies as the host, and even if it its technologies are slightly worse. This follows from the fact that $r^{*a} > \kappa_h$. In addition, under free trade, it gains from terms of trade manipulation.[8] Because r^* falls with infrastructure, this means the foreign country over-invests with respect to what its private sector would choose if left undistorted.

These results can be contrasted with the use of taxes. Absent foreign investments, a host country manipulates infrastructure investments downwards to shrink trade, similarly to how it would use trade taxes.[9] An economy that can manipulate terms-of-trade with tariffs will do so because, around free-trade, there are no distortions from tariffs and such manipulation can be done for free; in the case of infrastructure, around no foreign investment expanding infrastructure is free because its marginal cost and economic returns coincide, $r^* = \kappa$. In contrast, the foreign

[8] In addition, the foreign country in fact gains from investing for any fixed positive trade tax $t_h \geq 0$; as trade increases with the investment, there is a positive fiscal externality through tariff revenue.

[9] In a model with 2 countries, such as this, this effect is particularly strong because there are no substitute ports countries can use. In the quantitative model this effect is weaker because traders can re-route trade through other hubs.

country manipulates equilibrium infrastructure to facilitate trade, much as if it was subsidizing its foreign producers of exports or consumers of imports. Despite improving terms-of-trade, such transfers to foreign agents would never be optimal in a neoclassical model. However, around a point of no foreign investment, promoting infrastructure is either free or profit-generating due to potential under-provision abroad.[10] As a result, both host and foreign have incentives to distort the equilibrium around no foreign investment, and either tax private investors (in the case of the host) or subsidize them (in the case of the foreign investor).[11]

From the preceding discussion, it follows that in a Nash equilibrium the foreign country must invest. Hence in equilibrium, in a case of free trade we have from 15:

$$r^* = \kappa - \left(\left| \frac{dp_f^*}{dI^*} \right| Q^* + I_f^* \frac{dr^*}{dI^*} \right). \tag{21}$$

This result has several implications. First, the host country may be fully crowded out.This is an equilibrium if and only if, around that point, $\frac{dV_f}{dI_f} < 0$ or, from 16,

$$- \left| \frac{dp_f^*}{dI^*} \right| Q^* < I^* \frac{dr^*}{dI^*}. \tag{22}$$

where (I^*, Q^*) solve 13-21. When foreign-country prices are very responsive or the returns to infrastructure are not, the foreign country has stronger incentives to crowd out the host. Second, if 22 fails, then the equilibrium must have both countries investing. In that case, 15 and 16 readily imply that $r^* = \kappa$. Because $r^* = \kappa$ is what a global planner maximizing global welfare would choose, we conclude the equilibrium is efficient in this case but there is over-investment ($r^* < \kappa$) with crowding out. Third, we can inspect the infrastructure externalities around the equilibrium. In the crowding-out case, 22 implies $\frac{dV_h}{dI_f} < 0$: the host country would like to restrict foreign entry. However, without crowding out, $\frac{dV_h}{dI_f} = 0$. Fourth, with optimal tariffs, full crowding out remains a possibility. Regardless of crowding out, the equilibrium features under-investment with respect to a global planner because the terms-of-trade incentives are no longer present for the foreign investor. As with free trade, the host country would benefit from further restricting foreign investment around the equilibrium.

Proposition 2. *(Foreign Bias of Infrastructure Investment) Assume both countries have the same costs to develop infrastructure ($\kappa_M = \kappa_X = \kappa$) and are either in free trade ($t_M = t_X = 0$) or are in a trade war with optimal trade taxes. Then,*

(i) In the absence of international investment in infrastructure, the host country chooses a

[10] Starting around no investment, $r^{*a} > \kappa_f$; as long as $\kappa_h < r^{*a}$, investors from the home country would enter until $r^* = \kappa$.

[11] This discussion highlights the key role of modeling economic returns r to infrastructure investments. A model where each country can directly invest in lowering the trade costs τ without earning any economic return, such as Fajgelbaum and Schaal (2020) or Allen and Arkolakis (2022), would have different properties. In the data, most of the Chinese BRI investments have a direct economic return in the form of loan repayments. In some cases China has offered concessional grants with little economic return. We will incorporate information on the rates of returns of Chinese loans in our quantification.

level of infrastructure below the market by taxing private developers. Around that point, the foreign country gains from investing and its government implements investments above what private investors would choose. Foreign entry lowers welfare of the host country.

(ii) In a Nash equilibrium where both countries choose infrastructure (and possibly also tariffs) optimally and simultaneously, there must be foreign investment and the host country may invest or be fully crowded out.

(iii) Strategic competition leads to worldwide efficient investments under free trade only if both countries invest in equilibrium. Otherwise, it leads either to over-investment (under free trade and crowding out of the host country) or to under-investment (under optimal trade policies). In these inefficient equilibria cases, the host countries would be better off by restricting foreign investment around the equilibrium.

4.4 Geopolitical Preferences

One of the objectives of our quantitative analysis is to disentangle pure economic motivations in China's investments versus politically motivated investments. With that in mind, we can expand the objective function of countries to allow for a term that captures preferences over the welfare of a trade partner. In the spirit of a recent research at the intersection of trade and geopolitics such as Adão et al. (2026), Becko (2024), Clayton et al. (2026) and Mattoo et al. (2024), the objective function of the foreign country is now

$$W_j = V_j + \beta_{jj'} V_{j'}, \tag{23}$$

where V_j are defined in (1) and (2) and the $\beta_{jj'}$ are "political" preferences over the real income of a trade partner. Assuming zero tariffs and using (15) and (16), we obtain

$$\frac{dW_h}{dI_h} = -\left(1-\beta_{hf}\right)\left(\left|\frac{dp_f^*}{dI^*}\right| Q^* + I_f \frac{dr^*}{dI^*}\right) + \left(r^* - \kappa_h\right), \tag{24}$$

and

$$\frac{dW_f}{dI_f} = \left(1-\beta_{fh}\right)\left(\left|\frac{dp_f^*}{dI^*}\right| Q^* + I_f \frac{dr^*}{dI^*}\right) + \left(r^* - \kappa_f\right). \tag{25}$$

Because the terms-of-trade impacts are zero-sum, a negative weight over a trade partner magnifies the incentives to manipulate terms of trade and a positive weight tempers it (as long as it is less than 1). This property is in keeping with the findings in the previously cited literature. Our quantification relies on an extended version of these equations in a multi-country setting to back out the weights $\beta_{jj'}$. In a spirit closest to Adão et al. (2026) for the case of trade policy, we identify the weights $\beta_{jj'}$ around an observed equilibrium such that the first-order conditions of investing countries are satisfied.

5 Quantitative Framework

We develop a multi-country Armington trade model embedded in a multimodal transport network with endogenous transport costs and strategic infrastructure investment. This framework generalizes and nests the simple model presented earlier. The key two differences with the baseline model from Section 4 are as follows. First, now there are J countries (instead of 2), each producing its own differentiated good, and every country demands the output from every country. Production functions use domestic labor and the outside good and therefore have curvature (allowing output to expand and contract with trade) and now have country-specific shifters (a country's TFP shifter). On the demand side, each country has a different vector of demand shocks over imports from each origin. Second, now trade happens over a multi-modal transport network. Each countries consists of a set of nodes (representing seaports, airports, land crossings, and rail junctions). Each node s now operates a transport technology $T_s(Q_s, I_s)$ operating with decreasing returns as in the baseline model. However, now each trade flow congests the origin and destination nodes (instead of crossing through only one gate as in the baseline model). Moreover, the throughput Q_s adding congestion to the transportation node now adds up all the volume shipped through that node, including shipments en route to third countries. The network also includes trans-shipment costs when shipments move between different modes within a country, while international connections are within-mode.

5.1 Setup

Countries and Preferences The world economy consists of a set of countries $\mathcal{J} = \{1, .., J\}$, with China indexed by $j = CH$. There are $J + 1$ goods: J differentiated varieties—each country produces a unique variety j—and a homogeneous outside good. Each country is endowed with an exogenous population L_j and has indirect utility

$$V_j = U_j(C_j) + C_j^O, \tag{26}$$

where C_j^O denotes consumption of the outside good, and C_j is a CES aggregate of the differentiated varieties:

$$C_j = \left(\sum_{n=1}^{J} d_{nj}^{\frac{1}{\sigma}} (C_{nj})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \text{ with } \sigma > 0, \tag{27}$$

with d_{nj} denoting an origin-destination-specific preference shifter. Country j faces the budget constraint

$$C_j^O + \sum_{n=1}^{J} \left(p_{nj} + t_{nj}^M + t_{nj}^X \right) C_{nj} \leq \Pi_j^Y + \Pi_j^T + \Pi_j^I + \overline{O}_j + \mathcal{T}_j^{TR}, \tag{28}$$

where p_{nj} is the pre-tax price of good n upon arrival in country j, inclusive of transport costs. The terms t_{nj}^M and t_{nj}^X denote, respectively, the import tax set by importer j on exporter n and the export tax set by the exporter n on the importer j. On the income side, Π_j^Y represents profits from

production, Π_j^T are profits from the transport sector, and Π_j^I are profits from domestic and foreign infrastructure investments. The term $\overline{O}_j$ denotes country j's endowment of the outside good, and $\mathcal{T}_j$ captures rebated tariff revenue:[12]

$$\mathcal{T}_j^{TR} = \sum_n t_{nj}^M C_{nj} + \sum_n t_{jn}^X C_{jn}.$$

Production Country j produces its differentiated good using a Cobb-Douglas technology that combines labor L_j and the outside good O_j:

$$Y_j = A_j O_j^{\alpha_j} L_j^{1-\alpha_j}, \tag{29}$$

where A_j is total factor productivity and α_j a country-specific factor intensity. Firms sell their product at the local price p_{jj} and maximize profits, yielding in equilibrium

$$Y_j = (\alpha_j p_{jj})^{\frac{\alpha_j}{1-\alpha_j}} A_j^{\frac{1}{1-\alpha_j}} L_j \text{ and } \Pi_j^Y = (1-\alpha_j)\, p_{jj} Y_j. \tag{30}$$

Geography Each country j is represented by a set of nodes $\mathcal{S}(j)$, which includes a *central* node $s_0(j)$, where production and consumption take place, as well as transport nodes (e.g., seaports or rail hubs). The global set of nodes $\mathcal{S} = \cup_{j \in \mathcal{J}} \mathcal{S}_j$ is arranged on an undirected graph $(\mathcal{S}, \mathcal{E})$ where the $\mathcal{E} \subset \mathcal{S}^2$ describe feasible transport links. We denote $\mathcal{N}(s)$ the set of neighbors of node s.

Transport technology Goods are shipped across the transport network. Let $Q_{nss'}$ the quantity of good n transported over the link $(s, s') \in \mathcal{E}$ and define total flow through the node s as $Q_{ns} = \sum_{s'} (Q_{nss'} + Q_{ns's})$. We denote by p_{ns} the pre-tax price of good n at node s upon leaving the node. Abusing notation slightly, p_{nj} denotes the price of good n at the central node of country j, i.e., $p_{nj} \equiv p_{ns_0(j)}$.

As in the simple model, shipping is carried out by competitive firms. On link (s, s'), shipping companies purchase good n at node s at price p_{ns}, incur port fees τ_{ns} and $\tau_{ns'}$ at origin and destination, and pay an exogenous transport cost $\overline{\tau}_{nss'}$. They then sell the good at node s' at price $p_{ns'}$. Free entry yields the no-arbitrage condition:

$$p_{ns'} \leq p_{ns} + \overline{\tau}_{nss'} + \tau_{ns} + \tau_{ns'}, \text{ with equality if } Q_{ss'}^n > 0. \tag{31}$$

Shipping goods requires the services provided by infrastructure operators ("ports") at a each node. Handling goods is costly, with cost function $T_s(Q_s, I_s)$, measured in units of the outside

[12] As shown in the baseline model, any desired level of infrastructure investment from a country can be implemented with a mix of private-sector subsidies and public investments by that country. Moreover, the welfare implications depend on the total investment resulting from a given policy mix regardless of how they are implemented. Therefore, the quantitative model omits explicitly modeling the private sector. At any equilibrium of the model, a given mix of private and public investments can be implemented by allowing for private investors and properly choosing a subsidy to that sector

good, where

$$Q_s = \sum_{n=1}^{J} \omega_n Q_s^n. \tag{32}$$

is the total volume of goods transiting through node s and I_s is the quantity of infrastructure. As in the simple model, T_s is increasing and convex in Q_s (congestion), but decreasing and convex in I_s (i.e., infrastructure reduces costs with diminishing returns). Infrastructure I_s is rented at user cost r_s from either domestic or foreign suppliers. Ports operate in competitive markets and charge a per-unit fee τ_s^n to handle good n. Port operators solve the problem:

$$\Pi_s^T = \max_{Q_{ns}, I_s} \sum_n \tau_{ns} Q_{ns} - T_s\left(Q_s, I_s\right) - r_s I_s. \tag{33}$$

We assume that port operators are owned by the host country, so that total transport profits are $\Pi_j^T = \sum_{s \in \mathcal{S}(j)} \Pi_s^T$.

Infrastructure Country j can supply infrastructure I_s^j at node s at per unit cost κ_{js}, measured in terms of the outside good. The total supply of infrastructure at node s is

$$I_s = \sum_{j \in \mathcal{J}} I_s^j. \tag{34}$$

Total profits from infrastructure investment is

$$\Pi_j^I = \underbrace{\sum_{s \in \mathcal{S}(j)} \left(r_s - \kappa_{js}\right) I_s^j}_{\text{domestic investments}} + \underbrace{\sum_{s \in \mathcal{S} \setminus \mathcal{S}(j)} \left(r_s - \kappa_{js}\right) I_s^j}_{\text{foreign investments}} \tag{35}$$

Resource constraint For each good $n \in \mathcal{J}$, feasibility requires that for each country j and each node $s \in \mathcal{S}\left(j\right)$:

$$1_{s=s_0(j)} C_{nj} + \sum_{s' \in \mathcal{N}(s)} Q_{nss'} \leq 1_{s=s_0(j)} 1_{n=j} Y_n + \sum_{s' \in \mathcal{N}(s)} Q_{ns's}. \tag{36}$$

Condition (36) states that, at each node, total outflows (consumption and shipments) cannot exceed total inflows (production and incoming shipments). Consumption C_{nj} occurs only at the central node $s_0\left(j\right)$, while production Y_n occurs only at the central node of the producing country.

5.2 Equilibrium

We define an equilibrium given a set of infrastructure investments $\left\{I_s^j\right\}_{j \in \mathcal{J}, s \in \mathcal{S}}$ and tariffs $\left\{t_{nj}^M, t_{nj}^X\right\}$:

Definition. An equilibrium given infrastructure $\left\{I_s^j\right\}_{j \in \mathcal{J}, s \in \mathcal{S}}$ and tariffs $\left\{t_{nj}^M, t_{nj}^X\right\}$ is a set of prices $\{p_{ns}\}_{j \in \mathcal{J}, s \in \mathcal{S}}$, consumption $\{C_{nj}\}_{(n,j) \in \mathcal{J}^{\in}}$, output $\{Y_n\}_{j \in \mathcal{J}, s \in \mathcal{S}}$ and trade flows $\{Q_{nss'}\}_{j \in \mathcal{J}, (s,s') \in \mathcal{E}}$

such that:

1. In every country $j \in \mathcal{J}$, households maximize utility

$$U_j'(C_j) = P_j^C \tag{37}$$

$$C_{nj} = d_{nj}\left(\frac{p_{nj}^C}{P_j^C}\right)^{-\sigma} C_j \tag{38}$$

where $P_j^C = \left(\sum_{n=1}^J d_{nj}\left(p_{nj}^C\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$, $p_{nj}^C = p_{nj} + t_{nj}^M + t_{nj}^X$ and $p_{nj} = p_{ns_0(j)}$;

2. In every country $j \in \mathcal{J}$, firms maximize profits:

$$Y_j = (\alpha_j p_{jj})^{\frac{\alpha_j}{1-\alpha_j}} A_j^{\frac{1}{1-\alpha_j}} L_j \text{ and } \Pi_j^Y = (1-\alpha_j)\, p_{jj} Y_j. \tag{39}$$

3. In every node $s \in \mathcal{S}$, infrastructure operators maximize profits:

$$\tau_{ns} = \omega_n \frac{\partial T_s(Q_s, I_s)}{\partial Q_s}, \tag{40}$$

$$r_s = -\frac{\partial T_s(Q_s, I_s)}{\partial I_s}, \tag{41}$$

where $Q_s = \sum_n \omega_n Q_{ns}$ and $Q_{ns} = \sum_{s' \in \mathcal{N}(s)} (Q_{nss'} + Q_{ns's})$;

4. For every link $(s, s') \in \mathcal{E}$ and every good $n \in \mathcal{J}$, prices satisfy no-arbitrage:

$$p_{ns'} \geq p_{ns} + \tau_{ns} + \tau_{ns'} + \overline{\tau}_{nss'}, \text{ with } = \text{ if } Q_{nss'} > 0. \tag{42}$$

5. For every good $n \in \mathcal{J}$, country $j \in \mathcal{J}$ and node $s \in \mathcal{S}(j)$, the resource constraint is satisfied:

$$1_{s=s_0(j)} C_{nj} + \sum_{s' \in \mathcal{N}(s)} Q_{nss'} \leq 1_{s=s_0(j)} 1_{n=j} Y_n + \sum_{s' \in \mathcal{N}(s)} Q_{ns's}. \tag{43}$$

6. At every node $s \in \mathcal{S}$, the infrastructure market clears:

$$I_s = \sum_{j \in \mathcal{J}} I_s^j. \tag{44}$$

5.3 Key Welfare Features versus Baseline Model

This quantitative framework nests the baseline model we have studied in Section 4. It also includes new elements that may play a key role for welfare impacts. Now infrastructure, investments happen in a network and China can invest in a portfolio of ports. Now, countries are affected because the prices of their consumption and output change, and also because how much traffic

changes through the ports they own. For example, a country whose exports are typically routed through a given foreign port will typically benefit, on impact, when more investment happens in that port: the lower fees along the route to a final destination will lower the import price and increase demand. Similarly, if a country's imports from some country travel through a port that received investments, the country will benefit from investments happening in that port.

We can summarize these forces by recomputing the welfare gradient of each country in this case. Given any vector of bilateral (country-node) investments in the world dI_s^j in the world, including both foreign and domestic investments, the generalized version of 15 and 16 is now:

$$dV_j = \underbrace{Y_j\left(dp_{jj} + \overline{d\tau_j}\right) - \sum_n C_{nj} dp_{nj}}_{\text{ToT on final goods}} + \underbrace{\sum_{s\in\mathcal{S}\setminus\mathcal{S}(j)} I_s^j dr_s - \sum_{s\in\mathcal{S}(j)} \left(I_s - I_s^j\right) dr_s}_{\text{ToT on } I} + \underbrace{d\mathcal{T}_j^{TR} + \left(r_s - \kappa_j\right) dI_s^j}_{\text{Fiscal Revenue}}$$
$$+ \underbrace{\sum_{s\in\mathcal{S}(j)} \sum_{n\neq j} Q_{ns} d\tau_{ns}}_{\text{Foreign Demand for Own Ports}} \quad , \tag{45}$$

where $\overline{d\tau_j} \equiv \sum_{s\in\mathcal{S}(j)} \left(Q_{js}/Y_j\right) d\tau_{js}$ is the average transport fee charged by country j when exporting its goods. All the terms in the first line of 45 extend terms that already appeared in 15 and 16. The term in second line is zero in the baseline model, and it shows that how countries also care about the extent to which their ports are used to ship goods other than their own output. Countries benefit from investments that redirect trade to their ports, increasing congestion in their ports and therefore the fees τ_{ns} that the country that owns the port in s can charge for goods coming from country n.

We highlight that dV_j is the welfare change of any country j when any set of investments (domestic or international) take place in the world. Hence, these effects are present for China, host countries of Chinese investments, and third countries not receiving any investments.

6 Quantitative Results (in progress)

6.1 Equilibrium Notion for the Quantification

In the quantification we will consider alternative assumptions regarding the determination of infrastructure and tariffs (e.g., best response around a given initial investment or Nash equilibrium), and we explicitly state the framework used in each quantitative exercise. The main exercise in the current version of the paper assumes that, before China invests, host countries have a level of infrastructure at which private investors would be indifferent with respect to entry ($r_j = \kappa_j$). This information is used by the quantification to read off the κ_j of each country, with the r_j implied by the estimated model after matching the trade and congestion parameters to observed trade data. China implements optimal investments starting from this level of infrastructure using the κ_j for each country. Using observed investment's by China and the model-implied welfare gradients, we then use

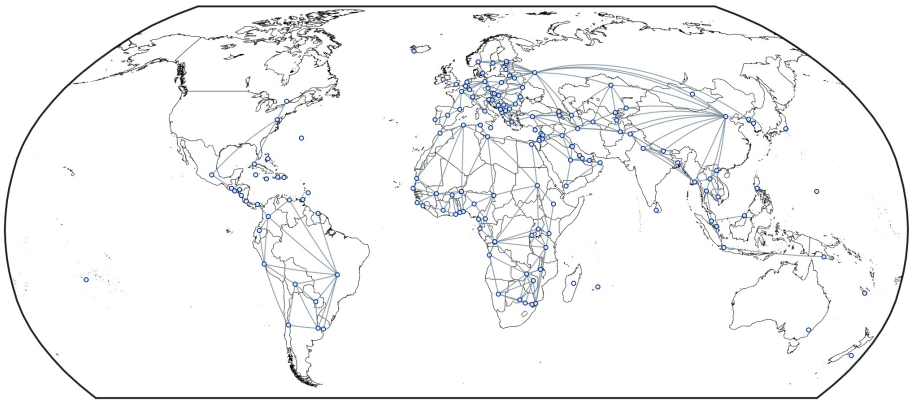
6.2 Parametrization

Our quantification focuses on land and maritime transport. To avoid large order-of-magnitude differences across countries, we restrict the sample to the 160 largest countries in the world. Each country $j \in \mathcal{J}$ is represented by a set $S(j)$ consisting of two nodes located at the country's capital: one land port and one seaport.

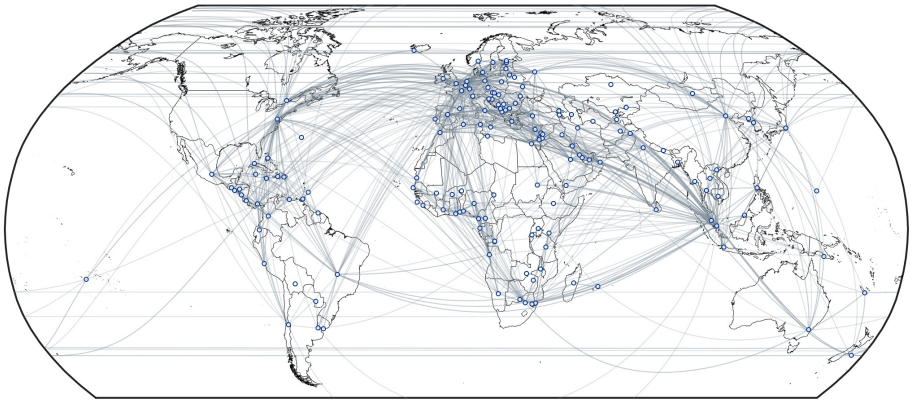
We construct the transport network as follows. Land nodes belonging to two countries are connected if the countries share a land border. Seaports are connected when direct container ship connections are observed in the data. This yields a land network with 560 edges (Figure 7a) and a maritime network with 1,297 edges (Figure 7b). Transshipment across transport modes is possible between the land and sea nodes within each country. We assume that the land port serves as the country's central node, where both national production and consumption occur. We denote by $m(s) \in \{land, sea\}$ the transport mode of node $s \in \mathcal{S}$.

Figure 7: Land and Sea Network

(a) Land (560 edges)



(b) Sea (1297 edges)



Transport costs for good n between two connected nodes s and s' consist of an exogenous

component and port fees at origin and destination:

$$\tau_{nss'} = \overline{\tau}_{nss'} + \tau_{ns} + \tau_{ns'}.$$

We parametrize the exogenous component as

$$\overline{\tau}_{nss'} = \begin{cases} \omega_n \exp\left(-\zeta_{m(s)} dist\left(s, s'\right)\right) & \text{if } m\left(s\right) = m\left(s'\right) \\ \omega_n TS & \text{if } m\left(s\right) \neq m\left(s'\right) \end{cases},$$

where ω_n is a good-specific shifter, $\zeta_{m(s)}$ is a transport mode-specific distance elasticity and $dist\left(s, s'\right)$ the distance in kilometers between the two nodes. TS is a general cost for transshipment.

Total transport costs at node s are given by $T_s\left(Q_s, I_s\right) = \overline{T}_{m(s)} Q_s^{1+\beta_{m(s)}} I_s^{-\gamma_{m(s)}}$, where $Q_s = \sum_n \omega_n \left(Q_{ss'}^n + Q_{s's}^n\right)$ is the total quantity of goods transiting through the port. Marginal port fees therefore equal

$$\tau_{ns} = \left(1 + \beta_{m(s)}\right) \omega_n \overline{T}_{m(s)} Q_s^{1+\beta_{m(s)}} I_s^{-\gamma_{m(s)}}.$$

The parameters $\overline{T}_{m(s)}$, $\beta_{m(s)}$ and $\gamma_{m(s)}$ denote, respectively, mode-specific cost shifters, congestion elasticities and infrastructure elasticities. The infrastructure index I_s proxies for the quantity of transport infrastructure in each country. We calibrate the economy before the start of the implementation of the BRI and assume that countries are in infrastructure autarky (i.e., $I_s^j = 0$ if $s \notin \mathcal{S}\left(j\right)$). To simplify notation, we denote by I_s^D the quantity of infrastructure pre-BRI installed by the domestic country. To construct I_s^D, we measure maritime infrastructure as the total number of sea ports and land infrastructure as the total kilometers of roads within a country.

To parametrize our model, we externally set a few parameters. Utility in country j, with population L_j, is given by $U_j\left(C_j\right) = L_j C_j^{1-\rho} / \left(1 - \rho\right)$. We set the curvature parameter to $\rho = 2$, consistent with standard values in the macroeconomic literature, implying an intertemporal elasticity of substitution (IES) of 0.5. In line with standard estimates in the trade literature, we set the CES elasticity of substitution in (27) to $\sigma = 5$. We model the demand-shifter d_{nj} as the product of an origin and destination fixed effects and a residual term:

$$d_{nj} = O_n D_j \varepsilon_{nj}.$$

Production in country n follows a Cobb-Douglas technology, $Y_n = A_n O_n^{\alpha} L_n^{1-\alpha}$. We set $\alpha = 0.33$ to match a standard labor share of 67%.

To parametrize the remaining parameters $\left\{\zeta_{m(s)}, \beta_{m(s)}, \gamma_{m(s)}, \omega_n, TS\right\}$, we use bilateral FOB trade flows. In the model, the FOB value of trade from origin n to destination j is given by

$$X_{nj}^{FOB} = p_{nn} d_{nj} C_j \left(\frac{p_{nj}^C}{P_j^C}\right)^{-\sigma}.$$

The consumer price p_{nj}^C equals the producer price p_{nn} plus the long-distance transport cost $\tau_{nj}^{n,LD}$

implied by the optimal route on the transport network. Taking logs and imposing the normalization $p_{nn} = 1$,[13] yields the estimating equation:

$$\ln X_{nj}^{FOB} = \underbrace{\ln O_n}_{\psi_n} + \underbrace{\ln C_j \left(P_j^C\right)^{\sigma-1} D_j}_{\psi^j} - \sigma \ln\left(1 + \tau_{nj}^{n,LD}\right) + \underbrace{\ln \varepsilon_{nj}}_{\tilde{\varepsilon}_{nj}}, \tag{46}$$

where ψ_n and ψ^j denote origin and destination fixed effects. We estimate this equation by nonlinear least squares, minimizing the squared residual $\sum_{n,j} \tilde{\varepsilon}_{nj}^2$. For each candidate parameter vector, we compute the long-distance transport costs $\tau_{nj}^{n,LD}$ under congestion, estimate (46), and evaluate the resulting residuals. The demand shifters O_n and D_j are recovered from the estimated fixed effects. Finally, we infer country-level productivity by equating each country's production of the differentiated good to GDP under the price normalization $p_{nn=1}$:

$$GDP_n \equiv p_{nn} Y_n = \alpha^{\frac{\alpha}{1-\alpha}} p_{nn}^{\frac{1}{1-\alpha}} A_n^{\frac{1}{1-\alpha}} L_n.$$

The calibrated parameters are reported in Table 3. Figure 8 illustrates the model's fit to GDP and international trade flows. For model validation, panel (c) compares model-implied gross trade flows through seaports with observe total container traffic, untargeted in our calibration.

Table 3: Model Parameters

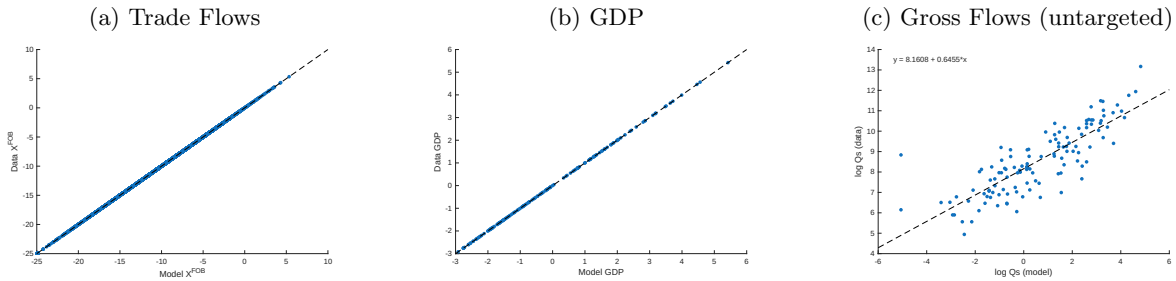
Parameter		Source	Value
Externally set			
Elasticity of production	α	66% labor share	0.3300
CES elasticity	σ	standard est.	5.0000
Curvature of utility	ρ	IES of 0.5	2.0000
Estimated			
Distance elasticity	ζ_{land}		0.0102
	ζ_{sea}		0.0203
Congestion elasticity	β_{land}		0.2390
	β_{sea}		0.1657
Infrastructure elasticity	γ_{land}		0.1645
	γ_{sea}		0.1178
Port coefficient	T_{land}		0.0515
	T_{sea}		0.0759
Transshipment cost	TS		0.0100

6.3 Welfare Impacts and Implied Geopolitical Weights of the BRI

We begin by evaluating the cross-country effects of the proposed BRI investments. In the absence of country-specific data on infrastructure construction costs relative to China, we adopt a conservative assumption: China faces the same investment costs as private investors in each host

[13] This normalization amounts to a choice of units for good n, with a corresponding rescaling of A_n, ω_n, O_n and all quantities of good n.

Figure 8: Calibration Fit

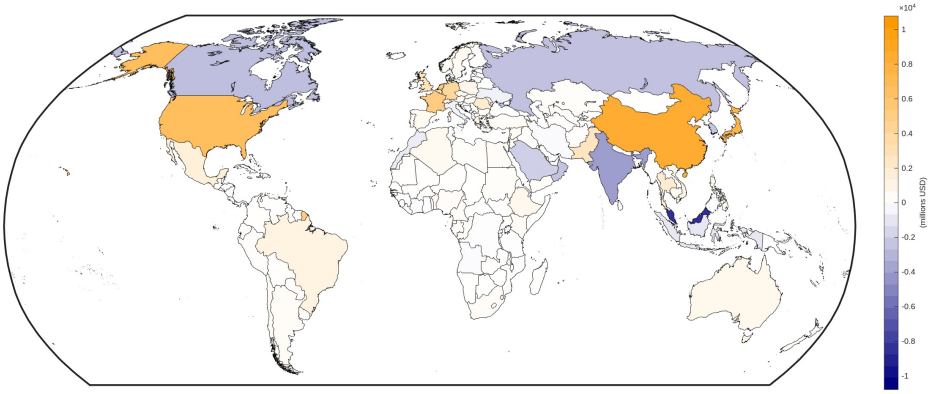


Notes: FOB trade flows in USD for 2010. Gross flows compare Q_s at all seaports in our model to the total number of container ships in the data.

country, as recovered from the calibrated economy. Formally, we set $\kappa_s^{CH} = r_s$. This assumption of symmetric technologies allows us to isolate the remaining differences between host-country and Chinese investment incentives.

Figure 9 reports the total welfare change in each country following the implementation of the BRI, relative to the calibrated baseline. China experiences the largest welfare gains, followed closely by its major trading partners, including the United States, Japan, and several European economies. By contrast, countries receiving substantial investments do not necessarily benefit, reflecting the interaction of multiple offsetting forces.

Figure 9: Welfare Impact of Proposed BRI by Countries



Notes: Welfare impact $V_j\left(\{I_s^D\}, \{I_s^{CH}\}_{BRI}\right) - V_j\left(\{I_s^D\}, 0\right)$ reported in millions of USD equivalent. Positive welfare changes are represented in orange and negative changes in blue.

To better understand these effects, we re-arrange the marginal welfare terms in 45 as

$$
\begin{aligned}
dV_j = & \underbrace{-\sum_n C_{nj} dp_{nj}}_{\text{consumer surplus}} + \underbrace{Y_j dp_{jj}}_{\text{production profits}} + \underbrace{\sum_{n \neq j} t^M_{nj} dC_{nj} + \sum_{n \neq j} t^X_{jn} dC_{jn}}_{\text{tariff revenue}} \\
& + \underbrace{\sum_{s \in \mathcal{S}(j)} \left(\sum_{n=1}^{J} Q^n_s d\tau^n_s - \left(I^D_s + I^{CH}_s \right) dr_s \right)}_{\text{port profits}} \\
& + \underbrace{\sum_{s \in \mathcal{S}(j)} I^D_s dr_s + 1_{j=CH} \sum_{j' \neq CH} \sum_{s \in \mathcal{S}(j')} \left(I^{CH}_s dr_s + \left(r_s - \kappa^{CH}_s \right) dI^{CH}_s \right)}_{\text{infrastructure returns}}
\end{aligned}
$$

Figure 10 presents the welfare decomposition across countries. Panel (a) shows the distribution of consumer-surplus gains. As expected, all countries benefit to varying degrees from improved access to cheaper foreign goods. China and its largest trading partners gain the most, reflecting the scale of their economies. More surprisingly, production profits (panel b) decline in most countries. This pattern reflects a reallocation of expenditure away from domestic goods toward imports. For most economies, increased foreign demand is insufficient to offset the contraction in domestic demand. Port profits (panel c) exhibit substantial heterogeneity. Countries receiving large infrastructure investments, such as Russia, experience rising port profits. In contrast, countries such as India face declines due to the diversion of gross trade flows toward better-connected infrastructure hubs. Infrastructure returns (panel d) are negative worldwide under our maintained assumption that China faces the same investment costs as domestic private investors. With symmetric costs, the only remaining force affecting returns is the decline in r_s driven by decreasing returns to infrastructure.

Can the proposed BRI investments be rationalized by particular geopolitical preferences? Formally, we ask whether the proposed allocation of investments can be interpreted as the outcome of China solving

$$
\max_{\{I^{CH}_s\}} V_{CH} \left(\left\{ I^D_s \right\}, \left\{ I^{CH}_s \right\} \right) + \sum_{j \neq CH} \Omega_j V_j \left(\left\{ I^D_s \right\}, \left\{ I^{CH}_s \right\} \right),
$$

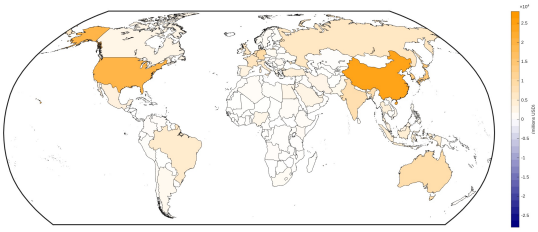
where Ω_j denotes the geopolitical weight assigned by Chinese decision makers to the welfare of country j. In this exercise, we assume that every country other than China is playing the infrastructure autarky equilibrium (calibrated economy) and that only China is able to invest abroad. The first-order conditions with respect to I^{CH}_s yield $2 \times J$ moment conditions

$$
\frac{\partial V_{CH}}{\partial I^{CH}_s} + \sum_{j \neq CH} \Omega_j \frac{\partial V_j}{\partial I^{CH}_s} = 0. \tag{47}
$$

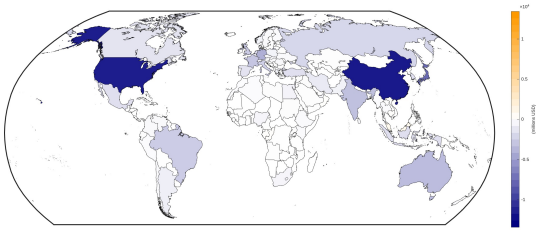
We estimate the geopolitical weights Ω_j by least squares, minimizing the residual of the first-order

Figure 10: Welfare Decomposition of Proposed BRI by Countries

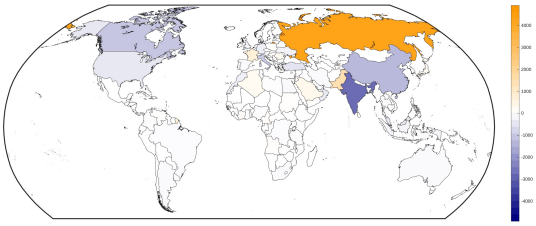
(a) Consumer surplus



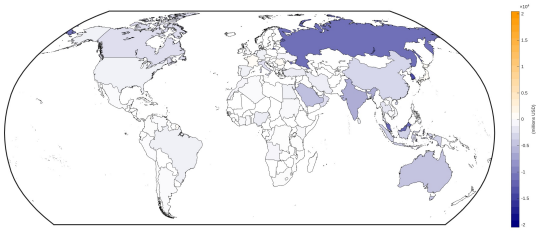
(b) Production profits



(c) Port profits



(d) Infrastructure returns



Notes: Consumer surplus is $U_j(C_j) - P_j^C C_j$, infrastructure returns are total returns $\left(r_j^I - \kappa_j\right) I_j$. Units in millions of USD.

conditions:

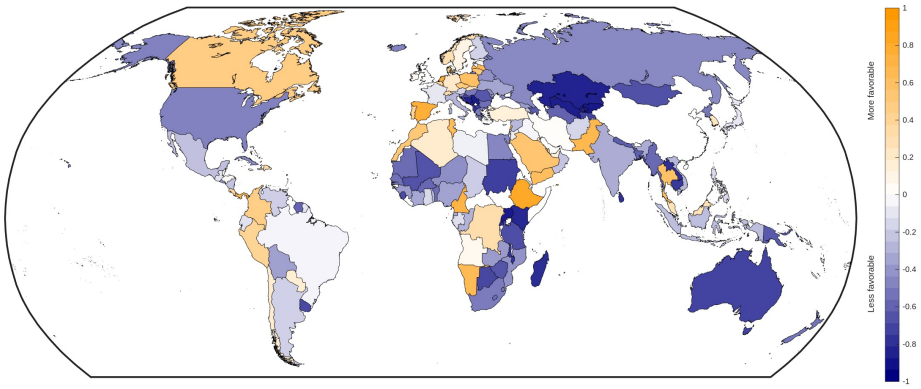
$$\sum_{s \in \mathcal{S}} \left(\frac{\partial V_{CH}}{\partial I_s^{CH}} + \sum_{j \neq CH} \Omega_j \frac{\partial V_j}{\partial I_s^{CH}} \right)^2 .$$

The resulting weights are reported in Figure 11. The implied geopolitical map differs sharply from the distribution of welfare gains. Under this interpretation, the observed BRI investment pattern is consistent with geopolitical preferences that place relatively high weight on several African and Middle Eastern economies (e.g., Ethiopia, Cameroon, and Saudi Arabia), Eastern European countries (including Poland and the Baltic states), Asian partners (notably Pakistan, Thailand, and Malaysia), and selected countries in the Americas (Colombia, Peru, and Canada). Despite experiencing welfare gains from the BRI, the United States receives a negative estimated weight. More strikingly, Russia—both a major trading partner and a key recipient of BRI investments—is also assigned a negative weight. Overall, the recovered geopolitical weights suggest that Chinese investment choices are more aligned with favoring selected developing economies, while placing negative weight on much of the developed world.

6.4 (Economic) Welfare Gradient and Optimal Network in the Absence of Political Weights

Absent geopolitical motives, how should a Chinese planner optimally allocate foreign infrastructure investments? Maintaining the assumption that Chinese construction costs equal those faced by domestic private investors, Figure 12 reports the welfare gradient $\partial V_{CH}/\partial I_s^{CH}$ associated with

Figure 11: Implied Country Weights Ω_j



Notes: Country weights Ω_j are ranked from highest (1) to neutral (0) in orange color and from neutral (0) to lowest (-1) in blue.

investments in each country's land ports (panel a) and seaports (panel b), evaluated at the calibrated economy. Consistent with the predictions of the theoretical framework, China has incentives to invest in the infrastructure of its trading partners even in the absence of a technological advantage. In particular, major trading partners and countries located along key trade corridors exhibit the largest welfare gradients.

We examine these patterns more systematically in Figure 13. Countries that are important destinations for Chinese exports (panel a) or major sources of Chinese imports (panel b) are strongly associated with higher welfare gradients. Similarly, countries through which large gross volumes of Chinese exports (panel c) or imports (panel d) transit tend to display larger infrastructure gradients.

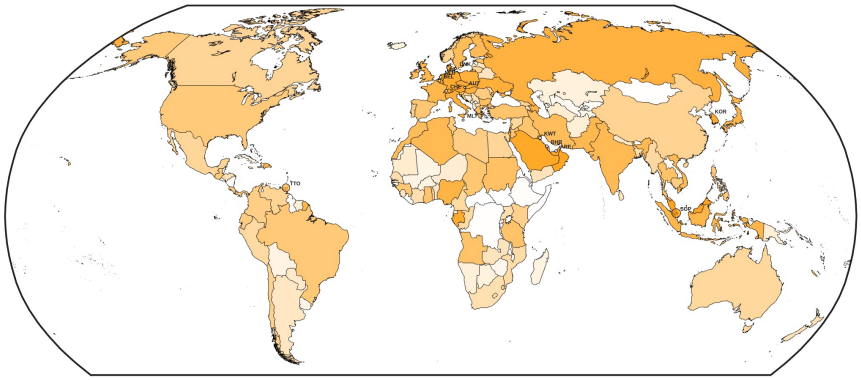
To conclude, we compare the proposed BRI allocation with the investment network that a Chinese planner without geopolitical preferences would optimally choose, assuming that the remaining countries play the infrastructure autarky equilibrium. We compute the optimum using a simple gradient-descent algorithm. The comparison reveals a markedly different allocation pattern. A purely Chinese-welfare maximizing planner would direct a larger share of investments toward China's most advanced trading partners, including the United States, Japan, and several European economies. In contrast, developing countries that are major recipients of the current BRI—particularly in Southeast Asia, Africa, and Latin America—would receive substantially less investment.

7 Conclusion

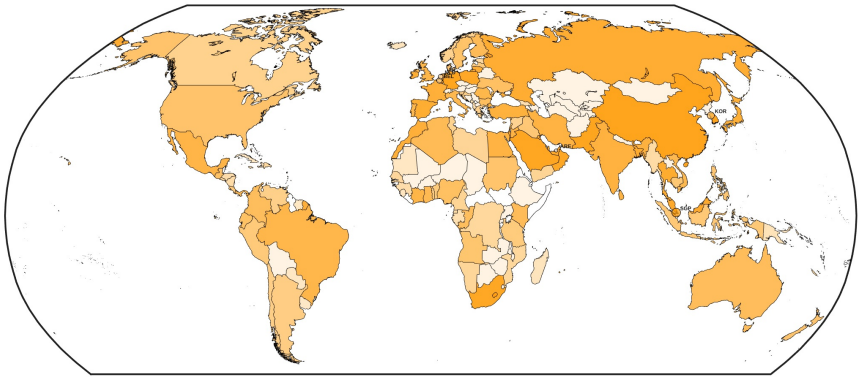
In this project we are studying China's Belt and Road Initiative (BRI). We have combined several datasets, including geocoded investment on ports, rail, land, and airports from different major investors, detailed information on port infrastructure, and port-to-port shipment data. Using

Figure 12: China's Infrastructure Gradient in Calibrated Economy

(a) Land



(b) Sea



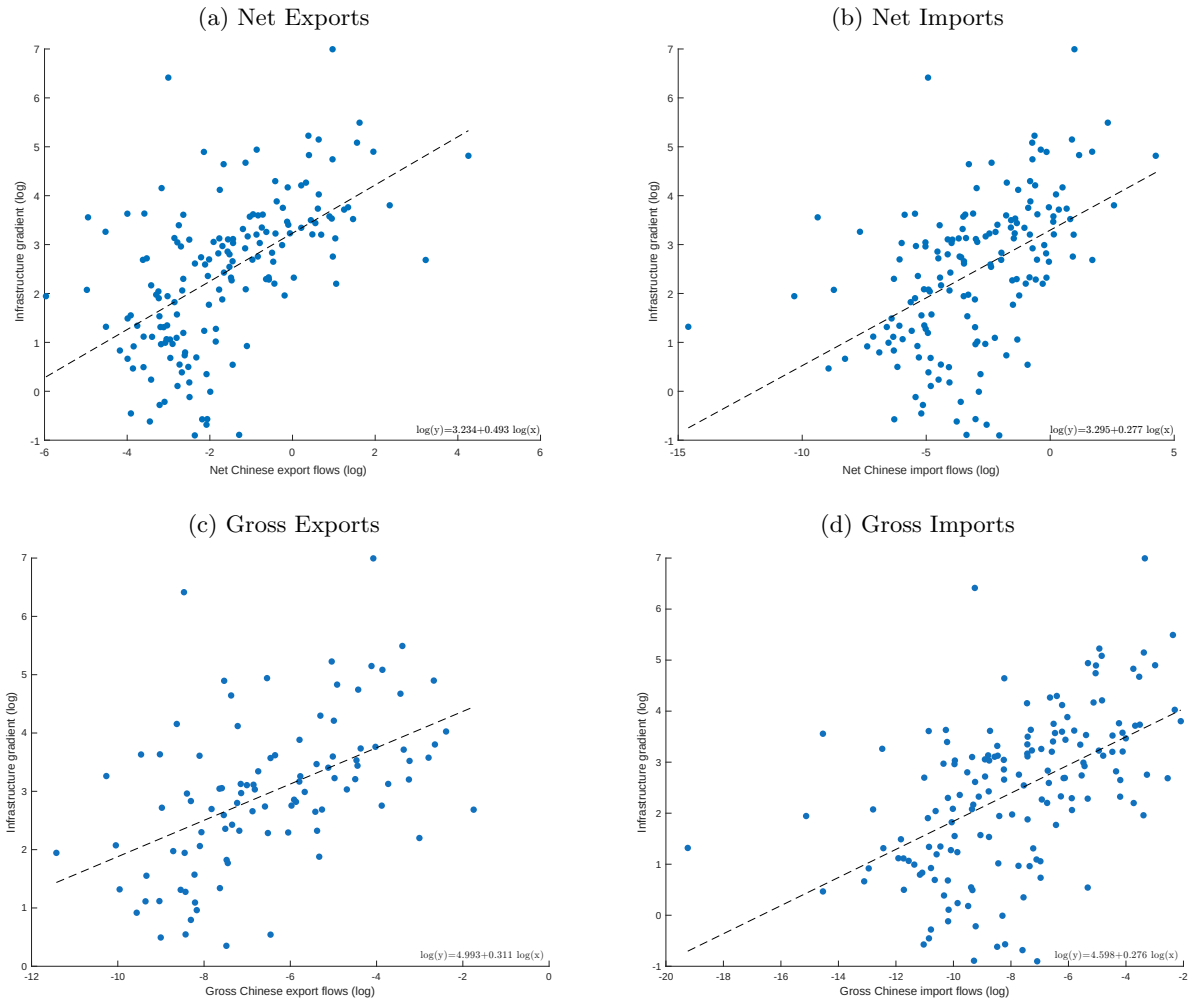
Notes: This figure represents $\partial V^{CH}/\partial I_s^{CH}$ at infrastructure autarky in utils, assuming that China's construction costs are equal to those of domestic private investors, i.e., $\kappa_s^{CH} = r_s^I$.

these data, we are descriptively studying determinants of Chinese investments vis-a-vis other major investors, and we are in the process of estimating the impacts of these investments on trade.

We use a standard two-country trade model with an outside good to theoretically study the strategic incentives of countries to invest in trade infrastructure. We identify a novel "foreign bias" in infrastructure investment: everything else the same, foreign countries have stronger incentives than host countries to invest in transport hubs. In a Nash equilibrium with host and foreign countries investing, foreign countries always invest. Thus the model can rationalize an economic motivation for China's overseas infrastructure investments and provides the basis for quantifying the relevance of these economic forces vis-a-vis geopolitical drivers.

We then develop a multi-country trade model with a transport network over different modes

Figure 13: Determinants of the Infrastructure Gradient



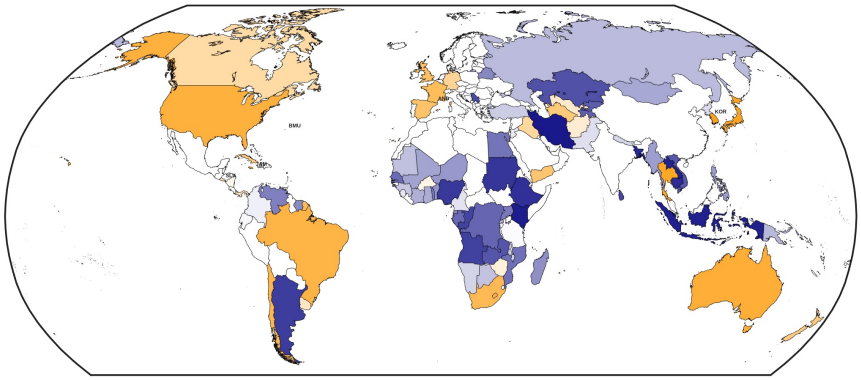
Notes: Net export are the FOB value of Chinese exports to each country, net import the FOB value of goods exported by each country to China. Gross exports represent the total FOB value $\sum_{s \in S(j)} p_{j_{CH} j_{CH}} \left(Q^{j_{CH}}_{ss'} + Q^{j_{CH}}_{s's} \right)$ of Chinese goods transiting through country j. Gross imports represent the total FOB value of foreign goods eventually consumed by China transiting through a country (attributed pro-rata in each node).

that incorporates congestion by node. In our preliminary quantification we measure China's economic benefits as well as those of host and third countries from China's investments, and identify geopolitical weights that explain the gap between the optimal purely economic investments and the actual investments. Our preliminary results indicate that the BRI generates positive economic returns for China and welfare gains for most countries—including the United States—even though China's political preferences appear biased against the U.S.. Our framework allows us to estimate what China's investment strategy might look like without geopolitical motives.

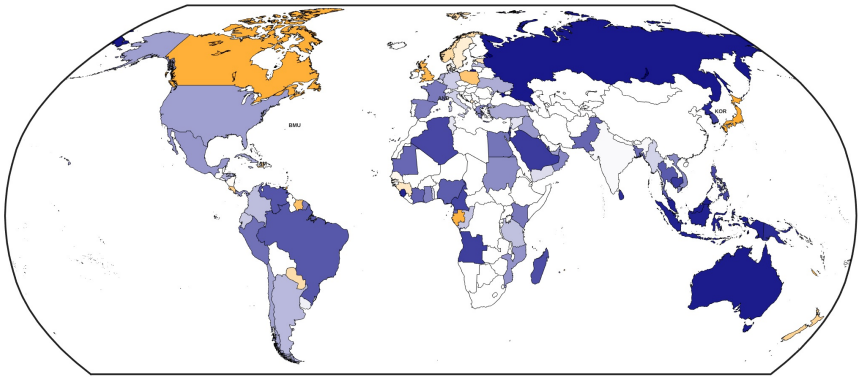
Several features are in progress. Our work in progress will estimate the impacts of BRI investments of port-level trade, refine our model features (such as adding intermediate inputs), bring in additional data to the quantification (such as details of port infrastructure, more detailed

Figure 14: Difference between Non-Geopolitically Motivated Optimum and Proposed BRI

(a) Land



(b) Sea



Notes: The map shows the difference between the non-geopolitically motivated optimum minus the proposed one. Countries in orange are those that would receive more investments without geopolitical preferences and blue those that would receive less.

geography and modes, and information about port ownership and returns to BRI loans), and implement additional counterfactuals such as assessing the optimal responses of the U.S. and other major organizations to the Chinese investments.

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8 Appendix to Section 4

Proof of Lemma 1

Consider an equilibrium $\left\{Q^*, r^*, \tau^*, p_M^*, p_X^*, I_{P,M}^*, I_{P,X}^*\right\}$ consistent with (13) and (14) given policies $\{s_j, I_{G,j}, t_j\}$. We partition possible equilibria in three cases: no private sector entry ($I_{P,j}^* = I_{P,k}^* = 0$), country j entry ($I_{P,j}^* > 0$), and country k entry without country j entry ($I_{P,k}^* > 0 = I_{P,j}^*$). We show country j can implement a $dI_j = dI^*$ by changing policies. First, suppose we start without private. Then $r^* + s_j < \kappa_j$ for $j = X, M$. Therefore, given any marginal shock, $I_{P,j} = dI_{P,j} = 0$ and public entry has a first order impact: $dI_{G,j} = dI_j = dI^*$. Second, assume country j entry. Then, $ds_j = -dr^*$. Private investment adjusts marginally to match dr^*, $dI_{P,j}^* = dI_j = dI^*$ such that $dr^* = -T_{IQ}dQ^* - T_{II}dI^* = ds_j$. Any desired dI_j can therefore be implemented with subsidies $ds_j^* = -\left(\frac{dr}{dI^*}\right) dI_j$. Third, if there is country k entry without country j entry, the initial equilibrium features $r^* + s_k = \kappa_k < \kappa_j$. Country j can offer a subsidy $s_j = \kappa_j - \kappa_k + s_k$ without any change in equilibrium outcomes or fiscal cost, at which point country j will be indifferent about entry, $r^* + s_j = \kappa_j$. Around that point, a further increase in s_j leads to country j firms crowding out all country k firms, with same outcomes as in the case with only country j entry (where we use that $\frac{dr^*}{dI^*} < 0$ as shown in Part (ii) of Proposition 1). Therefore, around any initial equilibrium, and therefore any set of parameters and country k policies, there is a variations in country j policies such that $dI_j = dI^*$. Part (iii) implies that country j cannot implement any I^* below that which would prompt empty from country k private firms, $\underline{I_{P,k}}$ such that $r^* + s_k = \kappa_k$. Therefore, country j can only implement $I^* > \min\left\{\underline{I_{P,k}}, I_{G,k}\right\}$.

Proof of Proposition 1

Part (i) Totally differentiating (13) and solving for $\frac{dQ^*}{dI^*}$ we have:

$$\frac{dQ^*}{dI^*} = \frac{T_{QI}}{U_{QQ} - \Psi_{QQ} - T_{QQ}} > 0, \tag{48}$$

and totally differentiating (8) and using (48):

$$\frac{d\tau^*}{dI^*} = \frac{U_{QQ} - \Psi_{QQ}}{U_{QQ} - \Psi_{QQ} - T_{QQ}} T_{QI} < 0$$

where to determine the signs we have used $T_{QI} < 0$, $U_{QQ} < 0$, $\Psi_{QQ} > 0$ and $T_{QQ} > 0$. Therefore, $\frac{dp_M}{dI} = U''(Q)\frac{dQ}{dI} < 0$ and $\frac{dp_X}{dI} = \Psi''(Q)\frac{dQ}{dI} > 0$. Totally differentiating (9) and using (48) we obtain:

$$\frac{dr^*}{dI^*} = -\frac{(T_{QI})^2}{U_{QQ} - \Psi_{QQ} - T_{QQ}} - T_{II} = -\frac{(T_{QI})^2 - T_{II}T_{QQ} + T_{II}(U_{QQ} - \Psi_{QQ})}{U_{QQ} - \Psi_{QQ} - T_{QQ}} < 0$$

where to determine the sign we have also used $T_{II} > 0$ and convexity of T, which implies $(T_{QI})^2 < T_{II}T_{QQ}$.

Part (ii) Totally differentiating (1) and (2) and using 3 and 4,

$$dV_j = \left(1_{j=X} dp_X^* - 1_{j=M} dp_M^*\right) Q^* + d\mathcal{T}_j. \tag{49}$$

Totally differentiating (12) and using 8 and 9, Lemma 1 implies whenever $dI_j = dI^*$ is implemented then:

$$d\mathcal{T}_j = 1_{(j \text{ is host})} \underbrace{\left(Q^* d\tau^* - I^* dr^*\right)}_{d\Pi_T} + \left(r^* - \kappa_j\right) dI_j + I_j dr^* + d\left(t_j Q^*\right). \tag{50}$$

Therefore, we can re-write 12 as follows:

$$d\mathcal{T}_j = 1_{(j \text{ is host})} \left(Q^* d\tau^* - I_{-j} dr\right) + 1_{(j \text{ is foreign})} I_j dr^* + \left(r^* - \kappa_j\right) dI_j + d\left(t_j Q^*\right). \tag{51}$$

where either $dr = 0$ and $r = \min \kappa_j$ (if $\sum_j I_{P,j}^* > 0$ in initial equilibrium) or $dr < 0$ and $r < \min \kappa_j$ (if $\sum_j I_{P,j}^* = 0$). Combining 51 with 49 we obtain

$$dV_j = \left(1_{j=X} dp_X - 1_{j=M} dp_M\right) Q + 1_{(j \text{ is host})} \left(Q d\tau - I_{-j} dr\right) + 1_{(j \text{ is foreign})} I_j dr + \left(r - \kappa_j\right) dI_j + d\left(t_j Q\right). \tag{52}$$

When $dI^* = dI_j$ and $dt_j = 0$, using $dp_X > 0 > dp_M$, 52 becomes:

$$dV_j = \left|dp_j^*\right| Q^* + 1_{(j \text{ is host})} \left(Q^* d\tau^* - I_{-j} dr^*\right) + 1_{(j \text{ is foreign})} I_j dr^* + \left(r^* - \kappa_j\right) dI_j + t_j dQ^*. \tag{53}$$

Further letting h be the host country and f be the foreign country and using the fact that $|dp_h^*| + d\tau^* = -\left|dp_f^*\right|$ we obtain 15 with 16.

Part (iii) From (52), when both $dI_j = dI^* \neq 0$ and $dt_j \neq 0$, using 3, 4, 8, and 9,

$$\begin{aligned} dV_j = &\left(1_{j=X} \Psi''\left(Q^*\right) - 1_{j=M} U''\left(Q^*\right)\right) Q^* dQ^* \\ &+ 1_{(j \text{ is host})} \left[\left(Q^* T_{QQ} + I_{-j} T_{IQ}\right) dQ^* + \left(Q^* T_{QI} + I_{-j} T_{II}\right) dI_j\right] \\ &+ 1_{(j \text{ is foreign})} I_j \left(-T_{IQ} dQ^* - T_{II} dI_j\right) \\ &+ \left(r - \kappa_j\right) dI_j + Q^* dt_j + t_j dQ^*. \end{aligned} \tag{54}$$

If country j is setting optimal tariffs then $\frac{dV_j}{dt_j} = 0$ when $dI_j = 0$, implying the optimal tariff. Therefore, at the optimal tariff,

$$dV_j = 1_{(j \text{ is host})} \left(Q^* T_{QI} + I_{-j} T_{II}\right) dI_j - 1_{(j \text{ is foreign})} I_j T_{II} dI_j + \left(r - \kappa_j\right) dI_j,$$

which can be expressed as 17 and 18.

Proof of Proposition 2

Parts (i) and (ii) are shown in the text. For part (iii), consider first the case with optimal tariffs. From part (ii) we must have that foreign necessarily invests and the host may invest:

$$\frac{dV_f}{dI_f} = I_f \frac{\partial r^*}{\partial I^*} + (r - \kappa) = 0, \tag{55}$$

$$\frac{dV_h}{dI_h} = Q^* \frac{\partial \tau^*}{\partial I^*} - I_f \frac{\partial r^*}{\partial I^*} + (r - \kappa) \leq 0. \tag{56}$$

In any equilibrium we have $r = \kappa - I_f \frac{\partial r^*}{\partial I^*} > \kappa$. Therefore, there is under-investment with respect to the global planner, who would choose $r = \kappa$. Only f entering is an equilibrium if, at the (I^*, Q^*) such that only f enters, host does not invest. Combining 55 and 56 as well as 8, and 9, this occurs if $\frac{\partial \tau^*}{\partial I^*} Q^* - 2I^* \frac{\partial r^*}{\partial I^*} = Q^* T_{QI}(Q^*, I^*) + 2I^* T_{II}(Q^*, I^*) < 0$. Assuming $T(Q, I) = \overline{T} Q^{1+\beta} I^{-\gamma}$, this condition is equivalent to $\beta > 2\gamma + 1$.

Consider next the case with free trade. From part (ii) we must have that foreign necessarily invests and the host may invest:

$$\frac{dV_f}{dI_f} = \left| \frac{dp_f^*}{dI^*} \right| Q^* + I_f \frac{dr^*}{dI^*} + (r^* - \kappa) = 0, \tag{57}$$

$$\frac{dV_h}{dI_h} = -\left(\left| \frac{dp_f^*}{dI^*} \right| Q^* + I_f \frac{dr^*}{dI^*} \right) + (r^* - \kappa) \leq 0. \tag{58}$$

If both countries enter, then $r^* = \kappa$, same as global planner. Only foreign entering is an equilibrium if, at the (I^*, Q^*) such that only f enters,

$$\begin{aligned} \frac{dV_h}{dI_h} &= -\left| \frac{dp_f^*}{dI^*} \right| Q^* - I^* \frac{dr^*}{dI^*} + (r^* - \kappa) \\ &= -2 \left(\left| \frac{dp_f^*}{dI^*} \right| Q^* + I^* \frac{dr^*}{dI^*} \right) < 0. \end{aligned}$$

In that case, $r^* = \kappa - \left(\left| \frac{dp_f^*}{dI^*} \right| Q^* + I^* \frac{dr^*}{dI^*} \right) < \kappa$. Therefore, there is over-investment.