Online Annex 3. Trade Patterns amid Shocks and a Changing Geoeconomic Landscape

Annex 3.1. Geoeconomic Fragmentation Scenarios

Three hypothetical scenarios are considered to illustrate the potential impact on trade and economic output from geoeconomic fragmentation, based on insights from recent IMF research.

Scenario 1 would entail the European Union and the United States ceasing all trade with Russia, while trade between other countries proceeds as normal, in line with the "strategic decoupling" scenario in Bolhuis, Chen, and Kett (2023).

Scenarios 2 and 3 illustrate the separation of the world into three blocs—an Eastern bloc around China and Russia, a Western bloc around the European Union and the United States, and a non-aligned, neutral block. We assume that trade ceases between countries in the Eastern and Western blocs, but the neutral bloc continues trading with any other partner. In Scenario 2, ME&CA countries are assumed to remain in the neutral bloc. In Scenario 3, blocs are determined based on United Nations General Assembly (UNGA) votes during the 77th General Assembly Session that began in September 2022 (the most recent UNGA session with available voting data). In contrast to some previous work that used only the resolution regarding the suspension of Russia's membership in the Human Rights Council on April 7, 2022 (for example, Campos and others 2023; October 2022 *Regional Economic Outlook: Asia and Pacific*), we use the entirety of UN votes during the 77th UNGA session (consistent with World Economic Outlook April 2023; IMF WHD Regional Economic Outlook, October 2023). We compute the ideal point distance measure for all countries following Bailey and others (2017), which measures geopolitical alignment consistently across time. It also has the advantage of not depending on the issues that are being put up for vote in UNGA. Using this measure, we separate the world into three blocs. Countries that are in the top 25th percentile of geopolitical distance from G7 countries are assigned to the Eastern bloc.[1] The Western bloc consists of the European Union and the United States. All other countries form the neutral bloc and remain able to trade with any bloc.

Annex 3.2. General Equilibrium Analysis with Structural Gravity: Assessing the Impact of Policy Reforms in the Context of Geoeconomic Fragmentation

General equilibrium analysis (GEA) of structural gravity models of trade offers a thorough method for studying the effects of geoeconomic fragmentation on exports and GDP. It enables the simulation of various geoeconomic scenarios, considering different policy changes, economic behaviors, and individual country level as well as global responses. It highlights how alterations in one area can influence global exports, imports, prices, and income distribution. Integrating GEA with structural gravity models allows for a detailed analysis of trade linkages and policy spillovers, offering a clearer view of global trade dynamics and economic outcomes. This enhanced analysis enables policymakers to evaluate the implications of trade policies and strategies comprehensively when trade shocks hit an economy.

To assess the impact of geoeconomic fragmentation and policy actions on bilateral trade flows, we adopt the specification of Larch and Yotov (2016), Yotov and others (2016), and Campos and others (2023), to estimate a structural gravity system and a series of a theory-consistent indexes that could be used to summarize, decompose, and aggregate the general equilibrium effects of changes in trade restrictions (based on a composite

[1] This is similar to the definition of the moderate scenario in IMF GFSR April 2023 Chapter 3. The main difference is that they cover 60 countries while we use UN vote information from the entire sample of 191 countries.

indicator of tariffs and nontariff barriers), upgrading infrastructure, and easing regulatory constraints.[2] The following structural gravity system is our departing point for the general equilibrium analysis:

$$X_{ij,t} = \frac{Y_{i,t}E_{j,t}}{Y_t}\left[\frac{t_{ij,t}}{\Pi_{i,t}P_{j,t}}\right]^{1-\sigma} \quad \text{(AII-1)}$$

$$\Pi_{i,t}^{1-\sigma} = \sum_j \left[\frac{t_{ij,t}}{P_{j,t}}\right]^{1-\sigma} \frac{E_{j,t}}{Y_t} \quad \text{(AII-2)}$$

$$\mathrm{P}_{j,t}^{1-\sigma} = \sum_j \left[\frac{t_{ij,t}}{\Pi_{j,t}}\right]^{1-\sigma} \frac{Y_{i,t}}{Y_t} \quad \text{(AII-3)}$$

$$p_{i,t} = \left[\frac{Y_{i,t}}{Y_t}\right]^{\frac{1}{1-\sigma}} \frac{1}{\alpha\Pi_{i,t}} \quad \text{(AII-4)}$$

$$E_{i,t}=\varphi_i Y_{i,t} = \varphi_i p_{i,t} Q_{i,t} \quad \text{(AII-5)}$$

where the subscript *t* refers to the year; $X_{ij,t}$ represents trade flows from country *i* (exporter) to country *j* (importer); $E_{j,t}$ is the total expenditure in importer country *j*; $Y_{i,t}$ refers to the total production in exporting country *i*; Y_t represents the world output; $t_{ij,t}$ is the bilateral trade frictions between countries *i* and *j*; $\sigma > 1$ is the elasticity of substitution among goods from different countries; α is the CES preference parameter; $P_{j,t}$ and $\Pi_{i,t}$ are the inward and outward multilateral resistances, respectively, and they are the vehicles that translate the initial partial equilibrium effects of trade policy, for example, at the bilateral level to country-specific effects on consumer and producer prices. While the direct effects do give the initial impact effects of trade costs on trade flows, the general equilibrium trade costs also take into account the changes in prices, incomes and expenditures induced by trade cost changes. $p_{i,t}$ denotes the factory-gate price for each variety of goods in the exporting country *i*; $Q_{i,t}$ is the value of total endowment (that is, quantity supplied) of each variety of goods in the origin country *i*; and the exogenous parameter φ_i defines the relation between the value of output and aggregate expenditure in country *i*, so that it faces a trade deficit if $\varphi_i > 1$, and runs a trade surplus when $0 < \varphi_i < 1$.

The trade costs, $\left[\frac{t_{ij,t}}{\Pi_{i,t}P_{j,t}}\right]^{1-\sigma}$, are pivotal to our analysis of the structural gravity model, as they significantly influence the volume of trade. Its natural interpretation is that it captures the total effects of trade costs that drive a wedge between the actual trade and the frictionless trade (hypothetical level of trade if there were no trade costs). It consists of the bilateral trade frictions, $t_{ij,t}$, (typically proxied by distance and trade policy variables); inward multilateral resistances $P_{j,t}$ and outward multilateral resistances $\Pi_{i,t}$. So, trade costs encompass all costs incurred in getting a good from the producer to the final consumer, excluding the production cost. These costs may include the geographical distance, which often proxies for transportation (both freight costs and time costs), policy barriers (tariffs, non-tariffs trade restrictions), information costs, currency exchange, legal and regulatory costs, cultural differences (language, colonial ties), etc. A widely used concept in the literature, which we adopt in our analysis, models trade costs as ‘iceberg costs’ (Samuelson, 1952), where only a fraction of goods are traded,[3] and can be directly incorporated as an augmentation of the distance or trade cost term. More importantly, when integrated into structural gravity models, iceberg trade costs enable us to conduct counterfactual analyses to assess the potential impacts of changes in trade policies or barriers on trade flows and welfare. By adjusting the magnitude of the iceberg costs, we can simulate various scenarios, such as the effects of reducing transportation costs or eliminating tariffs, and measure the consequent changes in trade volumes and economic welfare.

[2] For a more detailed explanation, see Yotov and others (2016).

[3] These costs include transportation expenses, tariffs, time costs, and other barriers to trade. Iceberg costs provide a realistic representation of the physical and intangible barriers that affect international trade, allow economists to model a wide range of trade barriers beyond tariffs, such as transportation costs, insurance, logistical inefficiencies, and regulatory burdens, which can all be conceptualized as ‘melting away’ a portion of the goods in transit. Iceberg trade costs fit naturally into our framework (i.e., structural gravity model), which relies on the assumption that trade flows are proportional to economic mass (e.g., GDP) and inversely proportional to distance (a proxy for trade costs).

Solving the gravity system (AII-1)-(AII-5) starts with estimating elasticities of bilateral trade determinants (trade costs, income level, distance, etc.) following the first equation. A robust approach to estimate the effects of some gravity variables requires using panel data. However, counterfactual experiments are usually performed with cross-sectional data. Accordingly, our analysis considers only cross-section data for the year 2019. We estimate the following simplified version of equation (AII-1) using bilateral trade data from CEPII gravity dataset (Conte, Cotterlaz, and Mayer 2022):

$$X_{ij} = \exp\left[\theta_i + \omega_j + \beta_1 Z_{ij}\right]\eta_{ij}, \qquad \text{(AII-6)}$$

where Z_{ij} is a vector of variable(s) either facilitating or restricting trade between countries i and j (trade restrictions, infrastructure, and regulatory quality). The dependent variable X_{ijt} includes domestic trade when $i = j$.[4] θ_i and ω_j are exporter and importer fixed effects, respectively, which absorb country-level co-variates such as GDP, population, and whether countries are landlocked. Another advantage of using the exporter and importer fixed effects is to fully account for the multilateral resistance terms, $P_{j,t}$ and $\Pi_{i,t}$, which are theoretical constructs and not directly observable. β_1 is a vector of unknown parameters (elasticities) to be estimated and η_{ij} is a lognormally distributed error term. The index of trade restrictions is set to zero for own country trade, which creates within-exporter variation in trade restrictions in the cross section.

Multiple versions of equation (AII-6) have been estimated using the Poisson Pseudo Maximum Likelihood (PPML) estimator.[5] Results are reported in Annex Table 3.1. Model (1) shows the results of estimating the gravity equation with no policy variables. Models (2)-(4) estimate model (1) augmented with the policy variables one at a time. As expected, all conventional gravity variables and the introduced policy variables are statistically significant and explain around 70 percent of the variation in exports. Model (5) includes all policy variables.

General Equilibrium Steps

Our general equilibrium analysis illustrates how each geoeconomic fragmentation scenario, characterized by the formation of trade blocs (as described in Annex 3.1), can negatively impact a country's exports and GDP. Such fragmentation increases trade costs, making a country's exports less competitive due to higher prices for foreign buyers. This can decrease export volumes and affect the output of exporting sectors, leading to a reduction in the overall GDP. Moreover, reduced market access limits the ability to diversify exports, increasing vulnerability to market-specific shocks and hindering export growth potential. Lastly, geoeconomic fragmentation may necessitate the reallocation of resources within the economy, leading to adjustment costs and temporary inefficiencies that further impact GDP and export capacity.

Step 1: Solve the baseline gravity model.

Equation (AII-6) is estimated using the PPML estimator to obtain point estimates of the variables of interest in this chapter. We find evidence that trade restrictions (tariffs and nontariff barriers), infrastructure, and regulatory quality matter for boosting trade flows. Next, with the estimated value of importer and exporter fixed effects, we construct the baseline values of inward and outward multilateral resistances terms, $P_{j,t}$ and $\Pi_{i,t}$. Together with data on output and expenditure, these values will be used to calculate the trade costs as well as any other general equilibrium indexes of interest in the baseline. As highlighted earlier, the standard practice suggested in the literature is to proxy for the bilateral trade cost, t_{ij}, by using a series of observable variables most of which have become standard covariates in the empirical gravity specifications (distance, borders, common official language, bilateral tariffs, trade agreement, etc.). For our purpose, the baseline trade costs are calculated as follows:

$$[\hat{t}_{ij}^{1-\sigma}]^{BLN} = \exp\,[\widehat{\theta}_i + \widehat{\omega}_j + \widehat{\beta}_1 Z_{ij}] \qquad \text{(AII-7)}$$

[4] See Yotov (2022) for the rationale of including domestic trade flows in the estimation of the structural gravity model.

[5] The PPML estimator is an easy and convenient solution to the high frequency of zero trade values in the data and the heteroscedasticity problem that arises if the gravity model is estimated in its log linear format. See Santos Silva and Tenreyro (2006) for more details.

This will enable the estimation of the trade elasticity of substitution, $\hat{\sigma}$. Based on the estimated trade cost (AII-7), we solve the structural gravity system (AII-2) - (AII-6) to obtain values of all indexes, including consumer prices and the (inward and outward) multilateral resistances.

Step 2: Define the counterfactual scenario.
The next step of our general equilibrium algorithm consists of defining our counterfactual exercise. First, we estimate the impact of the fragmentation scenarios described in Annex 3.1 by raising trade costs between countries that are in opposing geoeconomic blocs. Second, we simulate the hypothetical policy actions in the geoeconomic fragmentation scenarios. Our policy actions consist of reducing the gap in trade restrictions, infrastructure, and regulatory quality between ME&CA countries and advanced economies by 20 percent at the country level. Although our choice of the 20 percent reduction of the gap is hypothetical, considering a higher gap reduction would be costly and non-feasible for most countries in the region.

In addition to the impact on international trade (that is, real exports), improving infrastructure or the regulatory environment also boosts domestic trade (that is, domestic production that is consumed in the home country), in the model. However, throughout our analysis, we focus on the changes in real GDP due to the change in (real) exports, holding constant domestic consumption. This effectively isolates how much improvements in infrastructure or the regulatory environment would increase GDP through international trade.
Note that all counterfactual policy variables are in the vector Z_{ij}. The adjustment to the variables specified in the structural gravity model (trade restrictions, infrastructure, and regulatory quality) will deliver a new matrix of counterfactual bilateral trade cost (CFL).

$$[\hat{t}_{ij}^{1-\sigma}]^{CFL} = \exp\,[\widehat{\theta}_i + \widehat{\omega}_j + \widehat{\beta}_1 Z_{ij}^{CFL}] \qquad \text{(AII-8)}$$

Step 3: Solve the counterfactual model.
Next, the estimates of step 1 and step 2, and the values of trade elasticities, can be used to solve the structural gravity system in the counterfactual scenario. By doing so, we obtain the values of the counterfactual indexes of interest (that is, exports and output) in the "conditional" and in the "full endowment" general equilibrium assumptions.

The full employment general equilibrium reactions to hypothetical trade policy (infrastructure and regulatory quality) adjustments reflect alterations in factory-gate prices. These alterations are due to shifts in outward multilateral resistances, which subsequently affect the value of output and expenditures. Such changes directly influence trade flows and indirectly affect the multilateral resistances.

Step 4: Construct the indexes of interest (change in exports and change in output).
Following the calculation of the conditional and/or full endowment general equilibrium effects on trade cost indexes, the next step is to represent these general equilibrium effects as percentage changes relative to the baseline scenario.

$$\%\Delta\hat{X}_{it} = \frac{\hat{X}_{it}^{CFL} - \hat{X}_{it}^{BLN}}{\hat{X}_{it}^{BLN}} \times 100$$

$$\%\Delta\widehat{GDP}_{it} = \frac{\widehat{GDP}_{it}^{CFL} - \widehat{GDP}_{it}^{BLN}}{\widehat{GDP}_{it}^{BLN}} \times 100$$

The chapter reports changes in exports and GDP as changes relative to the baseline scenario without policy action.

Economically, the impact of the fragmentation scenarios depends on the extent to which countries substitute changes in trade with domestic consumption of domestic production. When fragmentation leads to lower exports (because of higher trade barriers with trade partners), the output losses in the scenarios are typically significantly smaller than the export losses because countries re-allocate their domestic production towards more domestic consumption and less exports for foreign consumption. This is mirrored by a decline in imports as higher domestic consumption of domestically produced output reduces import demand.

Data and Parameters

We use bilateral trade and geographic data from CEPII's Gravity dataset to estimate the model. The sample period consists of yearly observations from 2000–2020. Additional variables were included from various sources listed below:

Variable	Description	Source
GDP	GDP (in thousands of US$, unilateral)	CEPII
Trade Flows	Trade flow (in thousands of US$)	CEPII BACI
Tariffs	Average of effectively applied rates weighted by the product import shares corresponding to each partner country	World Bank, World Development Indicators
Nontariff barriers	Aggregate measure of trade restrictions based on the unweighted sum of IMF's AREAER binary variables related to (i) exchange measures; (ii) arrangements for payments and receipts; (iii) imports and imports payments; (iv) exports and exports proceeds, and (v) payment and proceeds from invisible transfers and current transfers.	IMF, Measure of Aggregate Trade Restrictions
Infrastructure	The Logistics Performance Index reflects perceptions of a country's logistics based on efficiency of customs clearance process, quality of trade and transport-related infrastructure, ease of arranging competitively priced shipments, quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled time. The index ranges from 1 to 5, with a higher score representing better performance.	World Bank, Logistics Performance Index
Regulatory Quality	Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. It is measured in units of a standard normal distribution, with mean zero, standard deviation of one, and running from approximately -2.5 to 2.5, with higher values corresponding to better regulatory quality.	World Bank, Worldwide Governance Indicators
Distance	Population-weighted average distance between the most populated cities of each country, arithmetic mean, in km bilateral.	CEPII
Contiguity (Dummy)	1 if the countries are contiguous (neighbors), bilateral.	CEPII
Common Language (Dummy)	1 if countries share common official or primary language, bilateral.	CEPII
Landlocked (Dummy)	1 if country is landlocked.	CEPII

We calibrate the elasticity of substitution (σ) as equal to 7, which implies a trade elasticity of 6. This corresponds to the mean value of long-run trade elasticities surveyed in Bolhuis and others (2023). In the short run, the elasticity of substitution is likely lower and thus trade and GDP losses would likely be larger.

The first stage of the structural estimation consists of estimating a reduced form model. We report the structural parameters for the different policy counterfactuals below:

Parameter	Value
$\hat{\beta}_{MATR}$	-.2274*** (.0159)
$\hat{\beta}_{infrastucture}$	.1533*** (.0300)
$\hat{\beta}_{regulation}$	.1223*** (.0443)

Sources: IMF staff calculations
Notes: Table reports parameter values for elasticity of trade with respect to MATR (an index of trade restrictions), infrastructure, and regulatory index. Standard errors are in parentheses. *** indicates significance at the 1% level.

Annex Table 3.1: Simple Gravity Model Regressions

Column1	(1)	(2)	(3)	(4)	(5)
VARIABLES	No Policies	T & NTB	Infrastructure	Regulatory	All Policies
Exporter non_tariffs barriers		0.0195**			0.00640
		(0.00990)			(0.0168)
Importer non_tariffs barriers		-0.0201**			-0.000551
		(0.00859)			(0.0158)
Importer Tariffs		0.00645			-0.0221
		(0.00835)			(0.0151)
Exporter Infrastructure			-0.0206		0.402**
			(0.0794)		(0.167)
Importer Infrastructure			0.237***		-0.176
			(0.0732)		(0.174)
Exporter Regulatory				-0.0670	-0.214**
				(0.0409)	(0.0929)
Importer Regulatory				0.105***	0.151
				(0.0358)	(0.0937)
Wxporter Log gdp	0.850***	0.847***	0.843***	0.853***	0.806***
	(0.0180)	(0.0202)	(0.0288)	(0.0198)	(0.0269)
Importer Log gdp	0.815***	0.811***	0.768***	0.802***	0.802***
	(0.0214)	(0.0195)	(0.0321)	(0.0221)	(0.0403)
Log_distance	-0.753***	-0.768***	-0.704***	-0.737***	-0.692***
	(0.0281)	(0.0340)	(0.0287)	(0.0286)	(0.0319)
Contiguity	0.520***	0.521***	0.555***	0.538***	0.592***
	(0.126)	(0.140)	(0.125)	(0.124)	(0.131)
Common language	0.231**	0.211*	0.237**	0.219**	0.214**
	(0.0917)	(0.114)	(0.0944)	(0.0894)	(0.106)
Exporter landlocked	-0.130	-0.0895	-0.167*	-0.129	-0.103
	(0.0882)	(0.0929)	(0.0968)	(0.0885)	(0.0957)
Importer landlocked	-0.223***	-0.215**	-0.298***	-0.247***	-0.279***
	(0.0838)	(0.0913)	(0.0951)	(0.0850)	(0.0990)
Constant	-8.548***	-8.385***	-8.914***	-8.662***	-8.758***
	(0.520)	(0.445)	(0.561)	(0.468)	(0.651)
Observations	27,867	19,329	20,430	26,174	15,044
R-squared	0.703	0.736	0.687	0.722	0.735

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Annex 3.3. Prolonged Red Sea Disruption Scenario

We simulate the impact of Red Sea tensions on MENA countries in a scenario in which those disruptions persist for one year. Trade costs are shocked, calibrated to the observed increase in shipping and insurance costs (τ), and scaled by each country's dependence on trade flows through the Bab el-Mandeb Strait (TD_i). The country-specific change in trade costs (ΔTC_i) is then given by:

$$\Delta TC_i = \tau \times TD_i$$

where $TD_i = \frac{Imports\ through\ Bab\ el-Mandeb}{Total\ Imports}$. Based on available data, we estimate τ at 1 percent. We then use the estimated structural gravity model to simulate an increase in tariffs by ΔTC_i.[6]

[6] For the simulation of this scenario, we use a short-run elasticity of σ equal to 3.16, following Bolhuis, Chen, and Kett (2023).

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