International Friends and Enemies*

Benny Kleinman†
Princeton University

Ernest Liu‡
Princeton University

Stephen J. Redding§
Princeton University, NBER and CEPR

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Abstract

We examine whether as countries become more economically dependent on a trade partner, they realign politically towards that trade partner. We use network measures of economic exposure to foreign productivity growth derived from the class of trade models with a constant trade elasticity. We establish causality using two different sources of quasi-experimental variation: China's emergence into the global economy and the reduction in the cost of air travel over time. In both cases, we find that increased economic friendship causes increased political friendship, and that our theory-based network measures dominate simpler measures of trading relationships between countries.

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†Dept. Economics, JRR Building, Princeton, NJ 08544. Email: binyamin@princeton.edu.

‡Dept. Economics, JRR Building, Princeton, NJ 08544. Email: ernestliu@princeton.edu.

§Dept. Economics and SPIA, JRR Building, Princeton, NJ 08544. Email: reddings@princeton.edu.

1 Introduction

> "Throughout history, anxiety about decline and shifting balances of power has been accompanied by tension and miscalculation ... Traditionally the test of a great power was its strength in war. Today, however, the definition of power is losing its emphasis on military force ... The factors of technology ... and economic growth are becoming more significant in international power." (Nye 1990, pp. 153-4)

We examine whether as countries become more economically dependent on a trade partner, they realign politically towards that trade partner. We use network measures of economic exposure to foreign productivity growth from the class of trade models with a constant trade elasticity. We define a country as an economic friend of a trade partner if its productivity growth raises the partner's real income and an enemy if the converse is true. We combine these economic exposure measures with a variety of alternative measures of political alignment, including United Nations voting, strategic rivalries and formal alliances. We establish causality using two different sources of quasi-experimental variation. First, we use China's emergence into the global economy following its domestic reforms of 1978 as an exogenous source of variation in other countries' real income exposure. Second, we use the reduction in the cost of air travel over time, which changes the relative real income exposure of country pairs with different sea distances relative to air distances. In both cases, we find that increased economic friendship causes increased political friendship, and that our theory-based network measures dominate simpler measures of trading relationships between countries.

Our empirical analysis is guided by a simple theoretical model, in which countries can take political actions that promote economic growth in their trade partners, but which are costly to undertake. In the Nash non-cooperative equilibrium, the larger the elasticity of a country's real income to economic growth in a trade partner, the greater the country's incentive to undertake political actions that raise its productivity growth. Providing empirical evidence on this relationship between political alignment and economic interests raises a number of challenges. Some studies measure economic dependence on a trade partner using bilateral trade. However, one country's real income exposure to another does not only depend on bilateral trade frictions, but also on trade frictions with other nations. Even taking this multilateral resistance into account yields an incomplete picture, because productivity growth in trade partners typically has other general equilibrium effects through the terms of trade.

To address these challenges, we use real income exposure measures derived from the class of trade models with a constant trade elasticity, which capture all general equilibrium effects in these models. Our exposure measures can be computed directly from observed trade data, using either exact-hat algebra techniques for the non-linear model solution, or using a linearization of the conditions for general equilibrium in these models. The former corresponds to an arc elasticity of real income with respect to an assumed productivity shock. The latter corresponds to a point elasticity with respect to a small productivity shock. In practice, we find similar results whether we use the arc or point elasticity, and regardless of the assumed size of the productivity shock for the arc elasticity, at least for productivity shocks up to the cumulative change in productivity over our more than forty-year sample period.

We stack these bilateral elasticities of real income with respect to productivity growth in matrix form, where the rows are the exposed trade partners, and the columns are the countries experiencing the productivity growth. A country is an economic friend of a trade partner if the corresponding element in the matrix is positive and an enemy if the converse is true. An advantage of this matrix representation is that we are able to use techniques from the networks literature to characterize the role of countries' positions within the network in influencing the effects of productivity growth. We evaluate the extent to which each country's productivity growth affects others (its "authority score" from graph theory) and the extent to which each country is affected by others' productivity growth (its "hub score" from graph theory). We thus provide new data on countries' roles in the global economy, both in terms of our exposure measures, and the network statistics derived from them. Our use of the terms "friends" and "enemies" echoes its use in neoclassical trade theory for the general equilibrium relationships between factor and goods prices, or goods outputs and factor endowments.

We combine our economic exposure measures with a range of different measures of countries' political alignment. First, we use three different measures of the bilateral similarity of countries' voting patterns in the United Nations General Assembly (UNGA). Second, we use measures of countries' "ideal points" or preferences relative to the US-led liberal order, based on the UNGA voting data. Third, we use measures of strategic rivalries, based on the perceptions of contemporary political decision makers, as to whether countries regard one another as actual or latent threats. We further disaggregate these strategic rivalries into those that are positional, spatial and ideological. Finally, we use measures of formal alliances between countries, including mutual defense pacts, neutrality and non-aggression treaties and ententes.

As a first source of exogenous variation in economic exposure to productivity growth, we use the natural experiment of China's emergence into the global economy following its domestic liberalization of 1978. We begin by regressing changes in political alignment towards China on changes in real income exposure to Chinese productivity growth over the period from 1980-2010. We find a strong positive and statistically significant relationship, which is particularly evident for nearby economies in South-East Asia, and a number of resource-rich countries in Africa and Oceania. We next use the structure of this class of constant elasticity trade models to construct an instrument for changes in real income exposure to Chinese productivity growth.

We start at the observed equilibrium in the data in 1980, and compute the counterfactual change in real income exposure to Chinese productivity growth implied by an exogenous increase in China's productivity, holding all else constant. This instrument captures the pure supply-side impact from China's productivity-enhancing reforms on other countries' real income exposure and can be computed for a range of different sizes for the exogenous increase in productivity. Even focusing on this exogenous source of variation, we find that as countries become more economically dependent on Chinese productivity growth, they realign politically towards China.

Second, we make use of the large-scale reduction in the cost of air travel that occurred over our sample period following Feyrer (2019). The key idea is that the position of land masses around the globe generates large differences between bilateral distances by sea and air, such that some bilateral pairs benefit more from the reduction in the cost of air travel than others. By exploiting variation in trade costs over time within bilateral pairs of countries, we control for a host of time-invariant factors that are specific to individual pairs of countries (e.g., geographical location, institutions, legal origin, common language etc.). We also include exporter-year and importer-year fixed effects, which control for the sign and absolute magnitude of productivity growth, as well as policy changes that are common to all trade partners and macro shocks. Using these differential changes in relative trade costs from reductions in the cost of air travel within bilateral pairs of countries, we find that increases in bilateral real income exposure raise bilateral political alignment. We show that these results are robust across a range of measures of bilateral political alignment (including UN voting, strategic rivalries and formal alliances). Therefore, these findings provide further support for the view that as a country becomes more economically dependent on its trade partner, it realigns politically towards that trade partner.

We first introduce our friend-enemy exposure measures for the influential class of single-sector models with a constant trade elasticity. We next show that this same representation holds across a wide range of specifications, including a state of the art quantitative trade model with multiple sectors and input-output linkages. We use this quantitative specification for our main empirical results and report a number of further specification checks. First, we show that our exposure measures are not well proxied by simpler measures of trading relationships between countries, such as bilateral trade flows. Second, we validate our real income exposure measures by showing that they have predictive power for separate data not used in their estimation. In particular, we show that they successfully detect increases in economic interdependence between countries following the formation of Preferential Trade Agreements (PTAs).

Our research contributes to several strands of existing work. First, we make use of recent advances in the development of quantitative international trade models. These models are sufficiently rich as to be able to connect directly to observed data on bilateral trade, but yet remain sufficiently tractable as to be amenable to analytical analysis and to be used for policy-relevant counterfactuals. Influential contributions to the development of these models and the related literature on sufficient statistics in international trade include Armington (1969), Jones and Scheinkman (1977), Wilson (1980), Eaton and Kortum (2002), Anderson and van Wincoop (2003), Arkolakis et al. (2012), Costinot et al. (2012), Caliendo and Parro (2015), Adão et al. (2019), Baqaee and Farhi (2019), Huo et al. (2019), Caliendo et al. (2019) and Allen et al. (2020).[1] We manipulate the conditions for general equilibrium in these models to construct network exposure measures of the elasticity of real income to foreign productivity growth. We demonstrate the robustness of our results to either using arc elasticities from the full non-linear model solution (for an assumed value of productivity growth), or point elasticities from a linearization of the conditions for general equilibrium (for small productivity growth). We show that these theory-based exposure measures dominate simpler measures of the trading relationships between countries.

Second, our paper is related to research on international political economy. One strand of this research has measured countries' bilateral political alignment using data on the similarity of their voting patterns in the United Nations General Assembly (UNGA), including Scott (1955), Cohen (1960), Signorino and Ritter (1999), Häge (2011) and Dicaprio and Sokolova (2018). Much of this literature focuses on the bilateral similarity of these voting patterns. In contrast, Bailey et al. (2017) uses information on the issues voted on to estimate countries' "ideal points," which correspond to their positions vis-a-vis the US-led liberal order.[2] Another line of this research has measured countries' bilateral political alignment using data on strategic rivalries, based on the perceptions of contemporary political decision markers, including Thompson (2001), Colaresi et al. (2010) and Aghion et al. (2018). Another branch of work has used data on formal alliances between countries, including Eisensee and Strömberg (2007), Gartzke (2007) and de Mesquita and Siverson (1995). A further vein of this research measures bilateral political attitudes using survey data and other information, including Alesina and Spolaore (2003), Guiso et al. (2009), Head et al. (2010), Head and Mayer (2013) and Bao et al. (2019). Our key contribution relative to this literature is to examine the relationship between these measures of bilateral political alignment and our new measures of the extent to which countries are economic friends and enemies.[3]

Third, our research connects with the empirical literature on war and trade. One strand of this work looks at the causal impact of war on trade, including Blomberg and Hess (2006) and

[1]The earlier theoretical literature on foreign productivity growth and domestic welfare includes the classic contributions of Hicks (1953), Johnson (1955) and Bhagwati (1958).

[2]Using UN and US data, Kuziemko and Werker (2006) shows that aid to a country increases when it rotates onto the Security Council. Using US aid data, Nunn and Qian (2014) shows that an increase in food aid increases the incidence and duration of civil conflicts. Using trade data, Meyersson et al. (2008) examines the impact of China's demand for natural resources on human rights in Sub-Saharan Africa.

[3]Several authors have drawn parallels between the current China-US tensions and earlier episodes of changing relative economic size, such as Japan and the United States in the 1980s, Britain and Germany at the turn of the 20th century, or Athens and Sparta in Ancient Greece. See Brunnermeier et al. (2018) and "China-US rivalry and threats to globalization recall ominous past, " Martin Wolf, *Financial Times*, 26th May, 2020.

Glick and Taylor (2010). Another line of this work looks at the opposite causal relationship of trade on the probability of conflict, including Polachek (1980), Polachek and Mcdonald (1992), Mansfield (1995) and Barbieri (2002). Combining these two strands, Martin et al. (2008) provide theory and evidence that globalization *decreases* the likelihood of *global* conflict, but *increases* the chance of *bilateral* conflict, because globalization increases countries' multilateral dependence on one another as a whole, but decreases a country's bilateral dependence on any one trade partner. Although the use of military force is the ultimate expression of political power, it is relatively rare. Furthermore, the international relations literature emphasizes softer forms of political power, including international agreements, supra-national institutions, and back-room diplomacy (see for example Nye 1990). We provide new theory and evidence on the extent to which these softer forms of political power are influenced by economic interests.

Fourth, we build on research that has developed instrumental variables for international trade shocks. An influential line of work has focused on the China shock, including Autor et al. (2013) and Pierce and Schott (2016). We use an exogenous increase in China's productivity from domestic reform as a first source of quasi-experimental variation in other countries' real income exposure. Another line of work has used geography as a source of variation in international trade flows, including Frankel and Romer (1999), Rodriguez and Rodrik (2001) and Feyrer (2019). We use the dramatic fall in the cost of air travel that occurred over our sample period as a second of quasi-experimental variation in countries' real income exposure. We demonstrate the robustness of our results across the use of both sources of quasi-experimental variation.

The remainder of the paper is structured as follows. Section 2 derives our economic friends and enemies measures. Section 3 introduces our data. Section 4 provides descriptive evidence on our economic exposure measures. Section 5 reports our main empirical results on political and economic friends. Section 6 concludes. A separate online appendix contains the derivations of theoretical results in the paper, extensions and supplementary empirical results.

2 Economic Friends and Enemies

In this section, we develop our main theoretical results for the relationship between political and economic friends and enemies. First, we formalize the relationship between political alignment and real income exposure. Second, we define our measure of real income exposure measure. Third, we show how techniques from the networks literature can be used to characterize patterns of bilateral real income exposure.

Fourth, we derive our real income exposure measure using a baseline constant elasticity trade model. Fifth, we show that our real income exposure measure has an intuitive interpretation in terms of the underlying economic mechanisms in this model. Sixth, we show that our real income exposure measure holds in a wider class of constant elasticity trade models, including extensions to multiple sectors and input-output linkages.

Political Alignment and Real Income Exposure We consider a world economy that consists of a set of countries indexed by $n, i \in \{1, \ldots, N\}$. We suppose that the representative agent in each country can undertake political actions that are costly in terms of utility but increase the productivity of trade partners (e.g., country n can vote more frequently in international organizations, such as the United Nations General Assembly (UNGA), to support initiatives that promote country i's economic development). The indirect utility of the representative agent in each country n ($\mathcal{U}_n$) depends on real income (u_n) and the utility costs (v_n) of undertaking separate political actions (ξ_{ni}) for each trade partner i:

$$\mathcal{U}_n = u_n - v_n\left(\xi_{nN}\right), \qquad \xi_{nN} = \left(\xi_{n1}, \ldots, \xi_{nN}\right). \tag{1}$$

The productivity of each trade partner i (z_i) depends on fundamental determinants of productivity ($\overline{z}_i$) and the political actions of all countries n (ξ_{ni}) through the function $f_i\left(\cdot\right)$:

$$z_i = \overline{z}_i f_i\left(\xi_{Ni}\right), \qquad \xi_{Ni} = \left(\xi_{1i}, \ldots, \xi_{Ni}\right). \tag{2}$$

In the Nash non-cooperative equilibrium, each country chooses its political actions towards each of its trade partners to maximize its indirect utility net of utility costs, taking as given the political actions of those trade partners. We thus obtain the following reaction function that implicitly determines country n's equilibrium political actions (ξ_{ni}) as a function of (i) the elasticity of country n's real income with respect to productivity in trade partner i, which we refer to as country n's real income exposure to trade partner i (U_{ni} as captured by the first term in parentheses); (ii) the elasticity of trade partner i's productivity with respect to country n's political actions (second term in parentheses); and (iii) the elasticity of country n's utility costs with respect to its political actions towards trade partner i (third term in parentheses):

$$\underbrace{\left(\frac{\partial \ln u_n}{\partial \ln z_i}\right)}_{U_{ni}}\left(\frac{\partial \ln z_i}{\partial \ln \xi_{ni}}\right)\frac{u_n}{v_n} - \left(\frac{\partial \ln v_n}{\partial \ln \xi_{ni}}\right) = 0. \tag{3}$$

In the trade part of our model, we assume a constant trade elasticity to compute real income exposure (U_{ni}). In the political part of our model, we remain non-parametric, allowing for general functional forms for the dependence of productivity ($f_i\left(\cdot\right)$) and utility costs ($v_n\left(\cdot\right)$) on political actions (ξ_{ni}). The second and fourth terms ($\frac{\partial \ln z_i}{\partial \ln \xi_{ni}}$ and $\frac{\partial \ln v_n}{\partial \ln \xi_{ni}}$, respectively) in the reaction function (3) capture the local elasticities of productivity ($f_i\left(\cdot\right)$) and utility costs ($v_n\left(\cdot\right)$) with respect to political actions (ξ_{ni}) for these general functional forms. Other things equal, the more sensitive a country's real income to economic growth in a trade partner (the larger U_{ni}) , the greater the country's incentive to undertake these political actions (the larger ξ_{ni}). We provide evidence on this prediction using exogenous variation in real income exposure (U_{ni}) from an exogenous increase in Chinese productivity and the reduction in the cost of air travel over time. Our measure of real income exposure takes into account general equilibrium effects, such that changes in productivity in trade partner i affect real income in country n not only directly, but also indirectly through changes in wages and prices. We now formally define and derive our real income exposure measure, before introducing our measures of bilateral political alignment, and discussing our identification strategy.

Real Income Exposure We use boldface, lowercase letters for vectors, and boldface, uppercase letters for matrices. We use the corresponding non-bold, lowercase letters for elements of vectors and matrices.

Each country has an exogenous supply of ℓ_n workers, who are each endowed with one unit of labor that is supplied inelastically. Goods are produced using labor and potentially also intermediate inputs. Goods can be traded between countries subject to iceberg bilateral trade costs, such that $\tau_{ni} \geq 1$ units of a good must be shipped from i in order for one unit to arrive in n. Each country is characterized by a Hicks-neutral productivity shifter $z_n \geq 0$.

We denote the wage (nominal income per capita) by w_n, and the consumption price index by p_n, such that $u_n = w_n/p_n$ corresponds to real income per capita. We define our real income exposure measure as the matrix $\boldsymbol{U}$ that satisfies the following vector equation:

$$\mathrm{d}\ln \mathbf{u} = \mathbf{U}\,\mathrm{d}\ln \mathbf{z}, \tag{4}$$

where $\mathrm{d}\ln \mathbf{z}$ is the $N \times 1$ vector of log changes in productivity in each country; $\mathrm{d}\ln \mathbf{u}$ is the $N \times 1$ vector of log changes in real income per capita ($\mathrm{d}\ln u_n$) induced by these log changes in productivity ($\mathrm{d}\ln z_n$); and $\boldsymbol{U}$ is a $N \times N$ matrix, where element $\boldsymbol{U}_{ni} = \mathrm{d}\ln u_n/\mathrm{d}\ln z_i$ captures the elasticity of real income in country n with respect to productivity growth in country i.

The matrix $\boldsymbol{U}$ summarizes the global network of bilateral exposure of real income per capita to productivity shocks. We refer to country n as being a "friend" of country i when this elasticity is positive and an "enemy" of country i when this elasticity is negative. In general, $\mathbf{U}$ is not necessarily symmetric: i could view n as a friend, while n views i as an enemy.

Hub and Authority Scores Our network exposure measure ($\boldsymbol{U}$) in equation (4) lends itself to the use of techniques from the networks literature to characterize the role of countries' positions within the network in influencing the impact of productivity growth. In particular, we use the authority and hub scores from Kleinberg (1999), which are generalizations of the centrality measures used for symmetric networks. These generalizations take into account that the network is asymmetric and hence the direction of relationships matters. The authority score captures the importance of a country as a source of real income shocks for other countries; the hub score summarizes the sensitivity of a country's real income to shocks in other countries. More formally, the hub and authority scores for real income exposure $\{h_i, a_i\}_{i=1}^N$ are defined as:

$$a_i = \lambda \sum_{n=1}^{N} \boldsymbol{U}_{ni} h_n, \qquad h_n = \mu \sum_{i=1}^{N} \boldsymbol{U}_{ni} a_i, \tag{5}$$

where λ and μ are scaling constants that are equal to the inverse norms of the vectors $\boldsymbol{a} \equiv [a_i]$ and $\boldsymbol{h} \equiv [h_n]$, respectively.

By substituting the definition of $\boldsymbol{h}$ into the definition of $\boldsymbol{a}$, and vice versa, we see that these hub and authority scores are the dominant eigenvector of $\boldsymbol{U}\boldsymbol{U}'$ and $\boldsymbol{U}'\boldsymbol{U}$, respectively, such that $\boldsymbol{a} \propto \boldsymbol{U}'\boldsymbol{U}\boldsymbol{a}$ and $\boldsymbol{h} \propto \boldsymbol{U}\boldsymbol{U}'\boldsymbol{h}$.[4] Intuitively, countries with higher authority scores are those whose productivity growth has a larger impact on other countries. In contrast, countries with higher hub scores are those more highly exposed to productivity growth in other countries. These hub and authority scores are computed jointly using equation (5), such that a country is an authority if it has a strong connection with hubs, and it is a hub if it has a strong connection with authorities.

From the bilateral matrix of real income exposure ($\boldsymbol{U}$), we thus obtain vectors that summarize the extent to which each country influences others (its authority score, $\boldsymbol{a}$) and the extent to which each country is influenced by others (its hub score, $\boldsymbol{h}$).

Measuring Real Income Exposure We now show how real income exposure can be measured using a baseline constant elasticity trade model. For expositional convenience, we first illustrate our approach using a single-sector constant elasticity Armington model, in which goods are differentiated by country of origin.[5] But we show below that our approach holds in a large class of constant elasticity trade models that spans most empirical research in international trade, including specifications with multiple sectors and input-output linkages.

We start with the indirect utility function and the goods market clearing condition that equates a country's income with expenditure on the goods produced by that country. We consider these relationships in a counterfactual equilibrium, and denote the counterfactual values of variables by a prime. Using exact-hat algebra, we can rewrite these equations in a counterfactual equilibrium in terms of the observed values of variables in an initial equilibrium (no prime) and the relative changes of these variables between the counterfactual and initial equilibria (denoted by a hat, such that $\hat{x}_i \equiv x_i'/x_i$). Implementing this approach, the counterfactual changes in nominal

[4]By the Perron-Frobenius theorem, $U'U$ and UU' each have a unique eigenvector with all positive entries; these are the dominant eigenvectors.

[5]See Section B of the online appendix for a more detailed exposition of this constant elasticity Armington model.

income per capita ($\hat{w}_i$) and real income per capita ($\widehat{u}_i$) in response to productivity shocks in the single-sector Armington model satisfy the following two equations:

$$\ln \hat{w}_i = \left(\frac{\theta}{\theta+1}\right) \ln \hat{z}_i + \frac{1}{\theta+1} \ln \left[\sum_{n=1}^{N} t_{in} \frac{\hat{w}_n}{\sum_{m=1}^{N} s_{nm} \hat{w}_m^{-\theta} \hat{z}_m^{\theta}}\right], \tag{6}$$

$$\ln \widehat{u}_i = \ln \hat{w}_i + \frac{1}{\theta} \ln \left[\sum_{n=1}^{N} s_{in} \hat{w}_n^{-\theta} \hat{z}_n^{\theta}\right], \tag{7}$$

where s_{ni} is the share of expenditure of importer n on exporter i; $t_{in} = s_{ni} w_n \ell_n / w_i \ell_i$ is the share of income of exporter i from importer n; $\theta = \sigma - 1 > 0$ is the elasticity of trade with respect to trade costs, where $\sigma > 1$ is the elasticity of substitution; and we report the derivation in Section B of the online appendix.[6]

Given an assumed productivity shock in a given country k ($\hat{z}_k$) and observed expenditure (s_{ni}) and income (t_{in}) shares in an initial equilibrium in the data, we can use this system of equations (6)-(7) to solve for the counterfactual changes in real income ($\widehat{u}_i$) in each country. We thus obtain the arc elasticity of the change in real income in each country i with respect to that productivity shock in country k: $\boldsymbol{U}_{ik} = \ln \widehat{u}_i / \ln \widehat{z}_k$, where $\ln \widehat{x}_i \simeq \mathrm{d} \ln x_i$ for small x_i. Repeating this process and undertaking counterfactuals for an assumed productivity shock in each country k, we can populate the elements of our real income exposure matrix $\boldsymbol{U}$ in equation (4).

We also can derive our real income exposure measure from a linearization of this constant elasticity trade model. Totally differentiating the indirect utility function and the goods market clearing condition, holding bilateral trade costs and endowments constant, we obtain:

$$\mathrm{d} \ln w_i = \sum_{n=1}^{N} t_{in} \left(\mathrm{d} \ln w_n + \theta \left(\sum_{h=1}^{N} \begin{array}{c} s_{nh} \left[\mathrm{d} \ln w_h - \mathrm{d} \ln z_h \right] \\ - \left[\mathrm{d} \ln w_i - \mathrm{d} \ln z_i \right] \end{array} \right) \right), \tag{8}$$

$$\mathrm{d} \ln u_n = \mathrm{d} \ln w_n - \sum_{i=1}^{N} s_{ni} \left[\mathrm{d} \ln w_i - \mathrm{d} \ln z_i \right]. \tag{9}$$

Stacking these comparative statics for each exposed country i (rows) and each shocked country k (columns), we obtain the following matrix representation of this linear system of equations:

$$\mathrm{d} \ln \mathbf{w} = \mathbf{T} \, \mathrm{d} \ln \mathbf{w} + \theta \cdot \mathbf{M} \times \left(\mathrm{d} \ln \mathbf{w} - \mathrm{d} \ln \mathbf{z} \right), \tag{10}$$

$$\mathrm{d} \ln \mathbf{u} \;=\; \mathrm{d} \ln \mathbf{w} - \mathbf{S} \left(\mathrm{d} \ln \mathbf{w} - \mathrm{d} \ln \mathbf{z} \right), \tag{11}$$

where $\mathbf{S} \equiv [s_{ni}]$ is the $N \times N$ matrix with the ni-th element equal to importer n's share of expenditure on exporter i; $\mathbf{T} \equiv [t_{in}]$ is the $N \times N$ matrix with the in-th element equal to exporter i's share of income from importer n; and we define $\boldsymbol{M} \equiv \boldsymbol{T}\boldsymbol{S} - \boldsymbol{I}$.

[6] Note that the order of the subscripts switches between the expenditure share (s_{ni}) and the income share (t_{in}), because the first and second subscripts will correspond below to rows and columns of a matrix, respectively.

Rearranging the nominal income per capita equation (10), taking the matrix inverse, and using the real income per capita equation (11), we recover our real income exposure measure:

$$\mathbf{U} \equiv -\frac{\theta}{\theta+1}\left(\mathbf{I}-\mathbf{S}\right)\left(\mathbf{I}-\mathbf{V}\right)^{-1}\mathbf{M}+\mathbf{S}, \qquad \mathbf{V} \equiv \frac{\mathbf{T}+\theta\mathbf{TS}}{\theta+1}-\mathbf{Q}, \tag{12}$$

where we define $q_n = w_n \ell_n$ as a country's nominal income; $\mathbf{Q}$ is an $N \times N$ matrix with the nominal income row vector $\mathbf{q}'$ stacked N times; the presence of the term in $\boldsymbol{Q}$ reflects our choice of world income as the numeraire, such that $\sum_{i=1}^{N} q_i \operatorname{d}\ln w_i = 0$ or $\mathbf{Q} \operatorname{d}\ln \mathbf{w} = \mathbf{0}$; and we report the full derivations in Section B of the online appendix.

We thus recover the point elasticity of each country's real income with respect to a productivity shock in any country ($\boldsymbol{U}_{in} = \operatorname{d}\ln u_i / \operatorname{d}\ln z_n$) for the entire network of bilateral comparisons from a single matrix inversion. Comparing equations (6)-(7) and (10)-(11), the exact-hat algebra approach involves the log of a weighted mean, while the linearization features a weighted mean of logs. These two approaches yield the same predictions in the two limiting cases of autarky ($t_{nn} \to 1$ and $s_{nn} \to 1$ for all n) and free trade ($t_{in} \to \bar{t}_i$ and $s_{ni} \to \bar{s}_i$ for all n, i). More generally, these two sets of predictions can differ from one another. The exact-hat algebra approach has the advantage of allowing for non-linearities, but requires the researcher to specify an assumed size of the productivity shock for which the arc elasticity is computed. To demonstrate that our empirical findings are not sensitive to the approach taken, or the assumed value for the productivity shock, we implement our analysis of the relationship between political and economic friendship using both approaches. In practice, we find the same qualitative and quantitative pattern of estimated coefficients regardless of which approach is taken.

Economic Interpretation We now use the linearization in equations (10) and (11) to show that our real income exposure measure ($\boldsymbol{U}$) has an intuitive interpretation in terms of the economic mechanisms in the model. From equation (10), the change in nominal income per capita ($\operatorname{d}\ln \mathbf{w}$) in response to a productivity shock is driven by two forces: a *market size effect* ($\mathbf{T} \operatorname{d}\ln \mathbf{w}$) and a *cross-substitution effect* ($\theta \cdot \mathbf{M} \times (\operatorname{d}\ln \mathbf{w} - \operatorname{d}\ln \mathbf{z})$). The market size effect ($\mathbf{T} \operatorname{d}\ln \mathbf{w}$) captures the impact of the productivity shock on total income in each market, where the effect of a change in income in market n on country i depends on the share of its income derived from that market (as captured by the income share matrix $\boldsymbol{T}$).

The cross-substitution effect ($\theta \cdot \mathbf{M} \times (\operatorname{d}\ln \mathbf{w} - \operatorname{d}\ln \mathbf{z})$) captures consumer substitution in each market in response to a productivity shock. This consumer substitution depends on the product of the income share and expenditure share matrices ($\boldsymbol{M} \equiv \boldsymbol{TS} - \boldsymbol{I}$), where the in-th element of the cross-substitution matrix ($\boldsymbol{M} \equiv \boldsymbol{TS} - \boldsymbol{I}$) is given by $m_{in} \equiv \sum_{h=1}^{N} t_{ih} s_{hn} - 1_{n=i}$. For $i \neq n$, the sum $\sum_{h=1}^{N} t_{ih} s_{hn}$ captures the overall competitive exposure of country i to country n, through each of their common markets h, weighted by the importance of market h for country

i's income (t_{ih}). As the competitiveness of country n increases, as measured by a decline in its wage relative to its productivity ($\mathrm{d}\ln w_n - \mathrm{d}\ln z_n$), consumers in all markets h substitute towards country n and away from other countries $i \neq n$. This substitution reduces income in country i and raises it in country n. With a constant elasticity import demand system, the magnitude of this cross-substitution effect in market h depends on the trade elasticity (θ) and the share of expenditure in market h on the goods produced by country n (s_{hn}): consumers in market h increase expenditure on country n by $(s_{hn} - 1)$ and lower expenditure on country i by s_{hn}. Summing across all markets h, we obtain the overall impact on country i's income.

Comparing equations (10) and (11), the change in real income per capita ($\mathrm{d}\ln \mathbf{u}$) in response to a productivity shock depends on the change in nominal income per capita ($\mathrm{d}\ln \mathbf{w}$) and the change in the cost of living ($\mathbf{S}\,(\mathrm{d}\ln \mathbf{w} - \mathrm{d}\ln \mathbf{z})$). This change in the cost of living in country n in turn depends on the share of expenditure (s_{ni}) that country allocates to each country i, as captured in the expenditure share ($\boldsymbol{S}$) matrix.

In general, the changes in nominal income per capita ($\mathrm{d}\ln w_n$) and real income per capita ($\mathrm{d}\ln u_n$) in a given country in response to a productivity shock in another country can be either positive (friends) or negative (enemies), depending on the geography of trade costs and market size, as summarized in the expenditure share ($\boldsymbol{S}$) and income share matrices ($\boldsymbol{T}$), and captured by the market size, cross-substitution and cost of living effects.

Extensions For expositional clarity, we have developed our real income exposure measure using the single-sector Armington model. But the same analysis holds throughout the influential class of trade models with a constant trade elasticity, including Ricardian models such as Eaton and Kortum (2002), and love of variety models such as Krugman (1980), as shown in Section C of the online appendix. Additionally, our baseline specification assumes a single final goods sector. But Section D.3 of the online appendix shows that the same approach can be applied in models with multiple industries, such as Costinot et al. (2012). Finally, Section D.6 of the online appendix show that the same methods can be implemented in state of the art quantitative models with multiple industries and input-output linkages, such as Caliendo and Parro (2015).

In our empirical application, we compute our real income exposure measures using both the exact-hat algebra and linearization approaches for a state of the art trade model with multiple industries and input-output linkages. Our real income exposure measure retains an intuitive interpretation in this richer specification. With multiple sectors, the cross-substitution $\boldsymbol{M}$ matrix accounts for the fact that a market is no longer a third country but is instead a country-industry. The competitive exposure of country i to country n in a country-industry market hk—for instance, countries i and n may compete for the textiles (k) in Singapore (h)—is the product between the income that country i derives from exporting textiles to Singapore and Singapore's within-sector expenditure share on textiles produced by country n, as demonstrated in Section D.3 of the online appendix.

With input-output linkages, the expenditure share ($\boldsymbol{S}$), income share ($\boldsymbol{T}$) and cross-substitution ($\boldsymbol{M}$) matrices must be further adjusted to take into account the network structure of production. The gross value of trade includes not only the direct value-added created in an exporter and industry but also indirect value-added created in previous production stages. Additionally, when evaluating the impact of productivity growth, we now need to take into account whether it reduces intermediate input costs or competitors' output prices at each production stage, as shown in Section D.6 of the online appendix.

3 Data

We now discuss the economic and political data that we use to construct our measures of real income exposure and bilateral political alignment, where further information on the data sources and definitions is reported in Section G of the online appendix.

3.1 Economic Data

Our data on international trade are from the NBER World Trade Database, which reports the value of bilateral trade between countries for around 1,500 4-digit Standard International Trade Classification (SITC) codes. The ultimate source for these data is the United Nations COMTRADE database and we use an updated version of the original dataset from Feenstra et al. (2005) for the time period 1970-2012.[7] We augment these trade data with information on countries' gross domestic product (GDP), population and geographical characteristics from the GEODIST and GRAVITY datasets from CEPII.[8] We measure bilateral air distance as the population-weighted average of the bilateral distances between countries' largest cities. We measure bilateral sea distance as the least-cost path by sea between countries' largest ports, for all bilateral pairs of countries that are connected by sea, as in Feyrer (2019).

We construct expenditure on domestic goods (X_{nnt}) as equal to gross output minus exports, as discussed further in Section G of the online appendix. In our multi-sector models, we distinguish 20 tradeable and 20 non-tradeable sectors according to the International Standard Industrial Classification (ISIC). In our baseline input-output specification, we use a common input-output matrix for all countries, based on the median input-output coefficients across the country sample in Caliendo and Parro (2015). This specification allows us to extend the country coverage to countries for which input-output matrices are not available or for which the reported input-

[7]See https://cid.econ.ucdavis.edu/wix.html.
[8]See http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp.

output matrices involve substantial imputation. But we also report a robustness test in which we use input-output matrices for a large number of countries from the EORA database, although these EORA matrices involve substantial imputation for some countries.[9] Given these trade and production data, we construct the $\mathbf{S}$, $\mathbf{T}$ and $\mathbf{M}$ matrices for both our single-sector model and our multi-sector model with input-output linkages. Our baseline sample includes a balanced panel of 143 countries over the 43 years from 1970-2012.

We combine these international trade data with the World Bank's "Content Of Deep Trade Agreements" database (Hofmann et al. 2017).[10] This database covers 279 agreements signed by 189 countries between 1958 and 2015, which reflects the entire set of preferential trade agreements (PTAs) in force and notified to the World Trade Organization as of 2015. Our main PTA measure is an indicator variable that equals one if a pair of countries participates in a PTA in a given year and zero otherwise.

3.2 Political Data

We combine a number of different measures of countries' bilateral political alignment from the political science and international relations literature. First, we use data on observed voting behavior in the United Nations General Assembly (UNGA) to reveal countries' bilateral political alignment. Second, we use measures of strategic rivalries, as classified by political scientists, based on contemporary perceptions of political decision makers. Third, we use information on formal alliances, including mutual defense pacts, neutrality and non-aggression treaties and ententes. A key advantage of each of these measures relative to data on military conflict is that much international political influence does not involve open hostilities, including international treaties, other supra-national agreements, international institutions, and back-room diplomacy.

United Nations Voting Country votes in the UNGA are recorded as "no" (coded 1), "abstain" (coded 2) or "yes" (coded 3). Our first measure of the similarity of countries' bilateral political attitudes is the S-score of Signorino and Ritter (1999), which equals one minus the sum of the squared actual deviation between a pair of countries' votes scaled by the sum of the squared maximum possible deviations between their votes. By construction, this S-score measure is bounded between minus one (maximum disagreement) and one (maximum agreement).

A limitation of this S-score measure is that it does not control for properties of the empirical

[9] In Section G of the online appendix, we report this robustness test, in which we construct domestic expenditure shares and country-specific input-output tables using the EORA Global Supply Chain Database (https://www.worldmrio.com/), for the shorter time period (1990-2015) and more aggregated industry classification for which these data are available. We find a strong correlation between our baseline measures using the NBER World Trade Database data and those using the EORA database where both data are available.

[10] See https://datacatalog.worldbank.org/dataset/content-deep-trade-agreements.

distribution function of country votes. In particular, country votes may align by chance, such that the frequency with which any two countries agree on a "yes" depends on the frequency with which each country individually votes "yes." Therefore, we also consider two alternative measures of bilateral voting similarity that control in different ways for properties of the empirical distribution of votes. First, the π-score of Scott (1955) adjusts the observed variability of the countries' voting similarity using the variability of each country's own votes around the average vote for the two countries taken together. Second, the κ-score of Cohen (1960) adjusts this observed variability of the countries' voting similarity with the variability of each country's own votes around its own average vote.

Finally, a potential limitation of these three measures of the bilateral similarity of voting patterns is that they do not control for heterogeneity in the resolutions being voted on. To address this concern, Bailey et al. (2017) use the observed UN votes to estimate a time-varying measure of each country's political preferences or "ideal points." They show that these ideal points consistently capture the position of states vis-à-vis the US-led liberal order. We use this approach to derive a measure of bilateral distance between countries' political attitudes by taking the absolute difference between the ideal points of countries i and j in each year t.

Strategic Rivalries Our second set of measures of countries' bilateral political alignment are indicator variables that pick up whether country i is a strategic rival of country j in year t, as classified by Thompson (2001) and Colaresi et al. (2010). These rivalry measures capture the risk of conflict with a country of significant relative size and military strength, based on contemporary perceptions by political decision makers, gathered from historical sources on foreign policy and diplomacy. Specifically, rivalries are identified by whether two countries regard each other as competitors, a source of actual or latent threats that pose some possibility of becoming militarized, or enemies. These rivalries are also further disaggregated into the following different types: (i) positional, where rivals contest relative shares of influence over activities and prestige within a system or subsystem; (ii) spatial, where rivals contest the exclusive control of a territory; and (iii) ideological, where rivals contest the relative virtues of different belief systems relating to political, economic or religious activities.

Strategic rivalry is much more prevalent than military conflict, as shown in Aghion et al. (2018). In our sample from 1970-2012, we find that a total of 42 countries have had at least one strategic rival; 74 country-pairs have been strategic rivals at some point; and the total number of country-pair-years that exhibit strategic rivalry is 2,452. For example, China is classified as a strategic rival of the U.S. (1970–1972 and 1996–present), India (the entire sample period), Japan (1996–present), the former Soviet Union (1970–1989), and Vietnam (1973–1991). By comparison, the United States is coded as a strategic rival of China (1970-72 and 1996-2012), Cuba (1970-

2012), and the former Soviet Union (1970-89 and 2007-2012). While there are many dimensions of strategic rivalry, and any one measure can be questioned, we focus on this standard measure from the political science and international relations literature, to ensure that our results are not driven by the use of non-standard measures of strategic rivalry.

Formal Alliances Our third set of political alignment measures are indicator variables for whether country i is in a formal alliance with country j in year t from the Correlates of War Formal Alliances v4.1 (Gibler 2008). This dataset records all formal alliances among states between 1816 and 2012, including mutual defense pacts, neutrality and non-aggression treaties, and ententes. A defense pact is the highest level of military commitment, requiring alliance members to come to each other's aid militarily if attacked by a third party. Neutrality and non-aggression pacts pledge signatories to either remain neutral in the case of conflict or not use force against the other alliance members. Ententes obligate members to consult in times of crisis or armed attack. Over our entire sample period from 1970-2012, 1,946 country-pairs are in a formal alliance, and 117 countries have at least one formal ally. In the year 2010, China had four allies: Iran, North Korea, Russia, and Pakistan. In contrast, the United States was in alliance with 49 nations in the same year, a significantly greater number than the median country, which has 10 allies.

4 Descriptive Evidence

In this section, we provide some descriptive evidence on our measures of real income exposure. In Subsection 4.1, we examine the evolution of real income exposure across countries and over time. In Section 4.2, we use our hub and authority scores to provide evidence on the large-scale changes in the centrality of countries in the network of real income exposure that occurred over our sample period. In Section 4.3, we report a external validation exercise for our real income exposure measures, in which show that they successfully detect changes in economic interdependence following the formation of Preferential Trade Agreements (PTAs).

Throughout our empirical analysis, we use our quantitative specification with multiple sectors and input-output linkages, as discussed in Section 2. In our baseline specification, we measure the elasticity of real income to foreign productivity growth using the point elasticity from the linearization of the conditions for general equilibrium. But we find the same qualitative and quantitative pattern of results using arc elasticities from exact-hat algebra counterfactuals.[11]

[11] In Section F of the online appendix, we report a robustness test using arc elasticities for 10 percent productivity shocks. For productivity shocks up to the cumulative change in the relative productivity of countries over our forty-year sample period, we find the same qualitative and quantitative pattern of results using either the point or arc elasticities, as discussed further in Section F of the online appendix.

4.1 Real Income Exposure

In Figure 1, we show the mean and standard deviation of real income exposure to foreign productivity shocks (excluding own productivity shocks) in our quantitative specification incorporating multiple sectors and input-output linkages. Four main features are apparent. First, we find that on average foreign productivity shocks raise domestic real income exposure, because the net effect of the market-size, cross-substitution and cost of living effects is typically positive. Around 30 percent of bilateral pairs are enemies, although these negative values for real income exposure are typically small in absolute magnitude. Enemies are frequently raw materials exporters that compete for markets, such as Chile and South Africa, and Saudi-Arabia and Niger. The absence of direct trade increases the probability that bilateral pairs are enemies, consistent with the cross-substitution effect being particularly strong in this case.

Second, we find that the mean elasticity of real income to foreign productivity growth is small, because our exposure measure is a local elasticity with respect to a small increase in productivity, foreign trade is a small share of income for most countries, most individual trade partners are a small share of foreign trade, and many individual trade relationships have zero flows.[12] Third, we observe substantial heterogeneity in real income exposure across individual pairs of trading partners, with the standard deviation larger than the mean. Fourth, we observe an increase in both the mean and standard deviation of real income exposure over time, consistent with increased globalization over our sample period enhancing countries' interdependence.

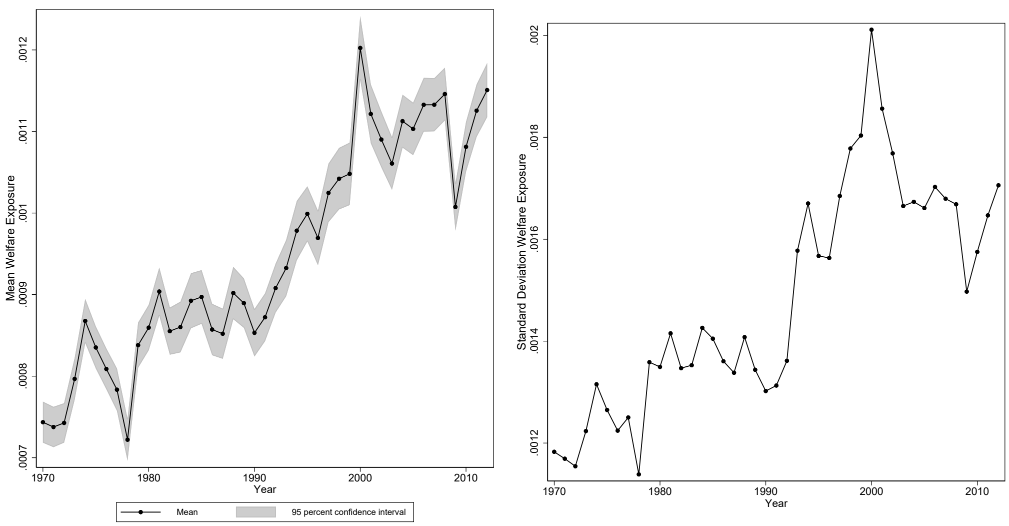
In Section E of the online appendix, we compare our real income exposure measure ($\boldsymbol{U}^{IO}$) to a number of simpler measures of trading relationships between countries: (i) log value of bilateral trade; (ii) aggregate import shares (the expenditure share matrix from our single-sector model ($\boldsymbol{S}^{SSM}$)); (iii) the expenditure share matrix from our input-output model ($\boldsymbol{S}^{IO}$); (iv) the income share matrix from our input-output model ($\boldsymbol{T}^{IO}$); and (v) the cross-substitution matrix from our input-output model ($\boldsymbol{M}^{IO}$). While our real income exposure measure has statistically significant correlations with all of these variables, we show that they are all imperfect proxies for our theory-based measure.

4.2 Hub and Authority Scores

As our approach recovers the bilateral network of real income exposure, we can use techniques from the networks literature to characterize the role of countries' positions within the network in shaping the impact of productivity growth. In particular, we use the authority and hub scores from Kleinberg (1999), which capture the extent to which a country affects others (authority

[12] To obtain the percentage change in real income in response to productivity shocks, one needs to multiply the elasticities in Figures 1 by the size of the shock. When we do so, we obtain similar predictions for the impact of productivity shocks to the existing quantitative trade literature.

Figure 1: Mean and Standard Deviation of Real Income Exposure to Productivity Shocks in Other Countries over Time



Note: Left panel shows mean real income exposure (black line) and the 95 percent confidence interval (gray shading); right panel shows the standard deviation of real income exposure (black line); both panels exclude own productivity shocks; NBER World Trade Database and authors' calculations using our input-output specification.

score) and the extent to which a country is influenced by others (hub score), as discussed in Section 2 above. We compute these hub and authority scores for real income exposure ($\boldsymbol{U}$) for each year of our sample period. We set the diagonal entries of $\boldsymbol{U}$ to zero, in order to focus on real income exposure to foreign productivity growth. We report 5-year moving averages to abstract from short-run fluctuations in international trade flows.

In Table 1, we list the five countries with the highest authority and hub scores for the years 1980 and 2010.[13] Countries with higher authority scores—the productivity growth of which generates the greatest real income impact to others—tend to be larger, although country-level GDP is only moderately correlated with authority scores, with a correlation coefficient of 0.66. The authority scores spotlight the decline of Japan, and the rise of China, which was outside of the top-5 in 1980, but had the greatest authority score in 2010. Table 1 also lists the countries that are most exposed to foreign productivity changes. The hub score weakly and negatively correlates (coefficient -0.10) with a country's GDP.

[13]In Section E of the online appendix, we provide further evidence on the evolution of the network of global bilateral real income exposure over our sample period using network graphs.

Table 1: Countries with the Highest Real Income Authority and Hub Scores, 1980 and 2010

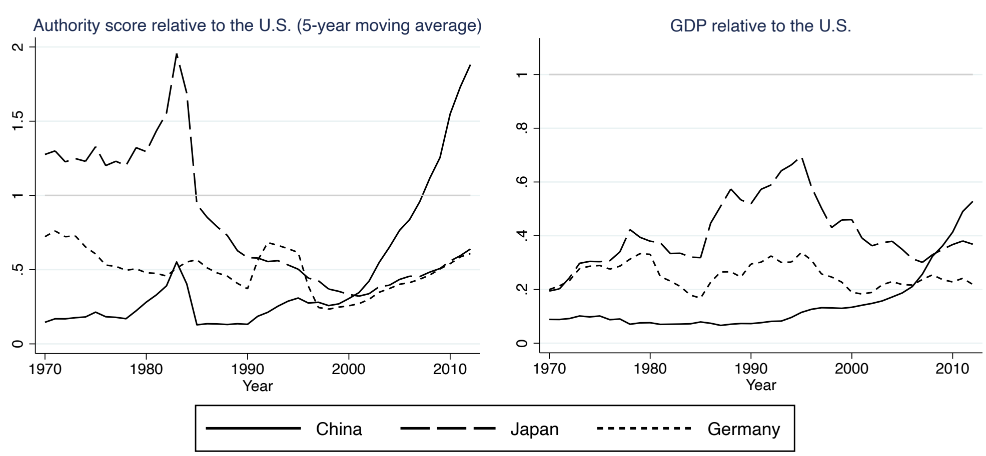
Countries with the highest authority scores		Countries with the highest hub scores	
1980	2010	1980	2010
1. United States	1. China	1. Cambodia	1. Syria
2. Japan	2. United States	2. Singapore	2. Singapore
3. Saudi Arabia	3. France	3. Trinidad and Tobago	3. Vietnam
4. United Kingdom	4. Japan	4. Somalia	4. Malaysia
5. France	5. Germany	5. Lebanon	5. Taiwan

Note: Authority and hub scores for real income exposure computed using equation (5) above in our input-output specification.

Even though correlated with GDP, the authority score has substantial independent variation. We find that countries more integrated into global value chains (including the South-East Asian countries of Singapore, Thailand, Malaysia, Taiwan towards the end of our sample period) tend to have greater authority scores relative to GDP. In contrast, commodity exporters (such as Brazil, Mexico, Chile, and Colombia) tend to have lower authority scores relative to GDP.

In the left panel of Figure 2, we show the authority score of China, Japan, and Germany relative to that of the U.S. over our sample period. In the right panel, we show the GDP of the same group of countries relative to that of the U.S.. A striking feature is that while the GDPs of Japan and China never exceed 70 percent of the U.S. level between 1970 and 2012, the authority scores of Japan and China far exceed those of the U.S. in the 1980s and 2010s, respectively. Therefore, these authority scores sharply illustrate the growing dependence of other countries on Chinese productivity growth over the course of our sample period.

Figure 2: Real Income Authority scores and GDP relative to the U.S. for China, Japan, and Germany



Source: NBER World Trade Database and authors' calculations using our input-output specification.

4.3 Validation Using Preferential Trade Agreements (PTAs)

We now provide a validation check on our real income exposure measure using separate data on PTAs not used in its construction. In particular, if our real income exposure measure correctly captures economic interdependence between countries, we would expect to observe systematic increases in real income exposure between member countries following the formation of a PTA. To examine this hypothesis empirically, we consider the following conventional event-study "difference-in-differences" specification:

$$\boldsymbol{U}_{nit}^{IO} = \sum_{s \in \{S_-, S_+\}} \beta_s (\mathbb{I}_{ni}^{PTA} \times \mathbb{I}_s) + \xi_{ni} + d_{ct} + h_{nit}, \tag{13}$$

where recall that n indexes importers, i denotes exporters and t corresponds to calendar year; $\mathbb{I}_{ni}^{PTA}$ is a dummy variable that equals one if an exporter-importer pair ever signs a trade agreement during our sample period; s is a treatment year index, which equals zero in the year an exporter-importer pair joins a PTA; therefore, negative values of s indicate years before joining a PTA and zero or positive values represent years after joining a PTA; $\mathbb{I}_s$ is a dummy variable that equals one in treatment year s and zero otherwise; we choose treatment year minus one as the excluded category; S_- and S_+ are the minimum and maximum values of treatment years, respectively; ξ_{ni} are exporter-importer pair fixed effects, which control for time-invariant factors that affect both bilateral real income exposure and whether an exporter-importer joins a PTA; d_{ct} are continent-year dummies, which control for secular changes over time in real income exposure and the propensity to join PTAs, where we allow these secular changes to vary by continent (results are similar with just year dummies); and h_{nit} is a stochastic error.

The key coefficients of interest are β_s on the treatment-year interactions, which capture the impact of the PTA on real income exposure in treatment year s, relative to the excluded category of treatment year minus one. Our inclusion of exporter-importer fixed effects controls for selection into PTAs based on time-invariant factors. Therefore, if exporter-importer pairs with high levels of real income exposure are more likely to form PTAs in all years, this is controlled for in the exporter-importer fixed effect. The key identifying assumption in equation (13) is parallel trends between the treatment and control group within continents. As a check on this identifying assumption, we include the treatment-year interactions for years both before and after joining a PTA, which allows us to provide evidence on whether treated exporter-importer pairs exhibit different trends from control pairs even before joining a PTA.

We report results using a number of different estimators of this event-study specification. We begin with the conventional two-way fixed effects estimator. However, a recent empirical literature has highlighted that the interpretation of this two-way fixed effects estimator can be problematic in the presence of treatment heterogeneity and a variable timing of the treatment. Therefore, we also report results using the alternative estimators of Chaisemartin and D'Haultfloeuille (2020) and Borusyak et al. (2021) that address this concern. In our application, we find a relatively similar pattern of results across all three of these estimators.

In Figure 3a, we display the estimated treatment-year interactions and 95 percent confidence intervals for real income exposure to productivity growth ($\boldsymbol{U}_{nit}^{IO}$) using the two-way fixed effects estimator. We find no evidence of statistically significant differences in trends between the treatment and control group in the years leading up to the formation of a PTA, which is consistent with the idea that the inclusion of the exporter-importer fixed effect largely controls for non-random selection into PTAs. In contrast, we observe a substantial and statistically significant increase in real income exposure to productivity growth ($\boldsymbol{U}_{nit}^{IO}$) immediately following the formation of a PTA, as expected if the PTA increases economic interdependence among member countries.

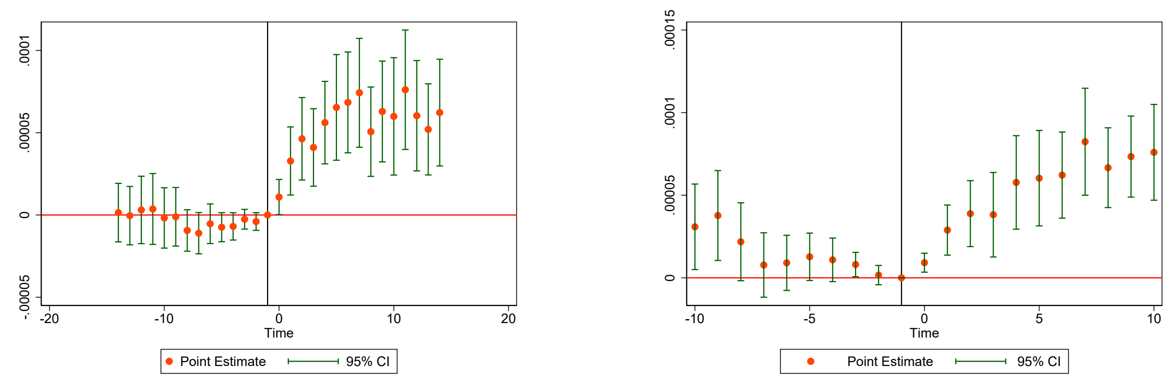
In Figure 3b, we show that we find a similar pattern of results using the Chaisemartin and D'Haultfloeuille (2020) estimator. In Section E of the online appendix, we report a number of additional robustness checks. We show that we find similar results if we control for the log value of bilateral trade between each exporter-importer pair, again confirming that our exposure measures cannot be fully captured by simpler measures of trading relationships. We also find similar results using the alternative event-study estimator of Borusyak et al. (2021).

Therefore, we find that our real income exposure measure successfully detects increased economic interdependence between member countries following the formation of a PTA, providing validation of it using separate data not used in its construction.

Figure 3: Estimated Treatment Effects of Preferential Trade Agreements (PTAs) on Real Income Exposure

(a) Importer Real Income Exposure to Exporter Productivity
Growth ($\boldsymbol{U}_{nit}^{IO}$)

(b) Importer Real Income Exposure to Exporter Productivity
Growth ($\boldsymbol{U}_{nit}^{IO}$)



Note: Estimated treatment-year interactions (β_s) from equation (13); Figure 3a shows results using the two-way fixed effects estimator; Figure 3b shows results using the Chaisemartin and D'Haultfloeuille (2020) estimator; we report results using the Borusyak et al. (2021) estimator in Section E of the online appendix.

5 Economic and Political Friends and Enemies

We now turn to our central empirical question of whether as countries become more economically dependent on a trade partner, they realign politically towards that trade partner. The key empirical challenge is that bilateral real income exposure depends on bilateral trade flows, which in general are endogenous to bilateral political alignment. Therefore, there could be reverse causality from bilateral political alignment to bilateral real income exposure, or both variables could be influenced by omitted third variables, such as geographical proximity.

We address this empirical challenge using two different sources of quasi-experimental variation. First, a large empirical literature following Autor et al. (2013) argues that China's rapid economic growth was driven its domestic supply-side reforms in 1978. Therefore, we use an exogenous increase in China's productivity from domestic reform as a source of exogenous variation in other countries' real income exposure.

Second, we use the large-scale reductions in the cost of air travel that occurred over our sample period as a source of exogenous variation in bilateral trade costs following Feyrer (2019).[14] The key idea underlying this approach is that the position of land masses around the globe generates large differences between bilateral distances by sea and the great circle distances that are more typical of air travel. As a result, countries with long sea routes relative to air routes benefit disproportionately from reductions in the relative cost of air travel, giving rise to uneven changes in bilateral trade costs over time.

5.1 Chinese Productivity Growth

We begin by illustrating the large-scale changes in political alignment and real income exposure towards China that occurred over our sample period. We next introduce the regression specification that we use to examine the relationship between changes in political alignment and changes in real income exposure induced by an exogenous increase in China's productivity. Throughout this section, we focus on our measures of bilateral political alignment using UN voting data, because there are relatively few changes in strategic rivalry or formal alliances between the single country of China and its trade partners over our sample period.

Geography of Real Income Exposure and Political Alignment In the top panel of Figure 4, we show maps of country real income exposure to Chinese productivity growth in 1980 (shortly after its market-orientated reforms) and 2010 (close to the end of our sample period). We divide the real income exposure distribution into five discrete cells, with darker red shading denoting

[14] Between 1955 and 2004, the cost of moving goods by air fell by a factor of ten (Hummels 2007). Before 1960, the air transport share of trade for the United States was negligible. By 2004, air transport accounted for over half of US exports by value, excluding Canada and Mexico (Feyrer 2019).

larger values. We hold the boundaries between these five discrete cells constant over time, so that the intensity of shading is comparable over time. We find positive real income effects of Chinese productivity growth on most countries.[15] In 1980, these effects are relatively modest, with the most positive real income effects concentrated in South-East Asia, Oceania and a number of African countries. By 2010, we find a substantial increase in the absolute magnitude of these real income effects, which are again geographically concentrated in South-Asia, Oceania and much of North and Sub-Saharan Africa, but now extend to a number of Latin American countries.

In the bottom panel of Figure 4, we show maps of the similarity of countries' voting patterns to China in the UNGA in both 1980 and 2010. We use our baseline κ-score measure of voting similarity, which controls for the empirical distribution of yes, no or abstain votes. We again divide the voting similarity measure into five discrete cells, holding the boundaries between these cells constant, and using darker red shading to denote greater voting similarity. Alongside the dramatic increase in real income exposure in the top panel, we find a large-scale increase in voting similarity in the bottom panel, consistent with a close relationship between increases in economic dependence on China and political realignment towards it.

Comparing the four panels, we find a striking resemblance in both levels and changes between the geographic patterns of voting similarity and real income exposure. The countries with the largest levels and changes in voting similarity to China in the bottom panel are clustered in South-East Asia and a number of North and sub-Saharan African countries, which corresponds closely to the countries with the largest levels and changes in real income exposure towards China in the top panel.

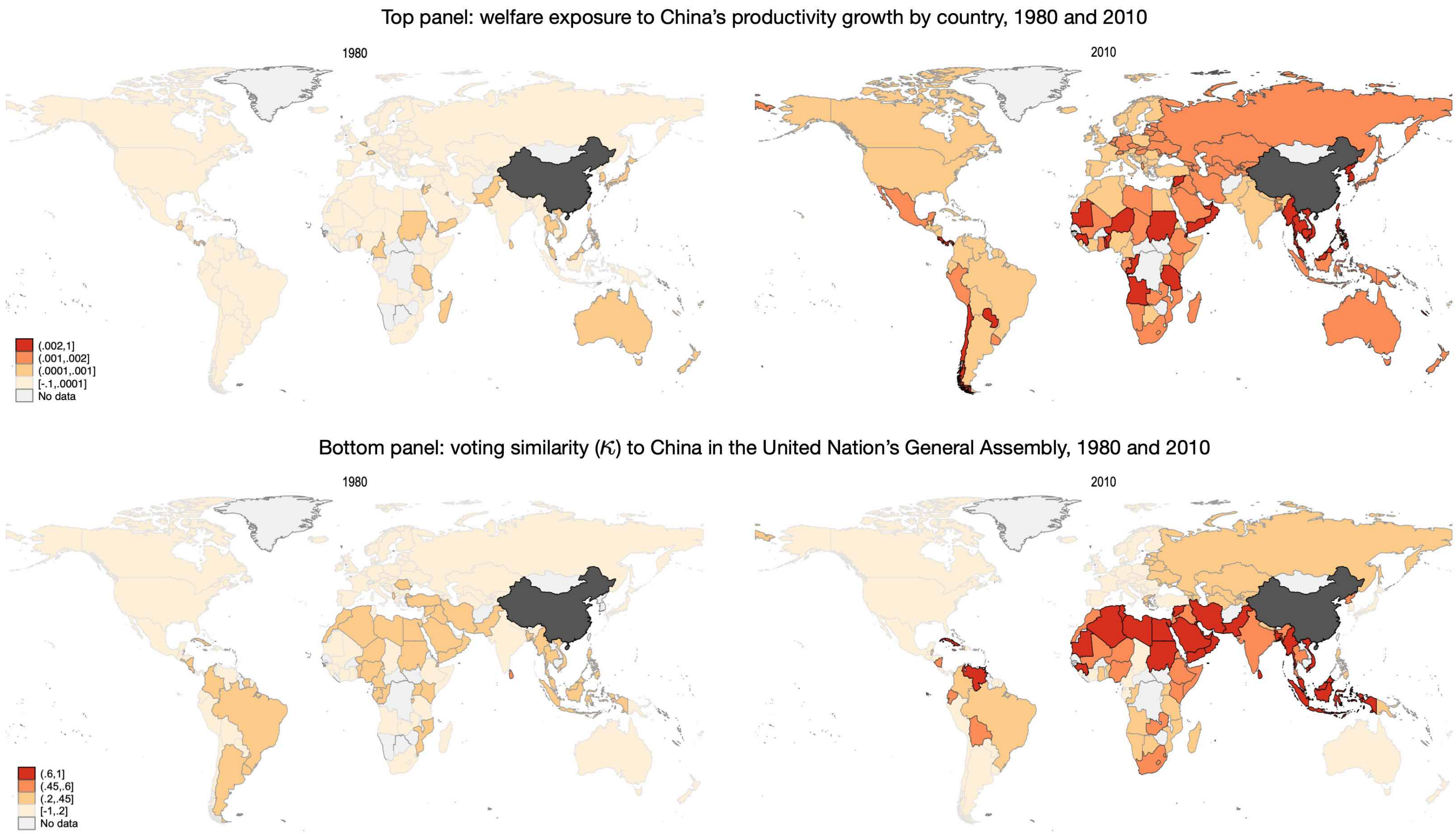
Long Differences Specification We now provide further regression evidence on this relationship between changes in political alignment and the changes in real income exposure. We begin by computing the 30-year change in countries' political alignment towards China ($\Delta \boldsymbol{A}_{nct}$) from 1980 (shortly after its domestic liberalization) to 2010 (shortly before the end of our sample period). We next relate this 30-year change in political alignment towards China ($\Delta \boldsymbol{A}_{nct}$) to the 30-year change in our input-output measure of countries' real income exposure to China ($\Delta \boldsymbol{U}_{nct}^{IO}$):

$$\Delta \boldsymbol{A}_{nct} = \beta \Delta \boldsymbol{U}_{nct}^{IO} + \ln \boldsymbol{X}_{nct} \gamma + \varepsilon_{nct}, \tag{14}$$

where the second subscript c denotes the single exporter of China; the first subscript n indexes other importing countries; $\ln \boldsymbol{X}_{nct}$ are controls; ε_{nct} is a stochastic error; and we drop China from the regression sample, because its political alignment towards itself is not well defined; observations correspond to a single long-differenced cross-section of countries.

[15]In contrast, we find negative effects on relative nominal income for a number of countries, highlighting the importance of distinguishing real income from nominal income, because of the strength of cost of living effects.

Figure 4: Country Real Income Exposure and Voting Similarity to China, 1980 and 2010



Note: Top panel shows our input-output measure of country real income exposure to China in 1980 and 2010 ($\boldsymbol{U}_{nit}^{IO}$); bottom panel shows the similarity of countries' votes in the UNGA to China in 1980 and 2010, using our baseline κ-score measure of voting similarity ($\boldsymbol{A}_{nit}^{\kappa}$); darker shades of red denote more positive values; the boundaries between the five discrete cells are held constant over time, such that the intensity of red shading is comparable over time. Source: NBER World Trade Database and authors' calculations.

We begin by estimating equation (14) using ordinary least squares (OLS). Although most of the change in real income exposure to China ($\Delta \boldsymbol{U}_{nct}^{IO}$) over this time period is likely to be driven by changes in the fundamental component of productivity from China's domestic reforms ($\overline{z}_{ct}$ in equation (2)), our political economy model implies a feedback from changes in political alignment ($\Delta \boldsymbol{A}_{nct}$) to changes in the endogenous component of productivity ($f_i(\cdot)$ in equation (2)). To isolate the change in real income exposure to China ($\Delta \boldsymbol{U}_{nct}^{IO}$) driven by changes in the fundamental component of productivity ($\overline{z}_{ct}$), we use the structure of our model to construct an instrument. In particular, we start at the observed equilibrium in the data in 1980, and compute the counterfactual change in real income exposure to Chinese productivity growth implied by an exogenous increase in China's productivity from domestic reform, holding all else constant. This instrument captures the pure supply-side impact of an exogenous increase in China's productivity on other countries' real income exposure and can be computed for a range of assumed sizes of the exogenous increase in productivity.[16]

In Column (1) of Table 2, we report the results of estimating equation (14) using OLS and our preferred κ-score measure of bilateral political alignment, which controls for the empirical frequency with which each country individually votes yes, no and abstain. We find a positive and statistically significant coefficient, implying that countries that experienced larger increases in real income exposure to China also experienced greater political realignment towards China. We find that this estimated coefficient is not only statistically significant but also economically relevant. The estimates in Column (1) imply that a one standard deviation in real income exposure to China in Column (1) leads to a 0.26 standard deviation increase in political alignment towards China. In Columns (2) and (3), we show that we find a similar pattern of results using alternative measures of the similarity of countries' votes in the UNGA: the simpler S-score measure (based on the sum of squared deviations in votes) and the π-score (which controls for the empirical frequency with pairs of countries jointly vote yes, no).

In Columns (4)-(6), we show that these findings are robust to controlling for changes in countries' log bilateral trade with China.[17] The estimated coefficients on changes in real income exposure remain positive, statistically significant and of around the same magnitude, for all three measures of bilateral political alignment. In contrast, the estimated coefficients on log bilateral trade are negative, and for some of the measures only statistically significant at the 10 percent level. Therefore, our theoretically-consistent real income exposure measure is not well approxi-

[16]In our baseline specification, we use an exact-hat algebra counterfactual for a 100 percent increase in China's productivity in our input-output model. We find similar estimated second-stage coefficients for alternative assumed sizes of the China productivity shock, or using our linearization of the input-output model, as discussed further in Section F of the online appendix.

[17]We use the change in the log of one plus bilateral trade to incorporate zero observations. We find similar results using the inverse hyperbolic sign or restricting the sample to observations with positive trade flows.

mated by simpler measures of trading relationships between countries.[18]

Table 2: Changes in Political Alignment towards China and Changes in Real Income Exposure towards China from 1980-2010

	(1) $\Delta\boldsymbol{A}^{\kappa}_{nct}$	(2) $\Delta\boldsymbol{A}^{S}_{nct}$	(3) $\Delta\boldsymbol{A}^{\pi}_{nct}$	(4) $\Delta\boldsymbol{A}^{\kappa}_{nct}$	(5) $\Delta\boldsymbol{A}^{S}_{nct}$	(6) $\Delta\boldsymbol{A}^{\pi}_{nct}$
$\Delta\boldsymbol{U}^{IO}_{nct}$	44.12***	22.69***	47.26***	51.74***	26.08***	58.38***
	(15.10)	(6.665)	(15.65)	(16.12)	(7.172)	(17.05)
$\Delta \ln \boldsymbol{X}_{nct}$				-0.0263*	-0.0117*	-0.0385***
				(0.0139)	(0.00597)	(0.0139)
Estimation	OLS	OLS	OLS	OLS	OLS	OLS
Observations	119	119	119	119	119	119
R-squared	0.0484	0.0491	0.0447	0.0776	0.0713	0.0950

Note: Long-differences specification from 1980-2010 for a cross-section of countries excluding China; each column corresponds to a separate regression, with the left-hand side variable reported at the top of the column and the right-hand side variables listed in the rows; $\Delta\boldsymbol{A}^{\kappa}_{nct}$ is the 30-year change in our preferred κ-score measure of country n's bilateral political alignment towards China that controls for the empirical distribution with which each country votes yes, no and abstain; $\Delta\boldsymbol{A}^{S}_{nct}$ is the 30-year change in the S-score measure of country n's bilateral political alignment towards China; $\Delta\boldsymbol{A}^{\pi}_{nct}$ is the 30-year change in the π-score measure of country n's bilateral political alignment towards China; $\Delta\boldsymbol{U}^{IO}_{nct}$ is the 30-year change in our input-output measure of country n's real income exposure to China; $\Delta \ln \boldsymbol{X}_{nct}$ is the 30-year change in the log of one plus country n's bilateral trade with China; standard errors in parentheses are heteroskedasticity robust; *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

In Columns (1)-(3) of Table 3, we report the results of re-estimating Columns (1)-(3) of Table 2 using instrumental variables. We instrument the change in real income exposure to China ($\Delta\boldsymbol{U}^{IO}_{nct}$) with our model-based instrument, namely the counterfactual change in real income exposure to China in response to an exogenous 100 percent increase in Chinese productivity.[19] We continue to find a positive and statistically significant relationship, consistent with exogenous increases in economic dependence on China causing political realignment towards China. We find an IV coefficient that is around twice as large as the OLS coefficient. This increase in the absolute magnitude of the coefficient is consistent with the idea that changes in political alignment are driven by long-run secular trends, whereas the observed changes in real income exposure are influenced by many sources of idiosyncratic shocks to bilateral trade. The OLS specification uses all of this variation in changes in real income exposure. In contrast, the IV specification focuses solely on the variation in changes in real income exposure driven by an exogenous secular increase in China's productivity. Once we focus on this secular variation in the IV specification, we find a stronger relationship between political and economic friendship. We find that our model-

[18]We also find the same pattern of results if we control for initial political alignment towards China, which confirms that our findings are not driven by political dynamics related to initial political alignment.

[19]As discussed above, we find similar results for alternative assumed sizes of the exogenous China productivity shock using exact-hat algebra counterfactuals, or using our linearization of the input-output model.

based instrument has power in the first-stage regression, using both the Kleibergen-Paap rk Wald F-statistic and the Anderson-Rubin Chi-squared statistic.

Table 3: Changes in Political Alignment towards China and Changes in Initial Real Income Exposure towards China from 1980-2010 (Instrumental Variables Specification)

	(1) $\Delta \boldsymbol{A}^{\kappa}_{nct}$	(2) $\Delta \boldsymbol{A}^{S}_{nct}$	(3) $\Delta \boldsymbol{A}^{\pi}_{nct}$	(4) $\Delta \boldsymbol{A}^{\kappa}_{nct}$	(5) $\Delta \boldsymbol{A}^{S}_{nct}$	(6) $\Delta \boldsymbol{A}^{\pi}_{nct}$
$\Delta \boldsymbol{U}^{IO}_{nct}$	101.3***	29.44***	105.5***	81.23***	25.94**	66.94***
	(27.67)	(11.25)	(30.10)	(22.68)	(11.70)	(24.89)
$\Delta \ln \boldsymbol{X}_{nct}$				-0.0173	-0.00302	-0.0333*
				(0.0157)	(0.00859)	(0.0171)
Estimation	IV	IV	IV	IV	IV	IV
Observations	119	119	119	119	119	119
Kleibergen-Paap F	21.82	21.82	21.82	10.66	10.66	10.66
Anderson-Rubin p-value	<0.01	<0.01	<0.01	<0.01	0.022	<0.01

Note: Long-differences specification from 1980-2010 for a cross-section of countries excluding China; each column corresponds to a separate regression, with the left-hand side variable reported at the top of the column and the right-hand side variables listed in the rows; $\Delta \boldsymbol{A}^{\kappa}_{nct}$ is the 30-year change in our preferred κ-score measure of country n's bilateral political alignment towards China that controls for the empirical distribution with which each country votes yes, no and abstain; $\Delta \boldsymbol{A}^{S}_{nct}$ is the 30-year change in the S-score measure of country n's bilateral political alignment towards China; $\Delta \boldsymbol{A}^{\pi}_{nct}$ is the 30-year change in the π-score measure of country n's bilateral political alignment towards China; $\Delta \boldsymbol{U}^{IO}_{nct}$ is the 30-year change in our input-output measure of country n's real income exposure to China; $\Delta \ln \boldsymbol{X}_{nct}$ is the 30-year change in the log of one plus country n's bilateral trade with China; Columns (1)-(3) instrument changes in exposure $\Delta \boldsymbol{U}^{IO}_{nct}$ with our model-based instrument, namely the counterfactual change in real income exposure to China in response to a 100 percent exogenous increase in productivity in China; Columns (4)-(6) instrument both $\Delta \boldsymbol{U}^{IO}_{nct}$ and $\Delta \ln \boldsymbol{X}_{nct}$ using our model-based instrument and the initial level of the log of one plus bilateral trade with China in 1980; Kleibergen-Paap is the Kleinbergen-Paap rk Wald F-statistic; Anderson-Rubin p-value is for the Anderson-Rubin χ^2-statistic; standard errors in parentheses are heteroskedasticity robust; *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

In Columns (4)-(6) of Table 3, we show that these results are again robust to controlling for changes in log bilateral trade with China. Since changes in log bilateral trade are also endogenous to changes in bilateral political alignment, we develop a second instrument to address this concern. While our model implies that real income exposure drives bilateral political alignment, it does not have a clear prediction for the impact of log trade conditional on real income exposure. Therefore, we treat log trade as a reduced-form control, and develop a reduced-form instrument for it. In particular, we use a shift-share type insight that the countries that experienced the largest increases in bilateral trade with China following its domestic productivity growth are likely to be those with the highest initial levels of bilateral trade with China. Based on this idea, we instrument the change in bilateral trade with China from 1980-2010 with its initial level in 1980. Once we instrument both changes in real income exposure and changes in bilateral trade using our two instruments, we continue to find a positive and statistically significant coefficient on changes in real income exposure, consistent with the idea that exogenous increases in economic dependence on China cause political realignment towards China. We find coefficients on log bilateral trade that are negative, and in some specifications statistically insignificant, once more confirming that our real income exposure measure is not well approximated by simpler measures of trading relationships between countries. Our instruments continue to have power in the first-stage regression, according to both the Kleibergen-Paap rk Wald F-statistic and the Anderson-Rubin χ^2-statistic.

Therefore, using quasi-experimental variation in other countries' real income exposure from an exogenous increase in productivity in China, we find that as countries become more economically dependent on China, they indeed realign politically towards it.

5.2 Reductions in the Cost of Air Travel

We next use the large-scale reduction in the cost of air travel that occurred over our sample period as an alternative source of quasi-experimental variation in real income exposure. To the extent that we find similar results using these two quite different sources of quasi-experimental variation, this provides further support for a causal effect of economic dependence on political alignment. Using the bilateral variation from reductions in the cost of air travel has the additional advantage that it allows us to include exporter-year and importer-year fixed effects as controls to capture exporter and importer-specific shocks that are common across all trade partners. This bilateral variation also allows us to consider a wider range of measures of bilateral political alignment, exploiting the many changes in strategic rivalry and formal alliances that are observed across all bilateral pairs of countries over our sample period.

We begin by introducing our regression specification and discussing the construction of our instrument using the reduction in the cost of air travel over time. We next report our main empirical results using measures of bilateral political alignment based on the UNGA voting data. Finally, we demonstrate the robustness of our results to the use of alternative measures of bilateral political alignment based on strategic rivalry and formal alliances.

Empirical Specification We consider the following second-stage regression specification relating bilateral political alignment ($\boldsymbol{A}_{nit}$) to bilateral real income exposure ($\boldsymbol{U}_{nit}^{IO}$) for importer n and exporter i at time t:

$$\boldsymbol{A}_{nit} = \beta^{A} \boldsymbol{U}_{nit}^{IO} + \vartheta_{ni}^{A} + \eta_{nt}^{A} + \mu_{it}^{A} + \epsilon_{nit}^{A}, \tag{15}$$

where observations are exporters i, importers n and years t; ϑ_{ni}^{A} is an importer-exporter fixed effect that captures time-invariant unobserved heterogeneity; η_{nt}^{A} and μ_{it}^{A} are importer-year and exporter-year fixed effects; and ϵ_{nit}^{A} is a stochastic error.

We expect countries that benefit more from a partner's productivity growth (more positive or less negative real income exposure $\boldsymbol{U}_{nit}^{IO}$) to be more politically aligned with that partner (higher $\boldsymbol{A}_{nit}$), which corresponds to a positive estimated coefficient β^{A}. In general, a country's political alignment towards a trade partner could depend on both the elasticity of its real income to productivity growth in that partner and the sign and magnitude of the productivity growth. We control separately for the sign and magnitude of exporter productivity growth using exporter-year fixed effects, exploiting the property that productivity growth is common across trade partners. We also control separately for importer-year fixed effects, which capture importer expenditure and price indexes, and other macro shocks that are common across trade partners. Finally, we control for time-invariant unobserved heterogeneity that is specific to each exporter-importer pair and affects both bilateral political alignment and real income exposure (e.g., geographical distance) through the inclusion of the exporter-importer fixed effects. We report standard errors clustered by country-partner pair to allow for serial correlation in the error term over time.

Despite the inclusion of the wide range of fixed effects, the OLS relationship between economic exposure and bilateral political alignment in equation (15) could still be influenced by simultaneity concerns and measurement errors. First, unobserved positive shocks to bilateral political alignment in the error term (ϵ_{nit}^{A}) could raise bilateral trade and hence raise real income exposure ($\boldsymbol{U}_{nit}^{IO}$), thereby introducing a positive correlation between real income exposure and the error term, and inducing an upward bias in the estimated coefficient (β). Second, political alignment is likely to be determined by secular forces that are slow moving compared to bilateral trade flows, which are subject to higher-frequency idiosyncratic shocks. These idiosyncratic shocks imply that observed bilateral trade flows need not perfectly capture long-run trade relationships. Therefore, even if these idiosyncratic shocks are independently distributed, they could act like classical measurement error in attenuating the estimated coefficient (β) towards zero.

Construction of the Instruments To address these concerns, we use the large-scale reduction in the cost of air travel over our sample period as a source of exogenous variation in bilateral trade costs following Feyrer (2019). We use this source of variation and the structure of our model to construct an instrument for real income exposure. First, we estimate a gravity equation specification that relates the expenditure share of importer n on exporter i in sector k (s_{nit}^{k}) to time-varying coefficients on air and sea distance. Second, we use this gravity equation estimation to predict expenditure shares (s_{nit}^{k*}), where we use an asterisk to denote the predicted value of a variable. Third, we use these predicted expenditure shares (s_{nit}^{k*}) and our linearization in equation (12) to compute predicted real income exposure ($\boldsymbol{U}_{nit}^{IO*}$). Fourth, we use predicted real income exposure ($\boldsymbol{U}_{nit}^{IO*}$) to instrument actual real income exposure ($\boldsymbol{U}_{nit}^{IO}$) in equation (15).

We now discuss our implementation of this approach in further detail. In the first step, we estimate the following log linear gravity equation for sectoral expenditure shares (s_{nit}^k):

$$\ln s_{nit}^k = \sum_{t=1}^{T} \sum_{k=1}^{K} \mathbb{I}_{tk} \left(\gamma_{tk}^a \ln \left(\text{airdist}_{ni} \right) + \gamma_{tk}^s \ln \left(\text{seadist}_{ni} \right) \right) + \vartheta_{ni}^k + \eta_{nt}^k + \mu_{it}^k + \epsilon_{nit}^k \tag{16}$$

where airdist_{ni} is the population-weighted average of the great circle distances between the largest cities within countries; seadist_{ni} is the least-cost path by sea between the leading ports of each country, for all bilateral pairs of countries that are connected by sea; γ_{tk}^a and γ_{tk}^s are the elasticities of expenditure shares to air and sea distance in year t and sector k; these elasticities capture secular changes over time in the relative importance of air and sea distance in determining trade flows; the main effects of both distance measures and any time-invariant unobserved heterogeneity are captured by the importer-exporter-sector fixed effect (ϑ_{ni}^k); the importer-sector-year (η_{nt}^k) and exporter-sector-year (μ_{it}^k) fixed effects control for changes over time in country income and price indexes and macro shocks; and ϵ_{nit}^k is a stochastic error.

In the second step, we use the fitted values for sectoral expenditure shares (s_{nit}^{k*}) from equation (16) to construct predicted expenditure share ($\boldsymbol{S}^{IO*}$), income share ($\boldsymbol{T}^{IO*}$) and cross-substitution ($\boldsymbol{M}^{IO*}$) matrices in our input-output model, as discussed in Section 2 above, and reported in further detail in Section D.6 of the online appendix. In the third step, we use these predicted expenditure share ($\boldsymbol{S}^{IO*}$), income share ($\boldsymbol{T}^{IO*}$) and cross-substitution ($\boldsymbol{M}^{IO*}$) matrices and our linearization of the conditions for general equilibrium to compute predicted real income exposure ($\boldsymbol{U}_{nit}^{IO*}$). Finally, in the fourth step, we instrument actual real income exposure ($\boldsymbol{U}_{nit}^{IO}$) using predicted real income exposure ($\boldsymbol{U}_{nit}^{IO*}$) in the following first-stage regression:

$$\boldsymbol{U}_{nit}^{IO} = \beta^U \boldsymbol{U}_{nit}^{IO*} + \vartheta_{ni}^U + \eta_{nt}^U + \mu_{it}^U + \epsilon_{nit}^U, \tag{17}$$

where ϑ_{ni}^U is an importer-exporter fixed effect; η_{nt}^U and μ_{it}^U are importer-year and exporter-year fixed effects, respectively; and ϵ_{nit}^U is a stochastic error.

In some of our empirical specifications, we include log bilateral trade ($\ln \boldsymbol{X}_{nit}$) as a control in equation (15) to demonstrate that our real income exposure measure is not well approximated by simpler measures of trade relationships. Since bilateral trade is also potentially endogenous to bilateral political alignment, we again develop a second instrument to address this concern. As discussed above, our model implies that real income exposure drives bilateral political alignment, but does not have a clear prediction for the impact of log trade conditional on real income exposure. Therefore, we treat log trade as a reduced-form control, and develop a reduced-form instrument for it. In particular, we estimate the following log linear gravity equation that relates aggregate bilateral trade to time-varying coefficients on air and sea distance:

$$\ln \boldsymbol{X}_{nit} = \sum_{t=1}^{T} \mathbb{I}_t \left(\gamma_t^a \ln \left(\text{airdist}_{ni} \right) + \gamma_t^s \ln \left(\text{seadist}_{ni} \right) \right) + \vartheta_{ni}^X + \eta_{nt}^X + \mu_{it}^X + \epsilon_{nit}^X \tag{18}$$

where γ_t^a and γ_t^s are the elasticities of aggregate trade flows to air and sea distance in year t; the main effects of both distance measures and any time-invariant unobserved heterogeneity are captured by the importer-exporter fixed effect (ϑ_{ni}^X); the importer-year (η_{nt}^X) and exporter-year (μ_{it}^X) fixed effects control for changes over time in country income and price indexes and macro shocks; and ϵ_{nit}^X is a stochastic error. We use the fitted values ($\ln \boldsymbol{X}_{nit}^*$) from this gravity equation (18) to instrument aggregate bilateral trade ($\ln \boldsymbol{X}_{nit}$).

Although both instruments use changes in the estimated coefficients on air and sea distance over time, there are two key differences between them. First, our first real income exposure instrument ($\boldsymbol{U}_{nit}^{IO*}$) uses the full structure of the model to compute predicted real income exposure ($\boldsymbol{U}_{nit}^{IO*}$) using our linearization of the conditions for general equilibrium. Therefore, this first instrument incorporates not only the direct effect of the reduction in the cost of air-travel relative to sea-travel, but also indirect effects from general equilibrium feedbacks. In contrast, our second bilateral trade instrument ($\ln \boldsymbol{X}_{nit}^*$) only uses the log linear structure of the gravity equation, and hence only captures the direct effect of lower costs of air travel. Second, our real income exposure instrument ($\boldsymbol{U}_{nit}^{IO*}$) estimates the gravity equation at the sectoral level rather than the aggregate level, because the expenditure share ($\boldsymbol{S}^{IO*}$), income share ($\boldsymbol{T}^{IO*}$) and cross-substitution ($\boldsymbol{M}^{IO*}$) matrices in our input-output model are constructed from sectoral expenditure shares. Therefore, our real income exposure instrument ($\boldsymbol{U}_{nit}^{IO*}$) also incorporates heterogeneity across sectors in the changes in the estimated coefficients on air and sea distance over time.

Since our second-stage regression (15) includes exporter-importer, exporter-year and importer-year fixed effects, we identify the estimated coefficient β^A from the relationship between changes over time within exporter-importer pairs in bilateral political alignment and real income exposure predicted by the time-varying coefficients on air and sea distance.

Baseline Empirical Results In Column (1) of Table 4, we report the results of estimating our second-stage regression (15) using OLS for our baseline κ-score measure of bilateral political alignment. We find a positive and statistically significant coefficient on real income exposure (β), confirming a strong relationship between increases in political alignment towards a trade partner and increases in economic dependence on that trade partner. In Columns (2) and (3), we show that we find similar results using alternative measures of the similarity of countries' votes in the UNGA: the simpler S-score measure (based on the sum of squared deviations in votes) and the π-score (which controls for the empirical frequency with which pairs of countries jointly vote yes, no). In Columns (4)-(6), we show that this positive and statistically significant relationship between bilateral political alignment and real income exposure is robust to controlling for the log bilateral trade between countries. Therefore, we again find that our theory-based measure is not well approximated by simpler measures of trading relationships between countries.

Table 4: Political and Economic Friends

	(1) $\boldsymbol{A}^{\kappa}_{nit}$	(2) $\boldsymbol{A}^{S}_{nit}$	(3) $\boldsymbol{A}^{\pi}_{nit}$	(4) $\boldsymbol{A}^{\kappa}_{nit}$	(5) $\boldsymbol{A}^{S}_{nit}$	(6) $\boldsymbol{A}^{\pi}_{nit}$
$\boldsymbol{U}^{IO}_{nit}$	24.20***	12.01***	25.77***	24.10***	11.85***	25.54***
	(3.824)	(2.099)	(4.085)	(3.836)	(2.101)	(4.092)
$\ln \boldsymbol{X}_{nit}$				0.000119	0.000185	0.000280
				(0.000238)	(0.000131)	(0.000275)
Estimation	OLS	OLS	OLS	OLS	OLS	OLS
Observations	653,214	653,214	653,214	653,214	653,214	653,214
R-squared	0.646	0.872	0.709	0.646	0.872	0.709

Note: Panel of exporter-importer-year observations from 1970-2012; all specifications include exporter-importer, exporter-year and importer-year fixed effects; $\boldsymbol{A}^{\kappa}_{nit}$, $\boldsymbol{A}^{S}_{nit}$ and $\boldsymbol{A}^{\pi}_{nit}$ are the κ-score, S-score and π-score measures of the bilateral similarity of countries' votes in the UNGA, respectively; $\boldsymbol{U}^{IO}_{nit}$ is real income exposure from our input-output specification; $\ln \boldsymbol{X}_{nit}$ is the log of one plus aggregate bilateral trade flows; standard errors in parentheses are clustered by exporter-importer pair; *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

In Columns (1)-(3) in Table 5, we re-estimate the specification from Columns (1)-(3) of Table 4 using two-stage least squares (2SLS), instrumenting actual real income exposure ($\boldsymbol{U}^{IO}_{nit}$) with predicted real income exposure ($\boldsymbol{U}^{IO*}_{nit}$). We continue to find a positive and statistically significant coefficient on real income exposure (β), consistent with the idea that exogenous increases in real income exposure to trade partners cause political realignment towards those trade partners. As for our earlier results for the China shock, we find that the IV coefficient is typically around twice as large than the OLS coefficient. Since our IV specification exploits secular changes in the coefficients on air and sea distance over time, these findings are again in line with the view that political alignment responds more strongly to long-run secular changes in real income exposure than to other shorter-term sources of fluctuation in real income exposure.[20] We find that the estimated coefficient on real income exposure is not only statistically significant but economically relevant, with the estimates in Column (1) imply that a one standard deviation increase in real income exposure leads to a 0.094 standard deviation increase in bilateral political alignment. We find that that our model-based instrument has power in the first-stage regression, using both the Kleibergen-Paap rk Wald F-statistic and the Anderson-Rubin χ^2-statistic.

In Columns (4)-(6) of Table 5, we show that these results are robust to controlling for log bilateral trade, where we instrument real income exposure and log bilateral trade using predicted real income exposure ($\boldsymbol{U}^{IO*}_{nit}$) and predicted log bilateral trade ($\ln \boldsymbol{X}^{*}_{nit}$). We continue to find a positive and statistically significant coefficient on real income exposure, which remains of around the same magnitude as in Columns (1)-(3). Therefore, we again find evidence of a causal relationship between increases in real income exposure and political realignment towards trade partners, and

[20]This pattern is also in line with the empirical literature on military conflict and trade, which typically finds that the IV coefficient is larger than the OLS coefficient, as in Polachek (1980) and Polachek and Mcdonald (1992).

our theoretically-consistent measure of real income exposure is not well approximated by simpler measures of trading relationships. Both instruments have power in the first-stage regressions, as shown by the Kleibergen-Paap rk Wald F-statistic and the Anderson-Rubin χ^2-statistic.

Table 5: Political and Economic Friends (Instrumental Variables Specification)

	(1) $\boldsymbol{A}^{\kappa}_{nit}$	(2) $\boldsymbol{A}^{S}_{nit}$	(3) $\boldsymbol{A}^{\pi}_{nit}$	(4) $\boldsymbol{A}^{\kappa}_{nit}$	(5) $\boldsymbol{A}^{S}_{nit}$	(6) $\boldsymbol{A}^{\pi}_{nit}$
$\boldsymbol{U}^{IO}_{nit}$	60.66***	22.63***	58.83***	77.09***	35.66***	77.35***
	(15.55)	(7.11)	(15.67)	(18.23)	(9.21)	(18.59)
$\ln \boldsymbol{X}_{nit}$				0.0255***	0.0202***	0.0287***
				(0.00299)	(0.00170)	(0.00326)
Estimation	IV	IV	IV	IV	IV	IV
Observations	480,452	480,452	480,452	480,452	480,452	480,452
Kleibergen-Paap F	33.69	33.69	33.629	271.6	271.6	271.6
Anderson-Rubin p-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Note: Panel of exporter-importer-year observations from 1970-2012; all specifications include exporter-importer, exporter-year and importer-year fixed effects; $\boldsymbol{A}^{\kappa}_{nit}$, $\boldsymbol{A}^{S}_{nit}$ and $\boldsymbol{A}^{\pi}_{nit}$ are the κ-score, S-score and π-score measures of the bilateral similarity of countries' votes in the UNGA, respectively; $\boldsymbol{U}^{IO}_{nit}$ is real income exposure from our input-output specification; $\ln \boldsymbol{X}_{nit}$ is the log of one plus aggregate bilateral trade flows; In Columns (1) to (3), real income exposure ($\boldsymbol{U}^{IO}_{nit}$) is instrumented with predicted real income exposure ($\boldsymbol{U}^{IO*}_{nit}$), which is computed using our linearization of the conditions for general equilibrium and fitted expenditure shares from the sectoral gravity equation (16) using time-varying coefficients on air and sea distance; In Columns (4) to (6), real income exposure ($\boldsymbol{U}^{IO}_{nit}$) and log one plus bilateral trade ($\ln \boldsymbol{X}_{nit}$) are instrumented using their predicted values ($\boldsymbol{U}^{IO*}_{nit}$, $\ln \boldsymbol{X}^{*}_{nit}$) based on the gravity equations (16) and (18) using time-varying coefficients on air and sea distance; Kleibergen-Paap F is the Kleibergen-Paap rk Wald F-statistic; Anderson-Rubin p-value is the p-value for the Anderson-Rubin χ^2-statistic; the second-stage R-squared is not reported for these IV specifications, because it does not have a meaningful interpretation; standard errors in parentheses are clustered by exporter-importer pair; *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

Strategic Rivalries, Ideal Distance and Formal Alliances Throughout our empirical analysis so far, we have focused on measures of the bilateral similarity of countries' votes in the UNGA. However, an advantage of using quasi-experimental variation from the reduction in the cost of air travel is that we can consider a wider range of measures of bilateral political alignment, exploiting the many changes in strategic rivalry and formal alliances that are observed across all bilateral pairs of countries over our sample period.

In Table 6, we estimate the same regression specification (15) using our measures of strategic rivalry, which capture the contemporary perceptions of policy-makers as to whether two countries regard each other as competitors, sources of threats or enemies. Panel A present the OLS estimates, while Panel B contains the IV estimates. Whether we consider all strategic rivalries (Column (1) in both panels), positional strategic rivalries (Column (2)), spatial strategic rivalries (Column (3)) or ideological strategic rivalries (Column (4)), we find the same pattern of results. In all cases, we find a negative and statistically significant relationship between the propensity with which countries are strategic rivals and bilateral real income exposure.

Table 6: Political and Economic Friends (Strategic Rivalries and Ideal Distance)

Panel A: OLS					
	(1)	(2)	(3)	(4)	(5)
	$\boldsymbol{A}_{nit}^{\text{Any}}$	$\boldsymbol{A}_{nit}^{\text{Pos}}$	$\boldsymbol{A}_{nit}^{\text{Spa}}$	$\boldsymbol{A}_{nit}^{\text{Id}}$	$\boldsymbol{A}_{nit}^{\text{Ideal}}$
$\boldsymbol{U}_{nit}^{IO}$	-3.038***	-0.767**	-1.093**	-1.777*	-29.03***
	(1.081)	(0.326)	(0.439)	(0.955)	(8.512)
$\ln \boldsymbol{X}_{nit}$	-0.000250**	-0.000107*	-0.000125**	-0.000172***	0.000534
	(0.0000841)	(0.0000590)	(0.0000623)	(0.0000530)	(0.000613)
Observations	788,396	788,396	788,396	788,396	623,586
R-squared	0.791	0.837	0.807	0.729	0.833
Panel B: IV					
	(1)	(2)	(3)	(4)	(5)
	$\boldsymbol{A}_{nit}^{\text{Any}}$	$\boldsymbol{A}_{nit}^{\text{Pos}}$	$\boldsymbol{A}_{nit}^{\text{Spa}}$	$\boldsymbol{A}_{nit}^{\text{Id}}$	$\boldsymbol{A}_{nit}^{\text{Ideal}}$
$\boldsymbol{U}_{nit}^{IO}$	-21.41**	-10.35**	-15.55**	-3.819	-88.06***
	(8.979)	(4.271)	(8.143)	(2.701)	(26.88)
$\ln \boldsymbol{X}_{nit}$	-0.00800***	-0.00346***	-0.00531***	-0.00288***	-0.00710
	(0.00171)	(0.000985)	(0.00155)	(0.000894)	(0.00465)
Observations	533,770	533,770	533,770	533,770	459,808
Kleibergen-Paap F	303.2	303.2	303.2	303.2	259.4
Anderson-Rubin p-value	<0.01	<0.01	<0.01	<0.01	<0.01

Note: Panel of exporter-importer-year observations from 1970-2012; all specifications include exporter-importer, exporter-year and importer-year fixed effects; $\boldsymbol{A}_{nit}^{\text{Any}}$, $\boldsymbol{A}_{nit}^{\text{Pos}}$ and $\boldsymbol{A}_{nit}^{\text{Spa}}$ and $\boldsymbol{A}_{nit}^{\text{Id}}$ are indicator variables for any, positional, spatial and ideological strategic rivalries, respectively; $\boldsymbol{A}_{nit}^{\text{ideal}}$ is the bilateral difference in countries' ideal points from the UNGA voting data; $\boldsymbol{U}_{nit}^{IO}$ is real income exposure from our input-output specification; $\ln \boldsymbol{X}_{nit}$ is the log of one plus bilateral trade; Panel A reports OLS estimates; Panel B reports IV estimates, in which we instrument real income exposure ($\boldsymbol{U}_{nit}^{IO}$) and log one plus bilateral trade ($\ln \boldsymbol{X}_{nit}$) using their predicted values ($\boldsymbol{U}_{nit}^{IO*}$, $\ln \boldsymbol{X}_{nit}^{*}$) based on the gravity equations (16) and (18) using time-varying coefficients on air and sea distance; Kleibergen-Paap F is the Kleibergen-Paap rk Wald F-statistic; Anderson-Rubin p-value is the p-value for the Anderson-Rubin χ^2-statistic; the second-stage R-squared is not reported for the IV specifications, because it does not have a meaningful interpretation; standard errors in parentheses are clustered by exporter-importer pair; *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

Consistent with the UNGA voting results above, we find a similar pattern of results in both the OLS and IV specifications, with an increase in the absolute magnitude of the estimated coefficient in the IV specification. The only exception is a statistically insignificant coefficient for ideological strategic rivalries in the IV specification, but even in this case the effect is negative and larger in absolute value than the OLS estimate, with the insignificance being driven by an increase in the standard error. Therefore, we again find support for a causal interpretation of the relationship between increased economic dependence on a trade partner and political realignment towards that trade partner. Our instruments continue to have power in the first-stage regression, as shown by the Kleibergen-Paap rk Wald F-statistic and the Anderson-Rubin χ^2-statistic.

Finally, in Column (5), we use the differences in countries' ideal points based on the UNGA voting data, again exploiting the bilateral variation across all pairs of countries. In the OLS specification in Panel A, we find a negative and statistically significant relationship between differences in countries' ideal points and real income exposure. In the IV specification in Panel B, we continue to find the same pattern of results when we focus on the variation in real income exposure predicted by the time-varying coefficients on air and sea distance. Again these findings are consistent with the view that increased economic friendship causes increased political friendship.

In Table 7, we re-estimate the same regression specification (15) using our measures of formal alliances between countries. The top panel reports the OLS estimates, while the bottom panel gives the IV estimates. We find the same pattern of results for any alliances (Column (1)), mutual defense pacts (Column (2)), non-aggression treaties (Column (4)) and ententes (Column (5)). Consistent with our baseline results above, we find a positive and statistically significant relationship between the frequency with which countries form alliances and bilateral real income exposure. When we instrument bilateral real income exposure ($\boldsymbol{U}_{nit}^{IO}$) and log one plus bilateral trade ($\ln \boldsymbol{X}_{nit}$) with their predicted values based on secular changes in the estimated coefficients on air and sea distance ($\boldsymbol{U}_{nit}^{IO*}$, $\ln \boldsymbol{X}_{nit}^{*}$), we again find that this relationship strengthens, with an increase in the absolute magnitude of the estimated coefficient. The only exception is for neutrality pacts, where the estimated coefficient is statistically insignificant in the OLS specification, but becomes positive and statistically significant in the IV specification. This pattern of results could reflect the fact that neutrality decisions are more tied to multilateral considerations (with all of a country's neighbors) rather than bilateral considerations (with one of a country's neighbors). Overall, using formal alliances, we again find support for the view that exogenous increases in economic dependence on a trade partner cause political realignment towards that trade partner.

Table 7: Political and Economic Friends (Formal Alliances)

Panel A: OLS					
	(1)	(2)	(3)	(4)	(5)
	$\boldsymbol{A}_{nit}^{\text{AllAny}}$	$\boldsymbol{A}_{nit}^{\text{AllDef}}$	$\boldsymbol{A}_{nit}^{\text{AllNeu}}$	$\boldsymbol{A}_{nit}^{\text{AllNon}}$	$\boldsymbol{A}_{nit}^{\text{AllEnt}}$
$\boldsymbol{U}_{nit}^{IO}$	4.545***	3.083**	0.958	3.668**	3.835***
	(1.199)	(1.255)	(0.957)	(1.445)	(1.143)
$\ln \boldsymbol{X}_{nit}$	-0.0000358	-0.000113	0.0000362	0.0000850	0.000146
	(0.000147)	(0.000133)	(0.0000705)	(0.000142)	(0.000119)
Observations	788,396	788,396	788,396	788,396	788,396
R-squared	0.899	0.902	0.564	0.897	0.908
Panel B: IV					
	(1)	(2)	(3)	(4)	(5)
	$\boldsymbol{A}_{nit}^{\text{AllAny}}$	$\boldsymbol{A}_{nit}^{\text{AllDef}}$	$\boldsymbol{A}_{nit}^{\text{AllNeu}}$	$\boldsymbol{A}_{nit}^{\text{AllNon}}$	$\boldsymbol{A}_{nit}^{\text{AllEnt}}$
$\boldsymbol{U}_{nit}^{IO}$	17.79***	15.02**	10.75**	21.90***	15.94***
	(6.11)	(6.707)	(5.368)	(7.103)	(5.752)
$\ln \boldsymbol{X}_{nit}$	0.0106***	0.0107***	0.000433	0.0153***	0.0108***
	(0.00243)	(0.00228)	(0.00107)	(0.00224)	(0.00170)
Observations	533,770	533,770	533,770	533,770	533,770
Kleibergen-Paap F	303.2	303.2	303.2	303.2	303.2
Anderson-Rubin p-value	<0.01	<0.01	0.1	<0.01	<0.01

Note: Panel of exporter-importer-year observations from 1970-2012; all specifications include exporter-importer, exporter-year and importer-year fixed effects; $\boldsymbol{A}_{nit}^{\text{AllAny}}$, $\boldsymbol{A}_{nit}^{\text{AllDef}}$, $\boldsymbol{A}_{nit}^{\text{AllNeu}}$, $\boldsymbol{A}_{nit}^{\text{AllNon}}$, and $\boldsymbol{A}_{nit}^{\text{AllEnt}}$ are indicator variables for any, defense, neutrality, non-aggression and entente formal alliances, respectively; $\boldsymbol{U}_{nit}^{IO}$ is real income exposure from our input-output specification; $\ln \boldsymbol{X}_{nit}$ is the log value of aggregate bilateral trade flows; Panel A reports OLS estimates; Panel B reports IV estimates, in which we instrument real income exposure ($\boldsymbol{U}_{nit}^{IO}$) and log one plus bilateral trade ($\ln \boldsymbol{X}_{nit}$) using their predicted values ($\boldsymbol{U}_{nit}^{IO*}$, $\ln \boldsymbol{X}_{nit}^{*}$) based on the gravity equations (16) and (18) using time-varying coefficients on air and sea distance; Kleibergen-Paap F is the Kleibergen-Paap rk Wald F-statistic; Anderson-Rubin p-value is the p-value for the Anderson-Rubin χ^2-statistic; the second-stage R-squared is not reported for the IV specifications, because it does not have a meaningful interpretation; standard errors in parentheses are clustered by exporter-importer pair; *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

6 Conclusions

We examine whether as countries become more economically dependent on a trade partner, they realign politically towards that trade partner. We use network measures of the elasticity of real income with respect to productivity growth in each trade partner. We define a country as a friend of a trade partner if this elasticity is positive and an enemy if this elasticity is negative. We derive these network exposure measures from the influential class of trade models with a constant trade elasticity. We use techniques from the networks literature to characterize how a country's position in the network influences its exposure to productivity growth in other countries and its impact on real income in other countries.

Our empirical analysis is guided by a simple theoretical model, in which countries can take political actions that promote economic growth in their trade partners, but which are costly to undertake. In the Nash non-cooperative equilibrium, the more sensitive a country's real income to economic growth in a trade partner, the greater the country's incentives to undertake political actions that raise its productivity growth. Since our measures of the elasticity of real income to productivity growth are microfounded in this class of trade models with a constant trade elasticity, they capture all general equilibrium effects in these models. We show how to compute these measures from observed trade data, using either exact-hat algebra techniques for the non-linear model solution given an assumed productivity shock (arc elasticities), or using a linearization of the conditions for general equilibrium (point elasticities). In practice, we find similar results whether we use the arc or point elasticities, and regardless of the assumed size of the productivity shock for the arc elasticities, at least for productivity shocks up to the cumulative change in the relative productivity of countries over our more than forty-year sample period.

We combine our economic exposure measures with a range of different measures of countries political alignment, including the similarity of countries' votes in the United Nations General Assembly (UNGA), measures of strategic rivalries based on the perception of contemporary political decision makers, and measures of formal alliances between countries. We establish causality using two different sources of quasi-experimental variation. First, we use an exogenous increase in China's productivity following domestic reform as a source of exogenous variation in other countries' real income exposure. Second, we use the reduction in the cost of air travel over time, which changes the relative real income exposure of country pairs with different sea distances relative to air distances. In both cases, we find that increases in economic dependence on a trade partner cause political realignment towards that trade partner. We show that our theory-based network exposure measures dominate simpler measures of trading relationships between countries. The consistency of our empirical results across these two different sources of quasi-experimental variation further strengthens the evidence in support of a causal relationship between economic and political friendship.

Overall, our findings are consistent with the view that economic dependence on a trade partner does indeed lead to political alignment towards that trade partner, highlighting the geopolitical implications of major changes in the relative economic size of countries.

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