

INTERNATIONAL MONETARY FUND

Geoeconomic Fragmentation and International Diversification Benefits

Tatsushi Okuda and Tomohiro Tsuruga

WP/24/48

IMF Working Papers describe research in progress by the author(s) and are published to elicit comments and to encourage debate.

The views expressed in IMF Working Papers are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

**2024
MAR**



WORKING PAPER

IMF Working Paper

Monetary and Capital Markets Department

**Goeconomic Fragmentation and International Diversification Benefits
Prepared by Tatsushi Okuda and Tomohiro Tsuruga***Authorized for distribution by Mahvash Qureshi
March 2024

IMF Working Papers describe research in progress by the author(s) and are published to elicit comments and to encourage debate. The views expressed in IMF Working Papers are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

ABSTRACT: This paper applies the two-country open-economy model with trade in stocks and bonds of Coeurdacier *et al.* (2010) to quantify the loss of international diversification benefits for major advanced economies, which have a significant presence in international financial markets, under goeconomic fragmentation. We perform counterfactual simulations under different hypothetical fragmentation scenarios in which these economies are unable to trade with geopolitically distant countries, as measured by voting disagreement on foreign policy issues at the United Nations General Assembly meetings during 2012-2021. The simulation results imply a potentially significant loss of international diversification benefits of financial openness for the considered advanced economies by limiting trading to partner countries that are geopolitical allies with highly synchronized business cycles.

RECOMMENDED CITATION: Okuda, Tatsushi and Tomohiro Tsuruga (2024) "Goeconomic Fragmentation and International Diversification Benefits" IMF Working Paper WP/24/48, International Monetary Fund, Washington DC.

JEL Classification Numbers:	F36; F41; F65
Keywords:	Geopolitical risk; financial integration; international risk sharing
Author's E-Mail Address:	TOkuda@imf.org , TTsuruga@imf.org

* The authors thank Luigi Zingales, Tobias Adrian, Fabio Natalucci, Mahvash Qureshi, Mario Catalán, IMF colleagues, and seminar participants at ASEAN+3 Macroeconomic Research Office, Asian Development Bank Institute, Bank for International Settlements, Bank of Japan, Hitotsubashi University, Hong Kong Monetary Authority, Japan Financial Services Agency, and World Bank for their invaluable comments. The authors thank Jinhyuk Yoo and Lu Zhang for carefully examining our codes. The authors are also grateful to Mustafa Yasin Yenice for data assistance. The views expressed in this paper are those of the authors and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

WORKING PAPERS

Geoeconomic Fragmentation and International Diversification Benefits

Prepared by Tatsushi Okuda and Tomohiro Tsuruga

Contents

1. Introduction	1
2. The Model	4
2.1 Setup	5
2.2 Equilibrium.....	7
2.3 Portfolio Choice (Zero-Order Portfolio).....	9
3. Scenarios	11
4. Numerical Parameterization	15
4.1 Benchmark Parameterization	15
4.2 Parameterization under Counterfactual Scenarios.....	19
5. Simulation Results	22
5.1 Performance of the Model	22
5.2 Volatility of Macro-Financial Variables and Diversification Benefits	23
5.3 Three Driving Factors	27
6. Conclusion.....	31
References	33
Appendices	37
A. Geopolitical Distance Measure	37
B. Size of Diversification Benefits.....	38
C. Log-Linearization of Equilibrium Equations	39
D. Simulated Macro-Financial Volatility in G7 Countries.....	41
E. Robustness	42
Figures	
Figure 1. Geopolitical distance and business cycle correlation with G7 countries	14
Figure 2. Macro-financial volatility in G7 countries	25
Figure 3. Loss of diversification benefit in G7 countries	26
Figure 4. Decomposition of the median increase of volatility in Figure 2	28
Figure 5. Cross-country output correlation.....	29
Figure 6. Output volatility in foreign country.....	30
Tables	
Table 1. Four scenarios	12
Table 2. Countries included in different scenarios	13
Table 3. Estimation results.....	18
Table 4. Benchmark parametrization of TFP and investment efficiency process	20

Table 5. TFP and investment efficiency process under fragmentation scenarios	21
Table 6. Local spending bias in consumption and investment under fragmentation and autarky scenarios	22
Table 7. Degree of equity home bias	23
Table 8. Fit of the model to data on selected macroeconomic variables	24

Appendix Figures

Figure A1. Macro-financial volatility in G7 countries	42
Figure A2. Loss of diversification benefit in G7 countries	42
Figure A3. Macro-financial volatility in G7 countries	44
Figure A4. Loss of diversification benefit in G7 countries	44

Appendix Tables

Table A1. Macro-financial volatility in G7 countries	41
Table A2. Local spending bias in consumption and investment under four scenarios	43

1 Introduction

Geopolitical tensions have increased globally over the past few years amid deteriorating diplomatic ties between the United States and China, and Russia’s invasion of Ukraine.¹ The rise in geopolitical tensions among major economies has intensified concerns about geoeconomic fragmentation, considered as a policy-driven reversal of financial and economic integration, often guided by strategic considerations (Aiyar et al. 2023).

Financial fragmentation from an escalation in geopolitical tensions can occur as barriers are raised to trade in financial assets, increasing costs associated with financial transactions, or because of a rise in uncertainty that deters investors from investing in potentially rival countries.² Indeed, recent empirical studies confirm that geopolitical forces affect investors’ cross-border portfolio investment allocations (Kempf et al. 2022, IMF 2023, Catalán et al. 2024). The loss of investment opportunities in foreign countries could in turn potentially reduce international diversification benefits from financial openness — that is, a decline in consumption volatility achieved through international risk sharing of business cycle shocks (Grubel 1968, Levy and Sarnat 1970, Obstfeld and Rogoff 1996, Coeurdacier and Rey 2013). In this context, the loss of diversification benefits could be particularly significant in major advanced economies that have a significant presence in international financial markets, benefiting from investment opportunities arising from growth in emerging market economies.³

Against this background, this paper assesses the impact of geoeconomic fragmentation on diversification benefits for major advanced economies, specifically the Group of Seven (G7) countries.⁴ It considers scenarios where geopolitical tensions hamper cross-border investment from G7 countries to countries with asynchronous business cycles. These scenarios build

¹For example, since 2018, the U.S. and China have engaged in a trade war, mutually escalating tariffs (Amiti et al. 2019, Fajgelbaum et al. 2019, Cavallo et al. 2021). Moreover, geopolitical tensions between Russia and the United States and European Union have heightened since Russia’s invasion of Ukraine in 2022 and the subsequent sanctions imposed by the former on Russia.

²For instance, governments may impose restrictions on capital flows or seize foreign assets of rival countries. Anticipation of such measures could also potentially decrease bilateral investment flows among rival countries.

³As discussed in Coeurdacier et al. (2020), the potential diversification benefits for emerging market economies could be more significant than those for advanced economies because the former economies exhibit higher overall macroeconomic volatility.

⁴The literature on diversification benefits has frequently examined G7 countries (French and Poterba 1991, Coeurdacier et al. 2009, Coeurdacier et al. 2010, Coeurdacier and Gourinchas 2016) due to relatively limited frictions in their financial markets and better data availability as well as because of their significant presence in international financial markets.

upon bilateral geopolitical distance between countries defined as the degree of disagreement in countries’ voting patterns in the United Nations General Assembly (UNGA) during 2012-2021.⁵ Specifically, we utilize a two-country open-economy model with equities and bonds developed by Coeurdacier et al. (2010) to examine the impact of changes in bilateral geopolitical distance. While Coeurdacier et al. (2010) calibrate both the “home country” and the “foreign country” to an average G7 economy, in this study, the “home country” corresponds to each G7 country, and the “foreign country” comprises other G7 countries and the 53 largest non-G7 countries.⁶

The model is calibrated and simulated for each G7 country under four scenarios: A baseline *full integration* scenario, an *autarky* scenario, and two counterfactual scenarios characterized by different degrees of fragmentation. Under the fragmentation scenarios, it is assumed that G7 countries are unable to engage in transactions with foreign countries with greater geopolitical distance, and must partly substitute the imported goods from those countries with domestic production.⁷ Note that these fragmentation scenarios are entirely hypothetical and do not imply their plausibility.

Defining the degree of diversification benefit as the percentage decrease in macro-financial volatility including consumption volatility achieved through cross-border investment, we show two main results. First, the diversification benefit for G7 countries attained through full integration—that is, the reduction of macro-financial volatility under the *full integration* scenario compared to the *autarky* scenario—is in the range of 5 percent to 15 percent. The size of diversification benefits is modest because business cycle risks in advanced countries are relatively small compared to those of emerging market countries (Pallage and Robe 2003, Aguiar and Gopinath 2007).⁸ Second, the loss of diversification benefits under fragmentation scenarios is substantial—under fragmentation, G7 countries could lose 20 percent to 50

⁵Due to data limitation, the voting patterns from 2022 are not considered. Construction of the geopolitical distance measure is discussed in Bailey et al. (2017) and Häge (2011). See Appendix A for more details. IMF (2023) shows that not only this geopolitical distance measure, but also a measure based on bilateral arms trades indicates a similar effect on investors’ cross-border portfolio investment allocations, confirming the relevance of geopolitical factors.

⁶The 60 largest countries are selected, based on their nominal GDP as of 2021, as reported in the IMF World Economic Outlook database.

⁷This study assumes that the countries excluded from cross-border financial transactions are also excluded from goods trading. The interpretation of this assumption is that the geoeconomic fragmentation hampers capital flows, and thus the trade activity to mitigate country-specific business cycle fluctuations, which requires capital inflows to compensate for the trade deficits in one of the pair countries, becomes impossible.

⁸Another reason is that we employ the model where domestic equity investment offers a hedging effect of labor income risks. It is also a production economy model where physical capital provides inter-temporal risk-sharing effects. For details, see Appendix B.

percent of the gains they obtain from full integration. This is because under fragmentation scenarios, countries with business cycles that are less synchronized with those of G7 countries (such as China and major commodity-exporting countries) are excluded from the list of G7 trading partners. As a result, G7 countries can invest only in countries whose business cycles are highly synchronized with their own cycles such as industrial countries in Europe. Additionally, an increase in the share of domestic production to partially substitute imported goods hampers risk sharing through goods trade, leading to an increase in the volatility of other macro-financial variables in the model.⁹

This study contributes to two strands of literature. First, it contributes to the literature on financial integration and international risk sharing. Most of the studies in this literature focus on the size of the impact of international risk sharing on the economy. These include studies on welfare costs that compare the business cycles in a model with fully integrated financial markets with those under autarky (Cole and Obstfeld 1991; Backus et al. 1992; Obstfeld 1994; van Wincoop 1994; Tesar 1995; van Wincoop 1999; Lewis 1999; Lewis 2000; Heathcote and Perri 2013). Other studies include Heathcote and Perri (2002) and Coeurdacier et al. (2009) that explore the consequences of limited risk diversification opportunities in international financial market regarding the degree of completeness of the financial market, while Kose et al. (2007) and Coeurdacier et al. (2020) compare advanced and emerging market economies in terms of the welfare gains from international risk-sharing. In contrast to these studies, we explore the implications of changes in trading and investing partner countries driven by geopolitical fragmentation, highlighting the importance of cross-country business cycle synchronization for diversification benefits, and offering a quantitative perspective on this issue.

This study also contributes to the literature on the effect of geopolitics on cross-border economic and financial activity. The existing literature on the issue explores the impact of geopolitical distance (or proximity) (Catalán et al. 2024), political ideology (Kempf et al. 2022), and trust (Guiso et al. 2009) on cross-border investment and capital allocations.

⁹We also provide approximate measures of welfare loss associated with changes in consumption volatility in Appendix B. The literature has compared the volatility of macroeconomic variables under different assumptions on international financial markets (e.g., Heathcote and Perri 2002, Coeurdacier et al. 2010, Heathcote and Perri 2013). Appendix B provides some estimates of the size of the diversification benefit under the *full integration* scenario and shows that the estimates are consistent with those by Coeurdacier et al. (2020). Note that as documented in the literature, the translation of changes in consumption volatility into those in welfare could vary significantly depending on the specification and parameters of consumers' utility.

Relatedly, Jung et al. (2021) and Salisu et al. (2023) examine the impact of geopolitical risk on equity markets and global financial cycles, respectively. Further, Ghasseminejad and Jahan-Parvar (2021) evaluate the impact of financial sanctions on firms. However, to the best of our knowledge, no study has examined the relationship between geopolitics and diversification benefits due to cross-border investment, and this study fills in the gap.

The rest of this paper is structured as follows. Section 2 lays out the model used in the paper. Section 3 describes the fragmentation scenarios, and Section 4 explains parameterization of the model. Section 5 presents the simulation results, first evaluating the fit of the data under the *full integration* scenario and then comparing the results from the *full integration* scenario with those under different fragmentation scenarios to estimate the loss of diversification benefits. Section 6 concludes. Appendices show additional results and robustness.

2 The Model

This section explains the application of the model of Coeurdacier et al. (2010), which is a two-country open-economy model with domestic and foreign equities and bonds, to assess the impact of geoeconomic fragmentation on international diversification benefits. We simulate the model to estimate the volatility of macro-financial variables under four scenarios with different degrees of geoeconomic fragmentation (as discussed below in Section 3). In the model, households hedge their wage income risk by investing in foreign equity, generating diversification benefits for the economy.

The model is useful to obtain plausible estimates of diversification benefits from foreign investment for two main reasons. First, because it generates plausible magnitudes of “equity home bias” for G7 countries—that is, the preference of domestic residents to hold local equity over foreign equity—which is critical to reasonably replicate the actual international portfolio allocation. In the model wage income and dividend from domestic equity investment are imperfectly correlated, thus offering some opportunities for domestic risk diversification and leading to home bias.¹⁰ Second, because the model generates plausible macro-financial dynamics by including total factor productivity (TFP) and investment-specific technology shocks.

¹⁰Regarding the equity home bias, see Coeurdacier et al. (2009), Coeurdacier et al. (2010), and Heathcote and Perri (2013). Coeurdacier and Rey (2013) provides an excellent literature survey.

In this study, the model takes each economy in G7 as the “home country” and the weighted average of other countries with which trading is possible (including other G7 countries) as the “foreign country”. The global economy under the *full integration* scenario is approximated by the largest 60 countries, including G7 and 53 non-G7 countries. These countries are chosen based on the size of nominal GDP as of 2021 using the IMF World Economic Outlook database, and account for 96 percent of the world output. The details of the model setup are as follows.

2.1 Setup

There are two countries: Home (H) and Foreign (F). Each country has a representative household and firm who live in periods $t = 0, 1, 2, \dots$. The households provide labor supply, consume tradable goods produced in the home and foreign countries, and invest in financial assets, which are composed of equity and bond securities issued in the home and foreign countries. The firms invest in capital and produce one tradable good using labor and capital. All markets are globally integrated and perfectly competitive. Further details are as follows.

Household. The representative household in country $i \in \{H, F\}$ has the following Constant Relative Risk Aversion (CRRA) utility.

$$\mathbb{E} \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{C_{i,t}^{1-\sigma}}{1-\sigma} - \frac{L_{i,t}^{1+\omega}}{1+\omega} \right) \right], \quad (1)$$

where $\sigma > 1$ and $\omega > 0$. $C_{i,t}$ represents consumer i 's aggregate consumption in period t , and $L_{i,t}$ represents labor in period t . $C_{i,t}$ is a composite index of home and foreign goods consumption and is given by:

$$C_{i,t} = \left[a^{\frac{1}{\phi}} C_{i,t}^i \frac{\phi-1}{\phi} + (1-a)^{\frac{1}{\phi}} C_{i,t}^j \frac{\phi-1}{\phi} \right]^{\frac{\phi}{\phi-1}}, \quad (2)$$

where $C_{i,t}^i$ ($C_{i,t}^j$) is country i 's consumption of the good produced in country i (j) in period t , and $\phi > 0$ is the elasticity of substitution between the two goods. In the symmetric deterministic steady state, $a \in (\frac{1}{2}, 1)$ represents the share of the local good in consumption spending, that is, the degree of local spending bias in consumption.

Given this consumption aggregator, the consumer price index is derived as,

$$P_{i,t} = \left[a P_t^{i1-\phi} + (1-a) P_t^{j1-\phi} \right]^{\frac{1}{1-\phi}}, \quad (3)$$

where P_t^i and P_t^j are the prices of goods produced in country i and j , respectively.

Setup of the international financial markets is as follows. There are real bonds denominated in the good produced in country i and country j , respectively. Investing in one unit of bond in country i (j) in period t gives one unit of good produced in country i (j) in all future periods. Both bonds are in zero net supply. Moreover, the firms in country i and country j issue equities that represents a claim to its stream of cash-flows $D_{i,t}$ and $D_{j,t}$, respectively. The supply of each share is normalized at unity.

Under the setup above, in period t , the household in country i faces the following budget constraint:

$$\begin{aligned} & P_{i,t}C_{i,t} + P_{i,t}^S S_{i,t+1}^i + P_{j,t}^S S_{j,t+1}^j + P_{i,t}^B B_{i,t+1}^i + P_{j,t}^B B_{j,t+1}^j \\ = & W_{i,t}L_{i,t} + (P_{i,t}^S + D_{i,t})S_{i,t}^i + (P_{j,t}^S + D_{j,t})S_{j,t}^j + (P_{i,t}^B + P_t^i)B_{i,t}^i + (P_{j,t}^B + P_t^j)B_{j,t}^j, \end{aligned} \quad (4)$$

where $P_{i,t}^S$ represents the price of equity in country i and $P_{i,t}^B$ represents the price of the bond in country i . $S_{i,t+1}^i$ ($S_{i,t+1}^j$) denotes the number of shares of equity in country i (j) held by the household in country i at the end of period t , while $B_{i,t+1}^i$ ($B_{j,t+1}^j$) represents claims to future payments of good produced in country i (j) held by the household in country i at the end of period t . $W_{i,t}$ is the country i nominal wage rate. Under the setup, the household maximizes the utility (equation (1)) subject to the budget constraint (equation (4)) by choosing consumption, labor supply, and equity and bond portfolios.

Firm. The representative firm produces a tradable good using labor and capital. In addition to total factor productivity (TFP) shocks, the model assumes shock to investment efficiency, which is an important source of fluctuations in real activity (Justiniano and Primiceri 2008, Justiniano et al. 2011).

The production technology of the firm is given as,

$$Y_{i,t} = \theta_{i,t}(K_{i,t})^\kappa(L_{i,t})^{1-\kappa}, \quad (5)$$

where $\kappa \in (0, 1)$. $K_{i,t}$ represents the country's capital stock. TFP, $\theta_{i,t} > 0$, is an exogenous random variable, and the process of $\theta_{i,t}$ is specified later in Section 4. The capital stock is accumulated as,

$$K_{i,t+1} = (1 - \delta)K_{i,t} + \chi_{i,t}I_{i,t}, \quad (6)$$

where $\delta \in (0, 1)$ represents the depreciation rate of capital. $I_{i,t}$ is the gross investment in country i in period t . $\chi_{i,t}$ is an exogenous shock to investment efficiency, and the process of

$\chi_{i,t}$ is specified later in Section 4. The gross investment is conducted using home and foreign goods as inputs:

$$I_{i,t} = \left[a_I^{\frac{1}{\phi_I}} I_{i,t}^i \frac{\phi_I - 1}{\phi_I} + (1 - a_I)^{\frac{1}{\phi_I}} I_{i,t}^j \frac{\phi_I - 1}{\phi_I} \right]^{\frac{\phi_I}{\phi_I - 1}}, \quad (7)$$

where $I_{i,t}^i$ ($I_{i,t}^j$) is the amount of good produced in country i (j) used for investment in country i . $a_I \in (\frac{1}{2}, 1)$ represents the degree of local bias in investment. ϕ_I represents the elasticity of substitution between domestic and foreign goods in investment. The investment price index is,

$$P_{i,t}^I = \left[a_I P_t^{i1 - \phi_I} + (1 - a_I) P_t^{j1 - \phi_I} \right]^{\frac{1}{\phi_I - 1}}. \quad (8)$$

Under the setup, the firm maximizes the present value of dividend payments, taking prices and wage rates as given.

2.2 Equilibrium

The equilibrium is defined as set of prices $\{P_{t,i}, P_t^i, P_{i,t}^S, P_{i,t}^B, W_{i,t}\}$ and allocations $\{C_{i,t}, C_{i,t}^i, C_{i,t}^j, L_{i,t}, S_{i,t}^i, S_{j,t}^i, B_{i,t}^i, B_{j,t}^i\}$ and $\{I_{i,t}, I_{i,t}^i, I_{i,t}^j, K_{i,t+1}, Y_{i,t}, D_{i,t}, D_{j,t}\}$ for households and firms in country $i \in \{H, F\}$ with $j \in \{H, F\} (j \neq i)$, respectively, such that $\{C_{i,t}, C_{i,t}^i, C_{i,t}^j, L_{i,t}, S_{i,t}^i, S_{j,t}^i, B_{i,t}^i, B_{j,t}^i\}$ solves the households' problem (equations (1), (2), and (4)) given $\{P_{t,i}, P_t^i, P_{i,t}^S, P_{i,t}^B, W_{i,t}\}$, $\{I_{i,t}, I_{i,t}^i, I_{i,t}^j, K_{i,t+1}, Y_{i,t}, D_{i,t}, D_{j,t}\}$ solves the firms' problem (equations (5), (6), and (7)) given $\{P_{t,i}, P_t^i, P_{i,t}^S, P_{i,t}^B, W_{i,t}\}$, and goods and asset markets are cleared as follows.

$$C_{H,t}^H + C_{H,t}^F + I_{H,t}^H + I_{H,t}^F = Y_{H,t}, \quad (9)$$

$$C_{F,t}^F + C_{F,t}^H + I_{F,t}^F + I_{F,t}^H = Y_{F,t}, \quad (10)$$

$$S_{H,t}^H + S_{H,t}^F = S_{F,t}^F + S_{F,t}^H = 1, \quad (11)$$

$$B_{H,t}^H + B_{H,t}^F = B_{F,t}^F + B_{F,t}^H = 0. \quad (12)$$

The first-order conditions constituting this equilibrium are derived as follows.

First-order conditions of the households. The first-order conditions of the household in country i , except for portfolio choices,¹¹ are given as follows.

$$C_{i,t}^i = a \left(\frac{P_t^i}{P_{i,t}} \right)^{-\phi} C_{i,t}, \quad (13)$$

¹¹The portfolio choice is to be shown in Section 2.3.

$$C_{i,t}^j = (1 - a) \left(\frac{P_t^j}{P_{i,t}} \right)^{-\phi} C_{i,t}, \quad (14)$$

$$L_{i,t}^\omega = \left(\frac{W_{i,t}}{P_{i,t}} \right) C_{i,t}^{-\sigma}, \quad (15)$$

$$1 = \mathbb{E}_t^i Q_{t,t+1} R_{j,t+1}^S, \quad (16)$$

$$1 = \mathbb{E}_t^i Q_{t,t+1} R_{j,t+1}^B, \quad (17)$$

for $j \in \{H, F\}$ where $R_{j,t+1}^S = \frac{P_{j,t+1}^S + D_{j,t+1}}{P_{j,t}^S}$ and $R_{j,t+1}^B = \frac{P_{j,t+1}^B + P_{t+1}^j}{P_{j,t}^B}$. Conditions (13) and (14) indicate the optimal allocation of consumption across goods produced in the home and foreign countries. Condition (15) represents the optimal labor supply condition, and conditions (16) and (17) show the Euler equations. $R_{j,t+1}^S$ and $R_{j,t+1}^B$ are the gross returns of equity j , and of the bond in country j , respectively (between t and $t + 1$). $Q_{i,t+1}^i \equiv \beta \left(\frac{C_{i,t+1}}{C_{i,t}} \right)^{-\sigma} \left(\frac{P_{i,t}}{P_{i,t+1}} \right)$ is a pricing kernel used in period t to value period $t + 1$ pay-offs.

First-order conditions of the firms. The first-order conditions of the firm in country i are given as follows. Due to the Cobb-Douglas technology, a share $1 - \kappa$ of output is paid to workers. Hence, the wage bill for the firm in country i is given by,

$$W_{i,t} L_{i,t} = (1 - \kappa) P_t^i Y_{i,t}, \quad (18)$$

where P_t^i represents the price of the good produced in country i and $W_{i,t}$ is the country i nominal wage rate.

For the sake of simplicity, investment is assumed to be financed out of retained earnings. Hence, a dividend $D_{i,t}$ to shareholders in country i is calculated as a share κ of the country's output minus physical investment as follows.

$$D_{i,t} = \kappa P_t^i Y_{i,t} - P_{i,t}^I I_{i,t}. \quad (19)$$

The firm chooses $I_{i,t}$ to equate the expected future marginal gain of investment to the marginal cost as follows.

$$1 = \mathbb{E}_t^i Q_{t,t+1}^i \frac{\chi_{i,t}}{P_{i,t}^I} \left[P_{t+1}^i \theta_{i,t+1} \kappa K_{i,t+1}^{\kappa-1} L_{i,t+1}^{1-\kappa} + (1 - \delta) \frac{P_{i,t+1}^I}{\chi_{i,t+1}} \right]. \quad (20)$$

The firm then chooses the amount of home good ($I_{i,t}^i$) and foreign good ($I_{i,t}^j$) which minimize the cost of investment ($I_{i,t}$). This yields the following first-order conditions for $j \in \{H, F\}$:

$$I_{i,t}^j = (1 - a_I) \left(\frac{P_t^j}{P_{i,t}^I} \right)^{-\phi_I} I_{i,t}, \quad (21)$$

$$I_{i,t}^j = (1 - a_I) \left(\frac{P_t^j}{P_{i,t}^I} \right)^{-\phi_I} I_{i,t}. \quad (22)$$

Terms of trade. Additionally, in the linearized model, terms of trade are determined as follows. Because there exist four types of shocks (TFP and investment efficiency shocks in home and foreign countries) and four types of financial assets (equities and bonds in home and foreign countries), the market is complete up to the first order. Hence, the terms of trade are pinned down to satisfy a risk-sharing condition that holds under complete market (Backus and Smith 1993 and Kollmann 1995). Specifically, the terms of trade, defined as $Q_t \equiv \frac{P_t^H}{P_t^F}$, moves in line with the condition in which the ratio of home to foreign marginal utilities of aggregate consumption, $\frac{C_{H,t}^{-\sigma}}{C_{F,t}^{-\sigma}}$ is equated to the consumption-based real exchange rate, $REER_t \equiv \frac{P_{H,t}}{P_{F,t}}$ up to first order.

Real corporate profits, equity and bond prices. Finally, we define additional variables of our interest. Combining the variables above, the real profits, real equity prices and real bond prices in the home country are defined as follows.

$$\Pi_{H,t} \equiv \frac{P_t^H Y_{H,t} - W_{H,t} L_{H,t}}{P_{H,t}}, \quad (23)$$

$$\widehat{P}_{H,t}^S \equiv \frac{P_{H,t}^S}{P_{H,t}}, \quad (24)$$

$$\widehat{P}_{H,t}^B \equiv \frac{P_{H,t}^B}{P_{H,t}}. \quad (25)$$

2.3 Portfolio Choice (Zero-Order Portfolio)

This section shows the optimal steady-state portfolio, the so-called zero-order portfolio in the literature.¹² The definition of “zero-order portfolio” is the portfolio decision rules evaluated at steady state values of state variables, where equilibrium portfolio holdings in period t ($S_{H,t}^H, S_{H,t}^F, S_{F,t}^F, S_{F,t}^H, B_{H,t}^H, B_{H,t}^F, B_{F,t}^F, B_{F,t}^H$) are the function of state variables in period $t - 1$.

The zero-order portfolio is derived as follows. The setup of the model indicates that the steady state is symmetric between home and foreign countries, meaning that the values of

¹²The portfolio is determined to effectively protect against fluctuations in both the real exchange rate and labor income. Specifically, because the differences in returns between bonds denominated in domestic and foreign goods are correlated with the real exchange rate, the bonds are employed to hedge against changes in the real exchange rate. Meanwhile, fluctuations in labor income are managed through the equity portfolio. For details of the derivation, see Coeurdacier et al. (2010).

state variables in the deterministic steady state in home and foreign countries are identical too.¹³ Hence, $S_H^H = 1 - S_H^F = S_F^F = 1 - S_F^H \equiv S$ and $B_H^H = -B_H^F = B_F^F = -B_F^H \equiv B$ holds, where the pair of (S, B) represents the zero-order equilibrium portfolio. Note that S denotes a country's holdings of local equity, while B denotes its holdings of bonds denominated in the local good. Coeurdacier et al. (2010) then find a unique portfolio (S, B) that makes the (“static”) budget constraint consistent with the efficient risk sharing conditions: the ratio of home to foreign marginal utilities of aggregate consumption is equated to the consumption-based real exchange rate up to first order, under any realization of shocks. Because the portfolio (S, B) affect the household's consumption only via budget constraint, zero-order portfolio can be identified. Specifically, the deviation of the relative consumption between home and foreign countries from an efficient risk sharing condition is expressed as a function of terms of trade and relative investment between home and foreign countries. The households in both countries then choose the portfolio (S, B) which attains the efficient risk sharing condition. The calculated zero-order portfolio (S, B) is given as follows.

$$S = \frac{1}{2} \left[1 + \frac{(2a_I - 1)(1 - \kappa)}{1 - (2a_I - 1)\kappa} \right] > \frac{1}{2}, \quad (26)$$

$$b \equiv \frac{B}{Y_H} = \frac{1}{2} \left[(1 - \Lambda) \left(1 - \frac{1}{\sigma}\right) (2a - 1) + \frac{(1 - \kappa)[\lambda^* - 1 + \Lambda(2a_I - 1)^2]}{1 - (2a_I - 1)\kappa} \right], \quad (27)$$

where $\Lambda \equiv \kappa / [\frac{1}{\delta} \frac{1-\beta}{\beta} + 1]$, $\lambda \equiv \phi(1 - (2a - 1)^2) + \frac{(2a - 1)^2}{\sigma} > 0$ (as $a \in (\frac{1}{2}, 1)$ implies $1 - (2a - 1)^2 > 0$), and $\lambda^* \equiv (1 - \Lambda)\lambda + \Lambda\phi_I(1 - (2a_I - 1)^2) > 0$.

The closed-form solution for the portfolio (26) indicates that the model generates equity home bias.¹⁴ One important observation is that the equity portfolio S solely depends on the local spending bias in investment (a_I) and the capital share (κ). In particular, degree of equity home bias is increasing in the local spending bias in investment, as observed in empirical studies (Heathcote and Perri 2013). Coeurdacier et al. (2010) and Coeurdacier and Rey (2013) discuss the intuition and mechanism behind the equity home bias of zero-order portfolio in this model and also provide supporting empirical evidence on the mechanism.

The mechanism behind equity home bias is that an increase in physical investment by a domestic firm decreases dividend to equity investors, lowering correlation between

¹³In a risky steady state, the asymmetry of shock processes result in the asymmetric steady state via precautionary savings (Coeurdacier et al. 2011 and Coeurdacier et al. 2020). This model, focusing on the local solution around the deterministic steady state, abstracts from this mechanism.

¹⁴Because countries are symmetric in a steady state, including the size of the countries, there exists home bias if $S > \frac{1}{2}$ holds.

labor income and dividends for household. Regarding local spending bias in investment, as the bias increases, domestic output increases more strongly with investment, leading to a larger increase in labor income. Hence, correlation between labor income and dividends for household is lowered more significantly. Because the lower correlation between labor income and dividend offers a higher degree of diversification, the household has stronger home bias in equity investment. The same mechanism applies to capital share because a higher capital share leads to a tighter relationship between domestic investment and output. When a domestic firm aims to increase its future output, it invests more in physical capital, resulting in higher demand for domestic good.

In the following, we simulate this model economy with the log-linearized (non-portfolio) first-order conditions in Subsection 2.2 and this zero-order portfolio.¹⁵ The log-linearized (non-portfolio) first-order conditions are shown in Appendix C. Note that, as shown in Devereux and Sutherland (2011), because the excess returns of any financial assets are zero at the steady state, the (log) linearized (non-portfolio) conditions depend only on the zero-order portfolio, and higher-order aspects of portfolio behavior are irrelevant for the first-order approximated macroeconomic dynamics.¹⁶

3 Scenarios

This section describes four scenarios for model simulations. The *full integration* scenario approximates the current global economy and international financial markets. We also consider two fragmentation scenarios (*moderate* and *extreme fragmentation*) where each G7 country does not transact with countries with high bilateral geopolitical distance. The bilateral geopolitical distance is measured with the average S score (Signorino and Ritter 1999) based on countries' voting in the UNGA during the period 2012-2021.¹⁷ Finally, we also consider an *autarky* scenario where G7 countries are self-sufficient and do not trade with any other economy. The effects of geoeconomic fragmentation on international diversification

¹⁵Coeurdacier et al. (2010) simulate the model with second-order approximated (non-portfolio) conditions and first-order approximated portfolio because their focus is on foreign asset dynamics. By contrast, because the focus in this study is on the macro-financial volatility, we simulate the model with the log-linearized conditions with zero order portfolio. This simplification makes the simulation numerically less expensive to a significantly large extent.

¹⁶In other words, the order of approximation of the model in our simulation is sufficient to explore the implications of the portfolio choice for the first-order properties of macroeconomic variables, such as the second moments (volatility).

¹⁷For details of the geopolitical distance measures, see Appendix A.

benefits for G7 are evaluated based on the impact of changes in the country composition of the “foreign country” on the volatility of macro-financial variables ($Y_{H,t}$, $C_{H,t}$, $\Pi_{H,t}$, $\hat{P}_{H,t}^S$, $\hat{P}_{H,t}^B$). Tables 1 and 2 summarize scenarios and key characteristics of the scenarios.

Table 1: Four scenarios

	Scenario	Partners in foreign countries
(1)	<i>Full integration</i>	All countries
(2)	<i>Moderate fragmentation</i>	75 percent of (1)
(3)	<i>Extreme fragmentation</i>	50 percent of (1)
(4)	<i>Autarky</i>	None

Full integration scenario The *full integration* scenario (1) describes the situation in which G7 countries can trade with, and invest in, all foreign countries. The “foreign country” approximates the global economy and international financial markets. We parameterize the model under this scenario so that the model simulation results fit the data.

Moderate and extreme fragmentation scenarios The *moderate* (2) and *extreme* (3) *fragmentation* scenarios are hypothetical scenarios where countries with an average geopolitical distance from the G7 countries exceeding the sample distribution’s top 25th and 50th percentiles, respectively, are excluded from the foreign country in the model.

Autarky scenario Finally, in the *autarky* scenario (4), the G7 countries are self-sufficient and financially cut off from all other economies, including the other G7 countries.

As shown in Table 2, under the *moderate fragmentation* scenario, some industrial countries and some commodity-exporting countries are excluded (e.g., China, India, Indonesia, and the middle eastern countries). Under the *extreme fragmentation* scenario, in addition to the countries excluded under the *moderate fragmentation* scenario, most of the remaining commodity-exporting countries (e.g., Russia and Latin American countries, including Brazil) are excluded. Under the *extreme fragmentation* scenario, the remaining partner countries consist primarily of industrial countries in Europe.

To interpret the above *fragmentation* scenarios from the viewpoint of international risk diversification, in Figure 1 we observe the relationship between geopolitical distance and business cycle correlations of G7 partner countries. Specifically, Figure 1 is created by

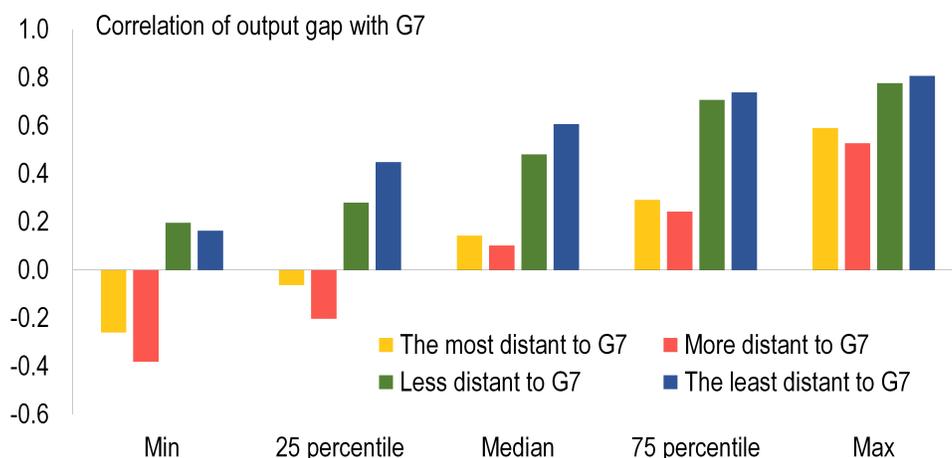
Table 2: Countries included in different scenarios

1	United States	XXX	31	Nigeria	XX
2	China	X	32	Egypt	X
3	Japan	XXX	33	United Arab Emirates	X
4	Germany	XXX	34	South Africa	XX
5	United Kingdom	XXX	35	Bangladesh	X
6	India	X	36	Denmark	XXX
7	France	XXX	37	Singapore	XX
8	Italy	XXX	38	Philippines	XX
9	Canada	XXX	39	Malaysia	XX
10	Korea	XXX	40	Hong Kong SAR	X
11	Russia	XX	41	Vietnam	X
12	Australia	XXX	42	Pakistan	X
13	Brazil	XX	43	Chile	XX
14	Islamic Republic of Iran	X	44	Colombia	XX
15	Spain	XXX	45	Finland	XXX
16	Mexico	XX	46	Romania	XXX
17	Indonesia	X	47	Czech Republic	XXX
18	Netherlands	XXX	48	Portugal	XXX
19	Saudi Arabia	X	49	New Zealand	XXX
20	Türkiye	XXX	50	Peru	XX
21	Switzerland	XXX	51	Greece	XXX
22	Poland	XXX	52	Iraq	X
23	Sweden	XXX	53	Ukraine	XXX
24	Belgium	XXX	54	Kazakhstan	XX
25	Thailand	XX	55	Hungary	XXX
26	Ireland	XXX	56	Qatar	X
27	Israel	XXX	57	Algeria	X
28	Argentina	XX	58	Morocco	XX
29	Norway	XXX	59	Kuwait	X
30	Austria	XXX	60	Slovak Republic	XXX

Note: Column 1 indicates the ranking of countries in terms of 2021 nominal GDP based on the 2022 October World Economic Outlook by the IMF. Column 3 shows the trading partners in each scenario: “XXX” represents countries included in the model as partner countries of G7 under all scenarios. “XX” represents the countries included in the model under the *full integration* and *moderate fragmentation* scenarios. “X” represents the countries included in the model only under the *full integration* scenario.

first calculating the pairwise cross-country output gap correlation between G7 countries and partner countries (over 1994-2019).¹⁸ Next, we compute the partner country’s correlation of output gap with the G7 countries by taking average of the pairwise correlation among G7 countries. We then divide the samples into four groups (“the least distant to G7”, “less distant to G7”, “more distant to G7”, and “the most distant to G7”) based on the bilateral geopolitical distance over 2012-2021.¹⁹ Finally, we calculate the minimum, first-to-third quantiles and maximum of the cross-border output gap correlation within each group. Figure 1 shows the cross-border output gap correlation of each group by each percentile.

Figure 1: Geopolitical distance and business cycle correlations with G7 countries



Sources: The United Nations “The National Accounts Main Aggregates Database” and authors’ calculations.

Note: “The least distant to G7”, “less distant to G7”, “more distant to G7”, and “the most distant to G7” consist of the group of countries whose average bilateral geopolitical distance with G7 countries is within the range of 0-25, 25-50, 50-75, and 75-100 percentile, respectively. “Min”, “25 percentile”, “median”, “75 percentile”, and “max”, represent the minimum, 25 percentile, median, 75 percentile, and the maximum of the correlations of yearly output gap between G7 countries and countries in each group. The output gap is estimated using Hodrick-Prescott filter (smoothing parameter is 100).

Figure 1 indicates that, across percentiles, “more distant to G7” and “the most distant to G7” exhibit low output gap correlation with the G7 countries while “the least distant to G7” and “less distant to G7” have a high correlation with the G7 countries. In other words, the figure shows that, among partner countries of G7 countries, countries with higher geopolitical distance with G7 tend to have less synchronized business cycles with the G7

¹⁸The outliers during the pandemic are excluded from samples.

¹⁹The sample period for geopolitical distance is more recent than that of the cross-country output gap correlation because our interest lies in the recent geopolitical relationships.

countries. Importantly, the former two groups are excluded from partner countries under the *fragmentation* scenarios, potentially implying that international risk diversification benefits could be substantially reduced under these scenarios. In what follows, we formally examine this hypothesis.

4 Numerical Parameterization

Our parametrization methodology is based on Coeurdacier et al. (2010) but differs from it in two key aspects. First, while Coeurdacier et al. (2010) calibrate all model parameters, this study estimates a few main parameters to achieve a better fit of the model to data and allow for heterogeneity of parameters across G7 countries.²⁰ Second, several parameters are set differently across the various scenarios. The detailed parameterization is described below.²¹

4.1 Benchmark Parameterization

First, we explain parametrization for the *full integration* scenario which approximates the current international financial markets. The model has nine types of parameters: (i) subjective discount factor (β), (ii) inverse of Frisch elasticity of labor supply (ω), (iii) capital share (κ), (iv) depreciation rate of capital (δ), (v) local spending bias in consumption and investment (a and a_I), (vi) inverse elasticity of inter-temporal substitution (σ), (vii) elasticity of substitution in consumption between domestic and foreign goods (ϕ), (viii) elasticity of substitution in investment between them (ϕ_I), and (ix) the processes of TFP and investment efficiency ($\theta_{H,t}$, $\theta_{F,t}$, $\chi_{H,t}$, $\chi_{F,t}$). In what follows, we assume that the log-deviation of the TFP and investment efficiency from the steady state values ($\widehat{\theta}_{H,t}$, $\widehat{\theta}_{F,t}$, $\widehat{\chi}_{H,t}$, $\widehat{\chi}_{F,t}$) follows the first-order autoregressive process as follows:

$$\widehat{\theta}_{H,t} = \rho_{\theta}^H \widehat{\theta}_{H,t-1} + \epsilon_{\theta,t}^H \quad (28)$$

$$\widehat{\theta}_{F,t} = \rho_{\theta}^F \widehat{\theta}_{F,t-1} + \epsilon_{\theta,t}^F \quad (29)$$

$$\widehat{\chi}_{H,t} = \rho_{\chi}^H \widehat{\chi}_{H,t-1} + \epsilon_{\chi,t}^H \quad (30)$$

$$\widehat{\chi}_{F,t} = \rho_{\chi}^F \widehat{\chi}_{F,t-1} + \epsilon_{\chi,t}^F \quad (31)$$

²⁰Our study considers parameterization for each G7 country while Coeurdacier et al. (2010) set the parameters assuming the average G7 country.

²¹Note that frequency of this model is annual as the same as Coeurdacier et al. (2010) and thus the parameterization is consistent with the annual model.

The conditions (28), (29), (30), and (31) indicate that the parameters relevant to these processes are the persistence of the processes $(\rho_\theta^H, \rho_\theta^F, \rho_\chi^H, \rho_\chi^F)$ and variance-covariance structure of the shocks $(std(\epsilon_\theta^H), std(\epsilon_\theta^F), corr(\epsilon_\theta^H, \epsilon_\theta^F), std(\epsilon_\chi^H), std(\epsilon_\chi^F), corr(\chi_\chi^H, \chi_\chi^F))$.²² Note that *std* represents the standard deviation and *corr* represents the correlation. Among these, the parameters (i)-(iv) are assumed to be common across G7 countries while parameters (v)-(ix) are country-specific.

4.1.1 Common Parameters for the G7 Countries

The parameters (i)-(iv) are calibrated as $\beta = 0.96$, $\omega = 0.5$, $\kappa = 0.4$, and $\delta = 0.1$ for all G7 countries following Coeurdacier et al. (2010).

4.1.2 Country-Specific Parameters

In terms of (v) local spending bias in consumption and investment (a and a_I), the calibration procedure follows Coeurdacier et al. (2010), but uses longer time series that include more recent data and consider the heterogeneity across G7 countries. Specifically, local spending biases in consumption and investment are updated based on historical import-to-GDP ratios for the period 1992-2019: 0.87 for the United States, 0.85 for Japan, 0.70 for Germany, 0.76 for the United Kingdom, 0.75 for France, 0.77 for Italy, and 0.70 for Canada.²³

Moreover, the parameters (vi)-(viii) are estimated to improve the fitness of the model simulations to empirical data. With the calibrated parameters for the *full integration* scenario, the parameters (vi)-(viii) are estimated to fit the macroeconomic dynamics of the model to that of historical data. We employ a Bayesian full information approach (Smets and Wouters 2003). Specifically, we set prior distributions of these parameters and then calculate the posterior distributions using a Metropolis-Hastings Markov chain Monte Carlo (MCMC) algorithm, where posterior means are used in simulation exercises. We use yearly data of real consumption and output in home country as observed variables.²⁴ In terms of (vi) inverse elasticity of inter-temporal substitution (σ), the prior distributions are set as uniform distributions between 1 and 2 because the estimates in the literature are in the

²²We assume that the correlation between TFP shock and investment efficiency shocks are zero following Coeurdacier et al. (2010).

²³The import-to-GDP ratio to calculate these figures are taken from the United Nations “The National Accounts Main Aggregates Database.”

²⁴These variables are one-sided Hodrick-Prescott filtered variables (smoothing parameter is 100). The original series is obtained from the United Nations “The National Accounts Main Aggregates Database.”

range of these parameters.²⁵ The means of the posterior distribution is close to 1 in all countries.²⁶ Regarding (vii) elasticity of substitution in consumption between domestic and foreign goods (ϕ) and (viii) elasticity of substitution in investment between domestic and foreign goods (ϕ_I), we set the uniform distributions between 0.6 and 1.5 which encompass the estimates in the literature.²⁷ The ranges of the posterior mean across the G7 countries are 0.7-1.3 and 0.7-1.1. Table 3 shows the details of the estimation results of these three parameters for each G7 country.

Finally, (ix) the processes of TFP and investment efficiency ($\hat{\theta}_{H,t}$, $\hat{\theta}_{F,t}$, $\hat{\chi}_{H,t}$, $\hat{\chi}_{F,t}$) are calibrated following Coeurdacier et al. (2010) using the dataset with the sample period of 1994-2019.²⁸ Specifically, regarding the process of TFP in home country, we obtain a series of TFP from the Penn World Table, version 10.0. (Feenstra et al. 2015), and calculate TFP cycles (percent deviation from the trend) by applying one-sided Hodrick-Prescott filter (smoothing parameter=100) to the logarithm of the TFP series ($\hat{\theta}_{H,t}$). We then estimate the first-order autoregressive model of the TFP cycles and obtain the persistence of the cycles (ρ_{θ}^H) and the standard deviation of the TFP shocks ($std(\epsilon_{\theta}^H)$) based on the residuals of the first-order autoregressive model. With respect to the process of TFP in foreign country, similar to home country TFP, we obtain a series of TFP from the Penn World Table and calculate the TFP cycles by applying the same HP filter to the logarithm of the TFP series ($\hat{\theta}_{F,t}$). Because the foreign country in this model corresponds to the group of partner countries, we obtain aggregate TFP cycles by taking the weighted-average of the TFP cycles in individual countries, based on real output (in US dollars) in the corresponding year. We then estimate the first-order autoregressive model of the TFP cycles and obtain the persistence of the cycles (ρ_{θ}^F) and the standard deviation of the TFP shock ($std(\epsilon_{\theta}^F)$) based on the residuals. Finally, we calculate the correlation of the TFP shocks in home and

²⁵For example, the posterior means of Smets and Wouters (2003) (Europe), Levin et al. (2006) (the United States), Sugo and Ueda (2008) (Japan) are 1.391, 2.045, and 1.249, respectively. The lower bound, 1, is necessary because this model considers the situation that $\sigma > 1$ holds as stated in Section 2.

²⁶These estimates are consistent with Christiano et al. (2005) which employs log utility. These estimates are also in line with the range of the estimates of posterior means for Europe and the United States obtained from open-economy models (De Walque and Wouters 2005 and De Walque and Wouters 2017) that range between 0.8-1.2.

²⁷For instance, Hooper and Marquez (1993) survey the estimates of long-run price elasticity of aggregate trade by time-series analysis, and report that the median estimates in the post-Bretton Woods era are 0.97 for the United States, 0.80 for Japan, 0.57 for Germany, 0.6 for the United Kingdom, and 1.01 for Canada. Moreover, Heathcote and Perri (2002) obtain 0.90. Further, based on the ranges of the estimates in the literature, Kollmann (2006) choose 0.6, 0.9, and 1.2, and Backus and Smith (1993), Chari et al. (2002) and Corsetti et al. (2008), respectively, select 1.5, 1.5, and 0.85 as calibrated parameters.

²⁸The sample period of the dataset used in Coeurdacier et al. (2010) is 1984-2004.

Table 3: Estimation results

(a) Inverse elasticity of inter-temporal substitution (σ)

Country	Prior	Posterior mean	90 percent interval
United States	uniform [1, 2]	1.037	1.004-1.085
Japan	uniform [1, 2]	1.006	1.001-1.014
Germany	uniform [1, 2]	1.011	1.001-1.026
United Kingdom	uniform [1, 2]	1.034	1.004-1.080
France	uniform [1, 2]	1.016	1.002-1.037
Italy	uniform [1, 2]	1.009	1.001-1.022
Canada	uniform [1, 2]	1.056	1.007-1.126

(b) Elasticity of substitution in consumption between domestic and foreign goods (ϕ)

Country	Prior	Posterior mean	90 percent interval
United States	uniform [0.6, 1.5]	0.774	0.617-1.021
Japan	uniform [0.6, 1.5]	0.896	0.643-1.249
Germany	uniform [0.6, 1.5]	1.262	0.972-1.467
United Kingdom	uniform [0.6, 1.5]	0.746	0.614-0.950
France	uniform [0.6, 1.5]	0.761	0.614-0.991
Italy	uniform [0.6, 1.5]	0.656	0.606-0.732
Canada	uniform [0.6, 1.5]	0.954	0.657-1.331

(c) Elasticity of substitution in investment between domestic and foreign goods (ϕ_I)

Country	Prior	Posterior mean	90 percent interval
United States	uniform [0.6, 1.5]	0.898	0.641-1.262
Japan	uniform [0.6, 1.5]	1.006	0.673-1.378
Germany	uniform [0.6, 1.5]	1.137	0.751-1.445
United Kingdom	uniform [0.6, 1.5]	0.888	0.637-1.262
France	uniform [0.6, 1.5]	0.874	0.630-1.241
Italy	uniform [0.6, 1.5]	0.746	0.615-0.944
Canada	uniform [0.6, 1.5]	1.030	0.674-1.408

foreign country ($corr(\epsilon_{\theta}^H, \epsilon_{\theta}^F)$), based on the residuals of the first-order autoregressive model in home and foreign countries. Regarding the processes of the investment efficiency ($\chi_{H,t}, \chi_{F,t}$), the series of investment efficiency is calculated by dividing the consumption deflator by the investment deflator following Justiniano et al. (2011), and the calculation of ($\rho_{\chi}^H, \rho_{\chi}^F, std(\epsilon_{\chi}^H), std(\epsilon_{\chi}^F), corr(\chi_{\chi}^H, \chi_{\chi}^F)$) follows that for TFP.

Table 4 shows the full list of these estimates. The ranges of the persistence of the TFP process in the home and foreign countries are, respectively, 0.54-0.84 and 0.69-0.72. The estimates of the home country include the parameter in Coeurdacier et al. (2010), equivalent to 0.75. The standard deviations of the TFP process in the home and foreign countries are 0.67-0.92 and 0.51-0.61, respectively. The estimates of the home country are somewhat lower than those in Coeurdacier et al. (2010), while the cross-country correlations are positive and in the range of 0.17-0.67, which includes the parameter in Coeurdacier et al. (2010).²⁹

Next, the ranges of the persistence of the investment efficiency process in the home and foreign countries are, respectively, 0.58-0.87 and 0.45-0.52. The estimates of home country are in line with the parameter in Coeurdacier et al. (2010) (0.79). The standard deviation of the investment efficiency process in the home and foreign countries are 0.34-0.76 and 0.87-0.88, which are lower than those in Coeurdacier et al. (2010) (1.20).³⁰ The cross-country correlations are positive and in the range of 0.19-0.34, which is consistent with the parameter in Coeurdacier et al. (2010) (0.19).

4.2 Parameterization under Counterfactual Scenarios

In addition to the benchmark *full integration* scenario, we simulate our model under three counterfactual scenarios: the *moderate fragmentation* scenario, the *extreme fragmentation* scenario, and the *autarky* scenario. This subsection explains the methodology to set the parameters under these three scenarios. Specifically, two sets of parameters are set differently across scenarios in order to reflect the differences of the scenario narratives: (i) the processes

²⁹The estimate of home country in Coeurdacier et al. (2010) is 1.20 and that of cross-country correlation is 0.45. Several factors contribute to the difference between Coeurdacier et al. (2010) and our estimates. First, the TFP series used in our study are taken from the Penn World Table, version 10.0. (Feenstra et al., 2015) while Coeurdacier et al. (2010) estimate them by assuming constant labor share and ignoring capital stocks, based on the OECD database. Second, the sample period is different between our study (1994-2019) and Coeurdacier et al. (2010) (1984-2004).

³⁰The difference in sample periods mainly contribute to this difference. Other than that, the difference in the proxy of the investment efficiency could also contribute to this difference: our study uses the ratio of consumption deflator to investment deflator while Coeurdacier et al. (2010) employ the ratio of consumer price index to investment deflator.

Table 4: Benchmark parametrization of TFP and investment efficiency process

(a) TFP process in home and foreign country ($\theta_{H,t}, \theta_{F,t}$)

Country	ρ_{θ}^H	$std(\epsilon_{\theta}^H)$	ρ_{θ}^F	$std(\epsilon_{\theta}^F)$	$corr(\epsilon_{\theta}^H, \epsilon_{\theta}^F)$
United States	0.84	0.67	0.72	0.61	0.17
Japan	0.69	0.72	0.72	0.54	0.27
Germany	0.59	0.67	0.72	0.53	0.30
United Kingdom	0.85	0.86	0.70	0.52	0.39
France	0.74	0.63	0.69	0.52	0.58
Italy	0.76	0.92	0.71	0.52	0.47
Canada	0.54	0.78	0.69	0.51	0.67

(b) Investment efficiency process in home and foreign country ($\chi_{H,t}, \chi_{F,t}$)

Country	ρ_{χ}^H	$std(\epsilon_{\chi}^H)$	ρ_{χ}^F	$std(\epsilon_{\chi}^F)$	$corr(\epsilon_{\chi}^H, \epsilon_{\chi}^F)$
United States	0.76	0.60	0.87	0.52	0.27
Japan	0.81	0.34	0.87	0.47	0.19
Germany	0.87	0.42	0.88	0.46	0.29
United Kingdom	0.58	0.90	0.87	0.46	0.34
France	0.81	0.40	0.87	0.46	0.29
Italy	0.69	0.50	0.87	0.46	0.20
Canada	0.78	0.76	0.87	0.45	0.28

of TFP and investment efficiency foreign country ($\theta_{F,t}$ and $\chi_{F,t}$), and (ii) local spending bias in consumption and investment (a and a_I). The detailed calibration procedures of these parameters are as follows.

Moderate and extreme fragmentation scenarios. The processes of the TFP and investment efficiency in the foreign country should differ, depending on the composition of the foreign country (i.e. trading partners of each G7 country) under the *full integration* and *fragmentation* scenarios. While the exogenous processes of the TFP and investment efficiency in individual partner countries are assumed to be identical across all scenarios, the weights for each economy in calculating the process of aggregate TFP and investment efficiency differ across scenarios. The weights are based on real output in the corresponding year.³¹ Table 5 shows the full list of the calibrated parameters in terms of TFP and investment efficiency processes in the foreign country.

The local spending biases in consumption and investment are set to be in line with the

³¹The real GDP (USD) for each country is obtained from the United Nations “The National Accounts Main Aggregates Database.”

scenario narratives. Specifically, under *fragmentation* scenarios, it is assumed that currently imported goods from the countries which are excluded from trading partners are to be produced by the remaining countries, including the home country, proportionately to the current production share of each country.³² Table 6 indicates the full list of the calibrated parameters regarding local spending bias.

Autarky scenario. In this scenario, the home country cannot engage in cross-border transactions with the foreign country, and thus the model abstracts from the parameters relevant to the processes of TFP and investment efficiency in the foreign country. Regarding the local spending bias in consumption and investment, we assume full bias ($a = a_I = 1$).

Table 5: TFP and investment efficiency process under fragmentation scenarios

(a) Moderate fragmentation scenario						
Country	ρ_θ^F	$std(\epsilon_\theta^F)$	$corr(\epsilon_\theta^H, \epsilon_\theta^F)$	ρ_χ^F	$std(\epsilon_\chi^F)$	$corr(\epsilon_\chi^H, \epsilon_\chi^F)$
United States	0.50	0.70	0.17	0.81	0.55	0.56
Japan	0.67	0.63	0.41	0.79	0.47	0.16
Germany	0.67	0.63	0.36	0.81	0.45	0.38
United Kingdom	0.62	0.60	0.56	0.80	0.43	0.42
France	0.64	0.61	0.69	0.80	0.45	0.30
Italy	0.65	0.61	0.48	0.80	0.44	0.38
Canada	0.65	0.61	0.65	0.80	0.43	0.50

(b) Extreme fragmentation scenario						
Country	ρ_θ^F	$std(\epsilon_\theta^F)$	$corr(\epsilon_\theta^H, \epsilon_\theta^F)$	ρ_χ^F	$std(\epsilon_\chi^F)$	$corr(\epsilon_\chi^H, \epsilon_\chi^F)$
United States	0.64	0.58	0.55	0.77	0.32	0.63
Japan	0.79	0.59	0.36	0.75	0.43	0.15
Germany	0.78	0.58	0.40	0.78	0.41	0.37
United Kingdom	0.76	0.55	0.76	0.77	0.39	0.32
France	0.77	0.57	0.74	0.77	0.40	0.41
Italy	0.77	0.56	0.61	0.77	0.40	0.38
Canada	0.78	0.57	0.38	0.77	0.39	0.58

³²Specifically, the local spending biases are calculated as follows. Denote the local spending bias under the *full integration* scenario by x and the import partner share of remaining trading partners under *fragmentation* scenarios by y . Then, the local spending biases under *fragmentation* scenarios are given as $x + (1 - x)(1 - y)(x/(x + (1 - x)y))$. The dataset of bilateral import partner share is obtained from World Bank, “World Integrated Trade Solution”.

Table 6: Local spending bias in consumption and investment under fragmentation and autarky scenarios

Country	Full integration	Moderate fragmentation	Extreme fragmentation	Autarky
United States	0.87	0.90	0.93	1.00
Japan	0.85	0.91	0.94	1.00
Germany	0.70	0.73	0.75	1.00
United Kingdom	0.76	0.79	0.80	1.00
France	0.75	0.78	0.80	1.00
Italy	0.77	0.80	0.81	1.00
Canada	0.70	0.73	0.76	1.00

5 Simulation Results

This section examines the performance of the model by presenting the degree of equity home bias and the simulation results of macro-financial volatility under the *full integration* scenario. It then compare the estimated macro-financial volatility under the counterfactual scenarios with those under the *full integration* scenario.

5.1 Performance of the Model

This section shows the fitness of the model to empirical data on the degree of equity home bias and volatility of macroeconomic variables.

Equity home bias. The equity home bias in home country in the model is calculated as $1 - (1 - S)/0.5$,³³ where S represents the share of domestic equity in home country's total equity investment S (equation 26) under the *full integration* scenario.

The empirical counterpart in G7 countries is then calculated based on the data on market capitalization³⁴ and IMF's Coordinated Portfolio Investment Survey (CPIS), following the formula in Coeurdacier and Rey (2013): The degree of the equity home bias of country i is calculated as $1 - \frac{\text{share of foreign equities in country } i\text{'s total equity investment}}{\text{share of foreign equities in the world market portfolio}}$.

Table 7 then compares the degree of equity home bias in the model and that based on empirical data, and shows that the estimates are similar to each other.

³³The denominator is set as 0.5 because the size of the home and foreign countries in a steady state are assumed symmetric in this model.

³⁴The stock market capitalization is based on World Federation of Exchanges.

Table 7: Degree of equity home bias

Country	Model	Data
United States	0.63	0.59
Japan	0.59	0.68
Germany	0.28	0.37
United Kingdom	0.39	0.49
France	0.38	0.60
Italy	0.41	0.30
Canada	0.28	0.49

Note: The degree of the equity home bias of country i in 2019. In terms of market capitalization data of several countries which are missing (from 2015 for the United Kingdom and Italy, and 2019 for France), the value is extrapolated by assuming that the changes in market capitalization follow those in Germany.

Macroeconomic variables. We next compare the dynamics of macroeconomic variables—the volatility (standard deviation), cyclicity (correlation with output), and cross-country correlation of macroeconomic variables (output, consumption, and investment)—generated by the model simulation under the *full integration* scenario with empirical data (for the period 1992-2019).

Table 8 compares the dynamics of macroeconomic variables generated by the model with empirical data. The empirical data is calculated based on the one-sided Hodrick-Prescott filtered (smoothing parameter=100) variables.³⁵ The table shows that the model performs well: it closely replicates the empirical standard deviation of output, consumption, and investment, and their correlation with output, while it is less successful in explaining empirical cross-country correlations.

5.2 Volatility of Macro-Financial Variables and Diversification Benefits

In this subsection, we analyze the impact of geopolitical fragmentation on macro-financial volatility, specifically on output, consumption, corporate profits, equity prices, and bond prices, and evaluate the potential loss of diversification benefits from the cross-border investment.

We begin by comparing the level of macro-financial volatility in different scenarios. Figure 2 shows the ratio of the volatility (standard deviation) of real output, consumption, corporate profit, equity price, and bond price under the *moderate* and *extreme fragmentation* scenarios

³⁵The original series are taken from the United Nations “The National Accounts Main Aggregates Database.”

Table 8: Fit of the model to data on selected macroeconomic variables

(a) Standard deviation (percent)

Country	Output		Consumption		Investment	
	Model	Data	Model	Data	Model	Data
United States	1.99	1.43	1.53	1.54	4.31	4.78
Japan	1.60	1.31	1.05	0.75	3.90	3.20
Germany	1.43	1.21	0.88	0.86	4.14	2.68
United Kingdom	2.51	1.57	1.83	1.90	6.34	3.81
France	1.51	1.22	1.04	1.10	3.67	3.16
Italy	2.15	1.68	1.49	1.74	5.06	5.07
Canada	1.66	1.29	1.03	0.80	5.88	3.53

(b) Correlation with domestic output

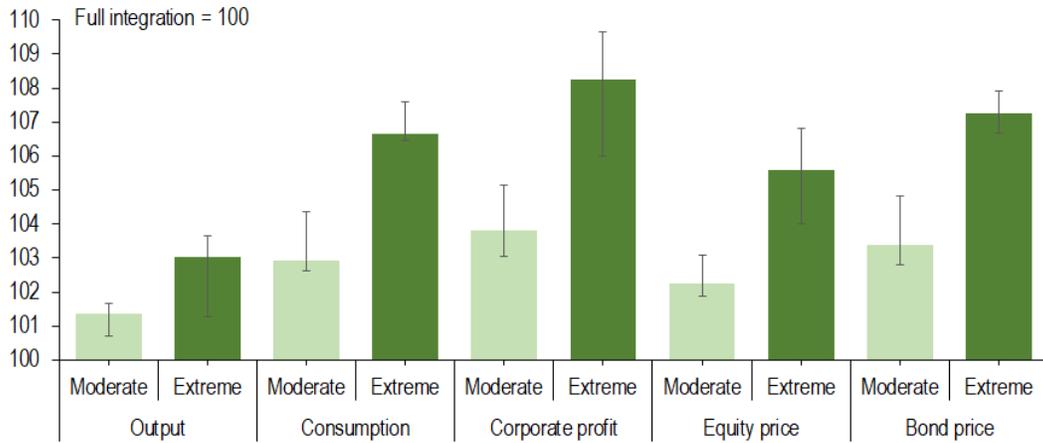
Country	Consumption		Investment	
	Model	Data	Model	Data
United States	0.86	0.94	0.81	0.93
Japan	0.83	0.69	0.86	0.82
Germany	0.74	0.60	0.74	0.83
United Kingdom	0.84	0.95	0.69	0.92
France	0.84	0.82	0.81	0.96
Italy	0.87	0.88	0.82	0.96
Canada	0.68	0.50	0.68	0.53

(c) Cross-country correlation

Country	Output		Consumption		Investment	
	Model	Data	Model	Data	Model	Data
United States	0.29	0.33	0.44	0.27	0.17	-0.12
Japan	0.33	0.69	0.51	0.22	0.18	0.46
Germany	0.35	0.63	0.86	0.20	-0.05	0.50
United Kingdom	0.58	0.61	0.79	0.59	0.00	0.45
France	0.66	0.66	0.81	0.70	0.36	0.43
Italy	0.63	0.60	0.74	0.63	0.33	0.21
Canada	0.60	0.60	0.88	0.81	-0.11	0.69

against those under the *full integration* scenario. The figure indicates that geopolitical fragmentation could exacerbate the vulnerability of G7 countries to shocks, increasing the volatility of their macro-financial variables. For example, under the *moderate* and *extreme* fragmentation scenarios, the median volatility of output increases by 1 and 3 percentage points, respectively, relative to the full integration scenario, while the median volatility of consumption, corporate profits, equity and bond prices increases in the range of 2 to 8 percentage points.

Figure 2: Macro-financial volatility in G7 countries



Note: Bars show the median volatility (standard deviation) of the variables in the home country under *fragmentation* scenarios. Whiskers indicate the interquartile range of the effect across the G7 countries.

Next, we translate the increase in the volatility of macro-financial variables under *fragmentation* scenarios into the loss of diversification benefits. The loss of diversification benefits in this study represents what percentage of the diversification benefits could be lost under different scenarios, relative to the *full integration* scenario. Specifically, we apply the following calculation, defining the space of scenarios as

$$\mathbb{S} = \{full\ integration, moderate\ fragmentation, extreme\ fragmentation, autarky\}.$$

We then define the diversification benefits of macro-financial variable x under scenario $s \in \mathbb{S}$ as the difference of the volatility of the variables ($= Vol(x|s)$) from those under *autarky* ($= Vol(x|autarky)$). Namely, the diversification benefits ($= \Delta Vol(x|s)$) are calculated by the following.

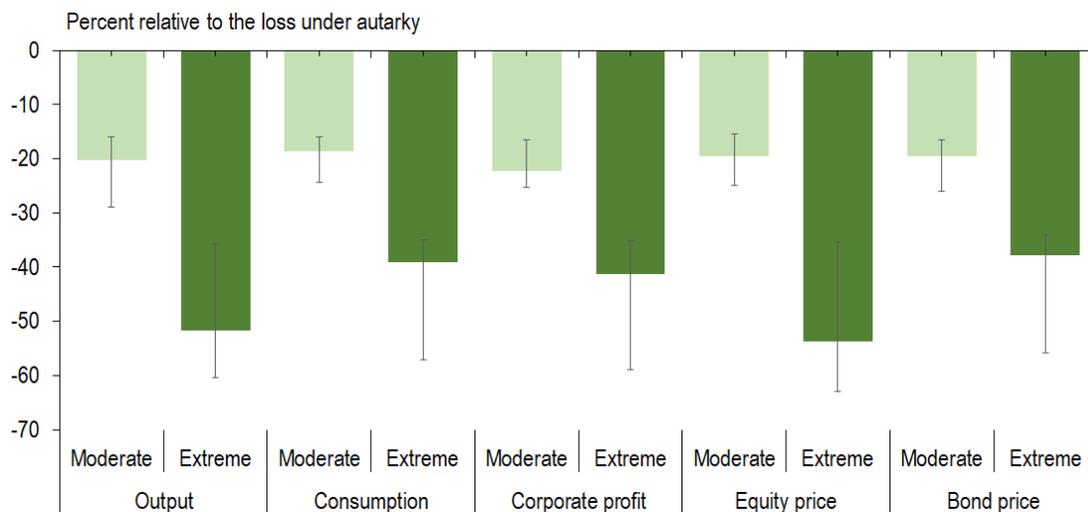
$$\Delta Vol(x|s) = Vol(x|autarky) - Vol(x|s), \quad \forall s \in \mathbb{S}. \quad (32)$$

Next, we compute the loss of diversification benefits of the variable x under scenario $s \in \mathbb{S}$ by taking the ratio of the diversification benefits under the scenario s against those under the *full integration* scenario. Namely, the corresponding loss of diversification benefits ($= Loss(x|s)$) is defined as follows.

$$Loss(x|s) = \left(\frac{\Delta Vol(x|s)}{\Delta Vol(x|full\ integration)} - 1 \right) \times 100, \quad \forall s \in \mathbb{S}, \quad (33)$$

where under the *full integration* scenario the loss of diversification benefits is zero, and under the *autarky* scenario the loss is 100 percent. Figure 3 shows the loss of diversification under *fragmentation* scenarios and demonstrates that the loss of diversification could be substantial: the *moderate fragmentation* scenario implies that about 20 percent of the diversification benefits for all of the macro-financial variables could be lost at the median, while nearly 40 to 50 percent of the benefits could be lost under the *extreme fragmentation* scenario.^{36,37}

Figure 3: Loss of diversification benefit in G7 countries



Note: Bars show the median of loss of diversification benefit under fragmentation scenarios. Whiskers indicate the interquartile range of the effect across the G7 countries.

³⁶Appendix D shows the values of macro-financial volatility in four scenarios. Further, appendix B explains the consistency of the size of the estimated diversification benefit under the *full integration* scenario with the literature.

³⁷Our results of *changes* in macro-financial volatility and the *loss* of diversification benefit above are robust to different sets of parameters while the *size* of the macro-financial volatility and diversification benefit varies. Appendices E.1 and E.2 show the results under different sets of parameters regarding the elasticity of substitution in consumption and investment between home and foreign goods, and the local spending bias in consumption and investment, respectively.

5.3 Three Driving Factors

In this subsection, the changes in volatility (Figure 2) are decomposed into three factors.

The first factor is an increase in the business cycle correlation between home and foreign countries. This occurs because the business cycles of the countries which are excluded from partners under *fragmentation* scenarios have lower cross-country correlation with G7 than those under the *full integration* scenario. This factor is represented by the differences in cross-country correlation of TFP and investment efficiency shocks under these scenarios.

The second factor is an increase in business cycle volatility in the foreign country. This is because the cross-country business cycle correlations among the partner countries under *fragmentation* scenarios are higher than those under the *full integration* scenario. This factor is represented by the differences in volatility of exogenous TFP and investment efficiency processes in foreign countries under these scenarios.

The third factor is an increase in the share of domestic production in the local goods markets for consumption and investment. This arises because, under *fragmentation* scenarios, the good produced in home country is assumed to substitute some proportion of the imported goods under the *full integration* scenario. This assumption corresponds with the situation where the goods imported from the partners excluded under *fragmentation* scenarios are produced by the home country and the remaining partners. This factor is represented by the differences in local spending bias of consumption and investment goods under these scenarios.

Figure 4 shows the results of the decomposition.³⁸ The figure indicates that under the *moderate fragmentation* scenario, the cross-country shock correlation and local spending bias

³⁸The decomposition is performed by simulating the model, keeping some of the parameters unchanged from the benchmark *full integration* scenario and following the procedures below.

First, the contribution of the cross-country business cycle correlation is calculated by simulating the model with cross-country shock correlation parameters under *fragmentation* scenarios while keeping other parameters unchanged from those under the *full integration* scenario. Specifically, we regard the difference between the simulated volatility under this setting and previously simulated volatility under the *full integration* as the contribution of the cross-country correlation.

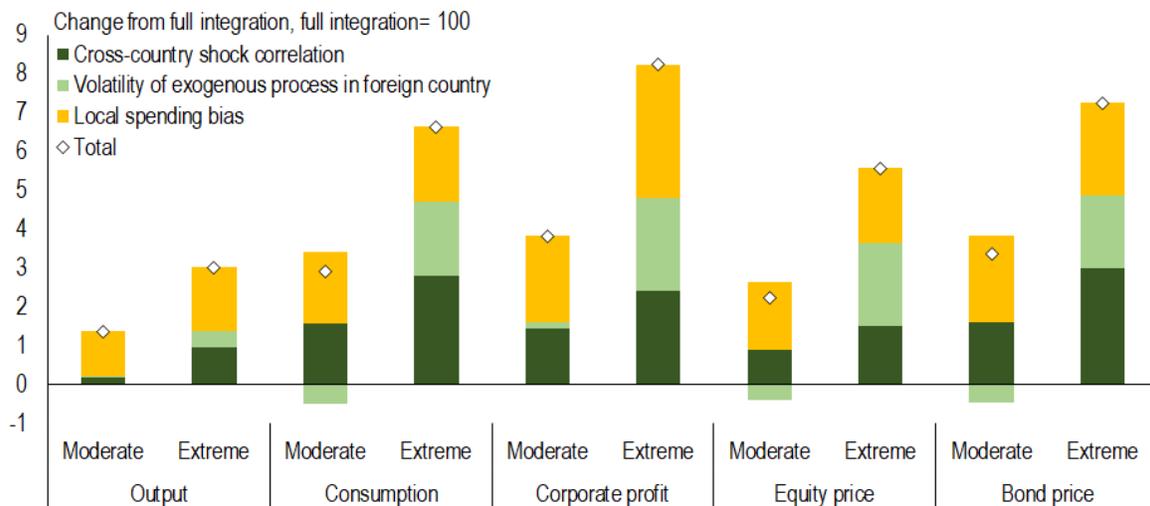
Second, the contribution of the volatility of exogenous processes is calculated by simulating the model with parameters of volatility and persistence of the TFP and investment efficiency process, in addition to cross-country shock correlation, under *fragmentation* scenarios while keeping the local spending bias unchanged from the *full integration* scenario. Specifically, the contribution of the volatile foreign TFP and investment efficiency is then calculated by the difference in the simulated volatility under this setting and the simulated volatility under the *full integration*, net of the effect of the contribution of the cross-country shock correlation.

Third, the contribution of the local spending bias is calculated by taking the difference between the simulated volatility under *fragmentation* scenarios and the sum of the aforementioned contributions. Hence, the second and third contributions include the contributions of the cross-terms of these three factors.

contribute to the increase in macro-financial volatility. The figure also demonstrates that under the *extreme fragmentation* scenario, all of the three factors contribute to the increase in macro-financial volatility. The figure also indicates that under the *extreme fragmentation* scenario the contribution of the cross-country shock correlation and volatility of exogenous process in foreign country increase significantly, relative to the *moderate fragmentation* scenario.

In the following, we provide the underlying economic intuition behind these contributions of the three factors.

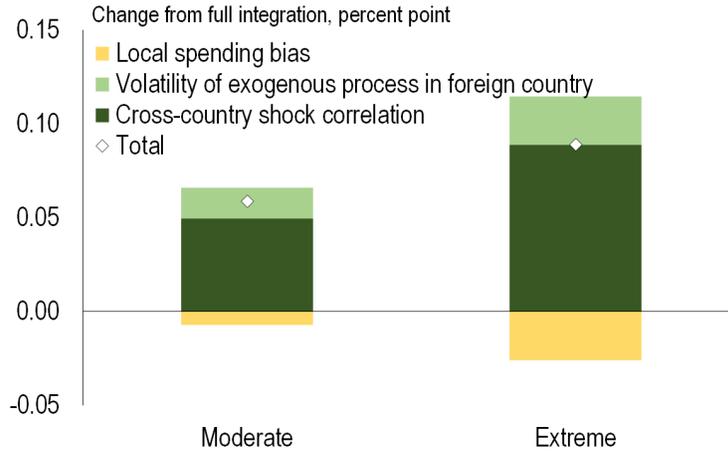
Figure 4: Decomposition of the median increase of volatility in Figure 2



Higher cross-country shock correlation. We begin by explaining why higher cross-country shock correlations contribute to the increase in macro-financial volatility. Comparing Tables 4 and 5 indicates that cross-country shock correlation tends to be higher under the *fragmentation* scenarios, and Figure 5 shows this increase in cross-country shock correlation contributes to the increase in the business cycle correlation.

This increase in cross-country business cycle correlation affects the macro-financial volatility via two channels. First, the volatility of common fluctuations in home and the foreign country driven by the combination of exogenous TFP and investment efficiency processes in home and foreign countries increases, which leads to the higher volatility of output and investment

Figure 5: Cross-country output correlation



Note: The decomposition methodology follows that used for Figure 4.

in the G7 countries.³⁹

Second, the terms of trade becomes less flexible, which leads to a higher sensitivity of macro-financial variables to common fluctuations in home and the foreign country. For example, if the negative TFP shock hits only the G7 countries, the price of the good produced in G7 countries becomes more expensive than the one produced in partner countries. This increase in the terms of trade alleviates the impact of negative TFP shocks on real variables. By contrast, if the negative TFP shock hits both G7 and partner countries due to high correlation, the relative price remains unchanged; thus, the alleviation mechanism becomes less powerful.

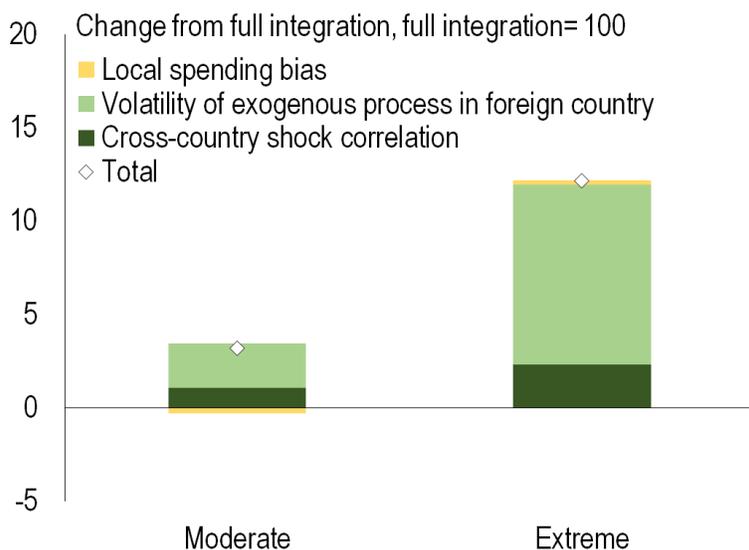
Higher volatility of exogenous process in foreign country. An increase in the volatility of exogenous processes, such as TFP and investment efficiency, in the foreign country increases the volatility of business cycles in the foreign country. Indeed, as indicated by panel (b) of Figure 6 which decomposes the changes in the volatility of output in the foreign country, volatility of exogenous processes in the foreign country strongly contributes to the increase in volatility of foreign output.

This effect is particularly pronounced under the *extreme fragmentation* scenario. The non-linear contribution of this factor originates from the observation in Section 3. Under the

³⁹Note that the impact of the common fluctuation in home and foreign countries on consumption cannot be canceled out by efficient risk sharing.

moderate fragmentation scenario, the foreign country consists of many European industrial countries as well as large commodity-exporting countries, such as Russia and Latin American countries including Brazil. Because the business cycle correlation of these commodity-exporting countries and the European industrial countries is low, international risk sharing among these countries makes the increase in volatility of foreign country moderate. Conversely, under the *extreme fragmentation* scenario, most of the commodity-exporting countries are excluded from the partners due to high geopolitical distance, and the remaining partner countries of the G7 consist mostly of European industrial countries. The business cycles among these countries are highly correlated, making the foreign country significantly more volatile.

Figure 6: Output volatility in foreign country



Note: The decomposition methodology follows that used for Figure 4.

Increase in local spending bias Under *fragmentation* scenarios, local spending bias increases, implying that domestic production of the G7 countries partly substitutes imports from countries excluded from their partners. This leads to an increase in macro-financial volatility by hampering the diversification of business cycles via goods trade. This is because a higher local spending bias increases the sensitivity of domestic consumption to domestic business cycles. Suppose domestic output increases and, as a result, the relative price of good produced in home country to that in foreign country (i.e. the term of trade) decreases.

Under these circumstances, if local spending bias is low, a household in home country who receives wages from the domestic firm only moderately increases consumption because the share of imported goods, which is now expensive for the household, in consumption is high. By contrast, if local spending bias is high, the household in home country can increase consumption since the share of imported goods in consumption is small. At the same time, a higher local spending bias decreases the sensitivity of domestic consumption to foreign business cycles because the share of imported goods in the consumption basket of the household in home country is lower.

In terms of the net impact of the first and second factors on consumption volatility, under the parameters in this study, the first factor prevails because the domestic business cycles are more volatile than foreign business cycles. This net increase in consumption volatility then affects other variables and leads to an increase in macro-financial volatility.

From the perspective of the quantitative impact of geopolitical fragmentation on macro-financial volatility, the increase in cross-country shock correlation and the increase in the volatility of exogenous processes in the foreign country are particularly noteworthy, as these factors significantly alter the results depending on the geopolitical configuration.⁴⁰ In this context, the *fragmentation* scenarios considered here based on geopolitical distance could be particularly harmful from the view of international risk diversification.

6 Conclusion

This study applies a two-country open-economy model to study the potential losses of international diversification benefits for G7 countries under different hypothetical scenarios of geopolitical fragmentation. Specifically, we consider scenarios in which G7 countries cannot engage in cross-border investment with a share of existing partner countries with greater geopolitical distance. We find that geopolitical fragmentation could significantly undermine the risk sharing benefits. Under the *moderate* and *extreme fragmentation* scenarios, where 25 percent and 50 percent of the partner countries are excluded due to high geopolitical tensions, the median volatility of output across G7 countries increases by 1 and 3 percentage points,

⁴⁰The increase of local spending bias depends on the assumption that the loss of imports from the excluded countries due to high geopolitical distance is substitutable by the remaining countries, including home country. We regard this assumption as reasonable. Nevertheless, if the imports can only be substitutable by foreign countries, the local spending share would be unchanged, and the third factor does not increase macro-financial volatility.

respectively, relative to the *full integration* scenario. The median volatility of consumption, corporate profits, equity, and bond prices increases, and the range is about 2 to 8 percentage points. The loss of diversification benefits under *fragmentation* scenarios compared to the *full integration* scenario is about 20 percent in the *moderate fragmentation* scenario and about 40-50 percent in the *extreme fragmentation* scenario, respectively.

We show three channels behind the increased macro-financial volatility due to geopolitical fragmentation. By excluding partner countries with high geopolitical distance, (i) cross-country business cycle correlation across G7 countries and their partner countries increases, (ii) the business cycle volatility in the foreign country increases, and (iii) local spending bias increases because domestic production partly substitutes imported goods from partner countries which are excluded under *fragmentation* scenarios. The analysis suggests that the first two factors are particularly prominent and closely linked with the geopolitical configuration.

It should be noted that this study only examines the loss of cross-border investment diversification benefits. Therefore, the estimates should not be interpreted as a comprehensive assessment of the impact of geopolitical fragmentation. For example, the framework does not consider the impact of capital reallocation on growth⁴¹.

There are several caveats to the analysis. To maintain tractability, the framework in this study simplifies a complex reality. For instance, the model assumes full substitutability of foreign goods production among G7 countries and their partner countries. The model also employs symmetry assumptions between the home and foreign countries, except for the processes of TFP and investment efficiency. Nevertheless, these caveats should not affect the key takeaway of the analysis: that geopolitical fragmentation between countries with asynchronous business cycles could potentially imply a substantial loss of international diversification benefits.

⁴¹The literature has extensively analyzed the impact of financial integration on economic growth via capital allocation. For more details, see Henry (2007), Kose et al. (2009), and Coeurdacier et al. (2020). Capital allocation can also affect TFP (Alfaro et al. 2009 and Fons-Rosen et al. 2013), but we abstract from this channel in our study.

References

- Aguiar, M. and Gopinath, G. (2007). Emerging Market Business Cycles: The Cycle Is the Trend. *Journal of Political Economy*, 115(1):69–102.
- Aiyar, S., Chen, J., Ebeke, C., Garcia-Saltos, R., Gudmundsson, T., Ilyina, A., Kangur, A., Kunaratskul, T., Rodriguez, S., Ruta, M., Schulze, T., Soderberg, G., and Trevino, J. (2023). Geoeconomic Fragmentation and the Future of Multilateralism. IMF Staff Discussion Notes 2023/001, International Monetary Fund.
- Alfaro, L., Kalemli-Ozcan, S., and Sayek, S. (2009). FDI, Productivity and Financial Development. *The World Economy*, 32(1):111–135.
- Amiti, M., Redding, S. J., and Weinstein, D. E. (2019). The Impact of the 2018 Tariffs on Prices and Welfare. *Journal of Economic Perspectives*, 33(4):187–210.
- Backus, D. and Smith, G. (1993). Consumption and Real Exchange Rates in Dynamic Economies with Non-Traded Goods. *Journal of International Economics*, 35(3-4):297–316.
- Backus, D. K., Kehoe, P. J., and Kydland, F. E. (1992). International Real Business Cycles. *Journal of Political Economy*, 100(4):745–775.
- Bailey, M. A., Strezhnev, A., and Voeten, E. (2017). Estimating Dynamic State Preferences from United Nations Voting Data. *Journal of Conflict Resolution*, 61(2):430–456.
- Catalán, M., Fendglu, S., and Tsuruga, T. (2024). A Gravity Model of Geopolitics and Financial Fragmentation. IMF Working Paper, International Monetary Fund, Washington D.C.
- Cavallo, A., Gopinath, G., Neiman, B., and Tang, J. (2021). Tariff Pass-Through at the Border and at the Store: Evidence from US Trade Policy. *American Economic Review: Insights*, 3(1):19–34.
- Chari, V. V., Kehoe, P. J., and McGrattan, E. R. (2002). Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates? *The Review of Economic Studies*, 69(3):533–563.
- Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy*, 113(1):1–45.
- Coeurdacier, N. and Gourinchas, P.-O. (2016). When bonds matter: Home bias in goods and assets. *Journal of Monetary Economics*, 82:119–137.
- Coeurdacier, N., Kollmann, R., and Martin, P. (2009). International Portfolios with Supply, Demand, and Redistributive Shocks. In *NBER International Seminar on Macroeconomics 2007*, NBER Chapters, pages 231–263. National Bureau of Economic Research, Inc.
- Coeurdacier, N., Kollmann, R., and Martin, P. (2010). International Portfolios, Capital Accumulation and Foreign Assets Dynamics. *Journal of International Economics*, 80(1):100–112.
- Coeurdacier, N. and Rey, H. (2013). Home Bias in Open Economy Financial Macroeconomics. *Journal of Economic Literature*, 51(1):63–115.

- Coeurdacier, N., Rey, H., and Winant, P. (2011). The Risky Steady State. *American Economic Review*, 101(3):398–401.
- Coeurdacier, N., Rey, H., and Winant, P. (2020). Financial Integration and Growth in a Risky World. *Journal of Monetary Economics*, 112(C):1–21.
- Cole, H. L. and Obstfeld, M. (1991). Commodity Trade and International Risk Sharing : How Much Do Financial Markets Matter? *Journal of Monetary Economics*, 28(1):3–24.
- Corsetti, G., Dedola, L., and Leduc, S. (2008). International Risk Sharing and the Transmission of Productivity Shocks. *The Review of Economic Studies*, 75(2):443–473.
- De Walque, Gregory, F. S. and Woutersy, R. (2005). An Estimated Two-Country DSGE Model for the Euro Area and the US Economy. mimeo.
- De Walque, Gregory, T. L. Y. R. and Wouters, R. (2017). An Estimated Two-Country EA-US model with Limited Exchange Rate Pass-Through. Working Paper Research 317, National Bank of Belgium.
- Devereux, M. B. and Sutherland, A. (2011). Country Portfolios In Open Economy Macro Models. *Journal of the European Economic Association*, 9(2):337–369.
- Fajgelbaum, P. D., Goldberg, P. K., Kennedy, P. J., and Khandelwal, A. K. (2019). The Return to Protectionism. *The Quarterly Journal of Economics*, 135(1):1–55.
- Feenstra, R. C., Inklaar, R., and Timmer, M. P. (2015). The Next Generation of the Penn World Table. *American Economic Review*, 105(10):3150–82.
- Fons-Rosen, C., Kalemli-Ozcan, S., Sorensen, B. E., Villegas-Sanchez, C., and Volosovych, V. (2013). Quantifying Productivity Gains from Foreign Investment. NBER Working Papers 18920, National Bureau of Economic Research, Inc.
- French, K. R. and Poterba, J. M. (1991). Investor diversification and international equity markets. *The American Economic Review*, 81(2):222–226.
- Ghasseminejad, S. and Jahan-Parvar, M. R. (2021). The Impact of Financial Sanctions: The Case of Iran. *Journal of Policy Modeling*, 43(3):601–621.
- Grubel, H. G. (1968). Internationally Diversified Portfolios: Welfare Gains and Capital Flows. *The American Economic Review*, 58(5):1299–1314.
- Guiso, L., Sapienza, P., and Zingales, L. (2009). Cultural Biases in Economic Exchange? *The Quarterly Journal of Economics*, 124(3):1095–1131.
- Häge, F. M. (2011). Choice or Circumstance? Adjusting Measures of Foreign Policy Similarity for Chance Agreement. *Political Analysis*, 19(3):287–305.
- Heathcote, J. and Perri, F. (2002). Financial Autarky and International Business Cycles. *Journal of Monetary Economics*, 49(3):601–627.
- Heathcote, J. and Perri, F. (2013). The International Diversification Puzzle Is Not as Bad as You Think. *Journal of Political Economy*, 121(6):1108–1159.
- Henry, P. B. (2007). Capital Account Liberalization: Theory, Evidence, and Speculation. *Journal of Economic Literature*, 45(4):887–935.

- Hooper, P. and Marquez, J. R. (1993). Exchange Rates, Prices, and External Adjustment in the United States and Japan. International Finance Discussion Papers 456, Board of Governors of the Federal Reserve System (U.S.).
- IMF (2023). *Global Financial Stability Report, April 2023*, chapter 3. "Geopolitics and Financial Fragmentation – Implications for Macro-Financial Stability". International Monetary Fund, Washington DC.
- Jung, S., Lee, J., and Lee, S. (2021). Geopolitical Risk on Stock Returns: Evidence from Inter-Korea Geopolitics. IMF Working Papers 2021/251, International Monetary Fund.
- Justiniano, A., Primiceri, G., and Tambalotti, A. (2011). Investment Shocks and the Relative Price of Investment. *Review of Economic Dynamics*, 14(1):101–121.
- Justiniano, A. and Primiceri, G. E. (2008). The Time-Varying Volatility of Macroeconomic Fluctuations. *American Economic Review*, 98(3):604–41.
- Kempf, E., Luo, M., Schafer, L., and Tsoutsoura, M. (2022). Political Ideology and International Capital Allocation. Working paper, National Bureau of Economic Research.
- Kollmann, R. (1995). Consumption, Real Exchange Rates and the Structure of International Asset Markets. *Journal of International Money and Finance*, 14(2):191–211.
- Kollmann, R. (2006). International Portfolio Equilibrium and the Current Account. CEPR Discussion Papers 5512, C.E.P.R. Discussion Papers.
- Kose, A., Prasad, E. S., and Terrones, M. (2007). How Does Financial Globalization Affect Risk Sharing? Patterns and Channels. IMF Working Papers 2007/238, International Monetary Fund.
- Kose, M. A., Prasad, E., Rogoff, K., and Wei, S.-J. (2009). Financial Globalization: A Reappraisal. *IMF Staff Papers*, 56(1):8–62.
- Levin, A., Onatski, A., Williams, J., and Williams, N. (2006). Monetary Policy under Uncertainty in Micro-Founded Macroeconometric Models. In *NBER Macroeconomics Annual 2005, Volume 20*, pages 229–312. National Bureau of Economic Research, Inc.
- Levy, H. and Sarnat, M. (1970). International Diversification of Investment Portfolios. *American Economic Review*, 60(4):668–675.
- Lewis, K. K. (1999). Trying to Explain Home Bias in Equities and Consumption. *Journal of Economic Literature*, 37(2):571–608.
- Lewis, K. K. (2000). Why Do Stocks and Consumption Imply Such Different Gains from International Risk Sharing? *Journal of International Economics*, 52(1):1–35.
- Obstfeld, M. (1994). Evaluating Risky Consumption Paths: The Role of Intertemporal Substitutability. *European Economic Review*, 38(7):1471–1486.
- Obstfeld, M. and Rogoff, K. (1996). *Foundations of International Macroeconomics*, volume 1. The MIT Press, 1 edition.
- Pallage, S. and Robe, M. A. (2003). On the Welfare Cost of Economic Fluctuations in Developing Countries. *International Economic Review*, 44(2):677–698.
- Salisu, A. A., Omoke, P. C., and Sikiru, A. A. (2023). Geopolitical Risk and Global Financial Cycle: Some Forecasting Experiments. *Journal of Forecasting*, 42(1):3–16.

- Signorino, C. S. and Ritter, J. M. (1999). Tau-b or Not Tau-b: Measuring the Similarity of Foreign Policy Positions. *International Studies Quarterly*, 43(1):115–144.
- Smets, F. and Wouters, R. (2003). An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area. *Journal of the European Economic Association*, 1(5):1123–1175.
- Sugo, T. and Ueda, K. (2008). Estimating a Dynamic Stochastic General Equilibrium Model for Japan. *Journal of the Japanese and International Economies*, 22(4):476–502.
- Tesar, L. L. (1995). Evaluating the Gains from International Risksharing. *Carnegie-Rochester Conference Series on Public Policy*, 42(1):95–143.
- van Wincoop, E. (1994). Welfare Gains from International Risksharing. *Journal of Monetary Economics*, 34(2):175–200.
- van Wincoop, E. (1999). How Big are Potential Welfare Gains from International Risksharing? *Journal of International Economics*, 47(1):109–135.

Appendices

A Geopolitical Distance Measure

Construction method. The bilateral geopolitical distance measure used in this study is calculated by multiplying the foreign policy proximity measures (S -scores, developed by Signorino and Ritter 1999) by -1 . Signorino and Ritter (1999)'s S -scores are calculated based on countries' observable behavior on foreign policy issues, that is, disagreements in their voting behavior in the United Nations General Assembly (UNGA). The scores are calculated as the average disagreement in UNGA voting based on the squared sum of the difference in voting between two countries and normalized to take values from 1 (complete disagreement) to -1 (complete agreement). Specifically, the calculation formula for the geopolitical distance between countries a and b in year t , $S_t(a, b)$, is given as follows.

$$S_t(a, b) \equiv (-1) \underbrace{\left[1 - \frac{\sum_{v,t} (X_{a,v,t} - X_{b,v,t})^2}{\frac{1}{2} \sum_v (d_{max,t})^2} \right]}_{\text{foreign policy proximity (S-scores)}}$$

where $X_{a,v,t}$ represents voting behavior of country a in year t , X refers to votes (*yea*(for) = 1, *abstain* = 2, and *nay*(against) = 3), and v indexes voting during sessions in a calendar year (adjusted for sessions towards the end of the year that could potentially run into January of the following year). $d_{max,t}$ stands for the maximum possible distance between the country pairs within the year. For instance, for a country pair with one voting *yea* and the other *nay* in a session, the implied distance would be 1. If the two countries voted the same, then the distance would be -1 .

Data. From 2012 to 2015, We take the geopolitical distance measure from the dataset prepared by Häge (2011), which followed the methodology of Signorino and Ritter (1999) based on UN voting data. From 2016 to 2021, we extend the end of the sample period utilizing Erik Voeten's database, which is a dataset of 196 economies' roll-call votes in the UN General Assembly from 1946 to 2021 (sessions 1-76).

Alternative measures and robustness. In terms of the measures for foreign policy proximity, in the literature, in addition to Signorino and Ritter (1999), Häge (2011) and Bailey et al. (2017) also offer alternative measures. Specifically, Häge (2011) proposes the so-called π -measure, which improves the chance correction and cost of forming ties. Häge (2011) argues that the π -measure has more desirable distributional properties and passes some key face validity tests. Moreover, Bailey et al. (2017) offer a further alternative to Signorino and Ritter (1999)'s measure, the *ideal point distance*, by estimating a discrete choice model with latent preferences. Overall, S -score is highly correlated with π -measure, and *ideal point distance*.

In terms of the robustness of the grouping for *fragmentation* scenarios, if we use the π -measure instead of S -score, the list of the countries excluded in the *extreme fragmentation* scenario are identical while some of the countries excluded in the *moderate fragmentation* scenario are not.⁴² Similarly, if we use the *ideal point distance* instead of S -score, the list of the countries excluded in the *extreme fragmentation* scenario are identical while some proportion of the countries excluded under the *moderate fragmentation* scenario are not.⁴³ Hence, the selection of the partner countries under fragmentation scenarios in our exercise is robust to the choice of the geopolitical distance measures.

⁴²With respect to the difference from Table 2, India, Pakistan, China, and Hong Kong SAR are included in partners while Singapore, Morocco, Nigeria, and Malaysia are excluded from the partners.

⁴³Concerning the difference from Table 2, India, China, Hong Kong SAR, and Pakistan are included in partners while Nigeria, South Africa, Malaysia, and Morocco are excluded from the partners.

B Size of Diversification Benefits

This appendix translates the changes in consumption volatility under four scenarios into the welfare (consumer utility) gains. Specifically, we estimate it by following van Wincoop (1994) (and van Wincoop (1999)): the welfare gains from reduction of consumption volatility are calculated as $\frac{-0.5\gamma}{r-\bar{\mu}}\Delta\sigma_c^2$ where γ represents the inverse elasticity of inter-temporal substitution (corresponds to σ in our model), r is the risk-free interest rate, $\bar{\mu}$ represents the risk-adjusted growth rate, and $\Delta\sigma_c^2$ indicates the changes in the variance of consumption from the *autarky* scenario to the *full integration* scenario. In our calculation, γ is obtained from Table 3, and $\Delta\sigma_c^2$ is calculated based on tables in appendix D. Because our model abstracts from r and $\bar{\mu}$, we borrow them from van Wincoop (1994) as $r = 0.027$ and $\bar{\mu} = 0.017$.⁴⁴

Under this assumption, the median of the estimates of the welfare gain from financial integration, that is, the transition from *autarky* scenario to the *full integration* scenario is equivalent to 0.21 percent increase of the permanent consumption.⁴⁵ In addition, the first-to-third quantiles of the estimates are 0.14-0.44. Moreover, under the *moderate* fragmentation scenarios, the median and first-to-third quantiles of the estimates are 0.18 and 0.13-0.38, respectively. Under the *extreme* fragmentation scenarios, the those of the estimates are 0.13 and 0.07-0.28, respectively. These imply that, under the *moderate* and *extreme* fragmentation scenarios, welfare gains from financial integration would reduce by around 20 and 40 percent, respectively.

We also compare our estimate of the implied welfare gains under the *full integration* scenario with the literature. The reported gains in the literature vary enormously, ranging from less than 0.1 percent to over 100 percent (see van Wincoop (1999) and references therein). Among those, in the following, we compare our estimates with the estimates by Coeurdacier et al. (2020), the study whose setup is relatively similar to ours.

While Coeurdacier et al. (2020) provide the estimates under a variety of the model specifications and parameterization, the columns for country *D* (advanced economies) in Table 3 indicate the estimates in the case where the relatively similar preference parameters to our study are used.⁴⁶ Specifically, the estimates with CRRA utility and low-risk aversion with no capital scarcity (both assume that the parameter of the degree of risk aversion is four, which corresponds with $\gamma = 4$ in the formula above) are 0.39 and 0.25, respectively, which are in the first-to-third quantiles of our estimates 0.14-0.44).⁴⁷

⁴⁴In van Wincoop (1994), these parameters are calibrated to estimate the welfare gains of financial integration for OECD countries.

⁴⁵Specifically, the definition of the welfare gains in van Wincoop (1994) is “The permanent relative increase in the expected level of the consumption path that would lead to the same welfare improvement as can be achieved international risk sharing.”

⁴⁶The structures are different between between our model and Coeurdacier et al. (2020) in three ways. First, Coeurdacier et al. (2020) consider risky steady state. Second, they include the channel via allocative efficiency of capital in addition to the international risk sharing channel. Third, they assume an incomplete financial market.

⁴⁷Note that van Wincoop (1994) reports that the median of the diversification benefits across G7 countries is around 0.9 percent, which is larger than Coeurdacier et al. (2020)’s and our results. According to the analysis Coeurdacier et al. (2020), this difference is likely to reflect the difference in the model structure. Specifically, van Wincoop (1994) considers endowment economy while Coeurdacier et al. (2020) and our model employ production economy with capital. In addition, van Wincoop (1999) considers endowment economy and reports larger diversification benefits than Coeurdacier et al. (2020). In a production economy with capital, the capital provides consumption some smoothing opportunity, and thus diversification benefits tend to be smaller than endowment economy.

C Log-Linearization of Equilibrium Equations

This section shows the log-linearized equilibrium equations around the steady state where all variables are symmetric and price level, TFP, and investment efficiency are normalized to the unity. In what follows, small letters indicate the log-deviation of the original variables from the steady state value. In terms of TFP and investment efficiency, the variables with hat represent the log-deviation from the steady state values.

Price index. Equations (3) and (8) are log-linearized as follows.

$$p_{H,t} = ap_t^H + (1-a)p_t^F, p_{F,t} = ap_t^F + (1-a)p_t^H, p_{H,t}^I = a_I p_t^H + (1-a_I)p_t^F, p_{F,t}^I = a_I p_t^F + (1-a_I)p_t^H.$$

Consumption allocation. Equation (2) is log-linearized as follows.

$$c_{H,t}^H = -\phi(p_t^H - p_{H,t}) + c_{H,t}, c_{H,t}^F = -\phi(p_t^F - p_{H,t}) + c_{H,t}, c_{F,t}^H = -\phi(p_t^H - p_{F,t}) + c_{F,t}, c_{F,t}^F = -\phi(p_t^F - p_{F,t}) + c_{F,t}.$$

Investment allocation. Equations (21) and (22) are log-linearized as follows.

$$i_{H,t}^H = -\phi_I(p_t^H - p_{H,t}^I) + i_{H,t}, i_{H,t}^F = -\phi_I(p_t^F - p_{H,t}^I) + i_{H,t}, i_{F,t}^F = -\phi_I(p_t^F - p_{F,t}^I) + i_{F,t}, i_{F,t}^H = -\phi_I(p_t^H - p_{F,t}^I) + i_{F,t}.$$

Labor supply. Equation (15) is log-linearized as follows.

$$\omega l_{H,t} = w_{H,t} - p_{H,t} - \sigma c_{H,t}, \omega l_{F,t} = w_{F,t} - p_{F,t} - \sigma c_{F,t}.$$

Wage bill. Equation (18) is log-linearized as follows.

$$w_{H,t} + l_{H,t} = p_t^H + y_{H,t}, w_{F,t} + l_{F,t} = p_t^F + y_{F,t}.$$

Dividend. Equation (19) is log-linearized as follows.

$$d_{H,t} = \frac{\kappa}{\kappa - \Lambda}(p_t^H + y_{H,t}) - \frac{\Lambda}{\kappa - \Lambda}(p_{H,t}^I + i_{H,t}), d_{F,t} = \frac{\kappa}{\kappa - \Lambda}(p_t^F + y_{F,t}) - \frac{\Lambda}{\kappa - \Lambda}(p_{F,t}^I + i_{F,t}).$$

Investment Euler. Equation (20) is log-linearized as follows.

$$\begin{aligned} c_{H,t} &= \mathbb{E}_t[\hat{c}_{H,t+1}] + \frac{1}{\sigma}\mathbb{E}_t[p_{H,t+1} - p_{H,t}] - \frac{1}{\sigma}\hat{\chi}_{H,t} + \frac{1}{\sigma}p_{H,t}^I \\ &\quad - \frac{\beta\kappa\delta}{\sigma\Lambda}\mathbb{E}_t\left[p_{t+1}^H + \hat{\theta}_{H,t+1} + (\kappa - 1)k_{H,t+1} + (1 - \kappa)l_{H,t+1}\right] - \frac{\beta(1 - \delta)}{\sigma}\mathbb{E}_t[p_{H,t+1}^I - \hat{\chi}_{H,t+1}], \\ c_{F,t} &= \mathbb{E}_t[\hat{c}_{F,t+1}] + \frac{1}{\sigma}\mathbb{E}_t[p_{F,t+1} - p_{F,t}] - \frac{1}{\sigma}\hat{\chi}_{F,t} + \frac{1}{\sigma}p_{F,t}^I \\ &\quad - \frac{\beta\kappa\delta}{\sigma\Lambda}\mathbb{E}_t\left[p_{t+1}^F + \hat{\theta}_{F,t+1} + (\kappa - 1)k_{F,t+1} + (1 - \kappa)l_{F,t+1}\right] - \frac{\beta(1 - \delta)}{\sigma}\mathbb{E}_t[p_{F,t+1}^I - \hat{\chi}_{F,t+1}]. \end{aligned}$$

Stock Euler. Equation (16) is log-linearized as follows.

$$\begin{aligned} c_{H,t} &= \mathbb{E}_t[c_{H,t+1}] + \frac{1}{\sigma}\mathbb{E}_t[p_{H,t+1} - p_{H,t}] - \frac{1}{\sigma}\mathbb{E}_t[\beta p_{H,t+1}^S + (1 - \beta)d_{H,t+1} - p_{H,t}^S], \\ c_{F,t} &= \mathbb{E}_t[c_{F,t+1}] + \frac{1}{\sigma}\mathbb{E}_t[p_{F,t+1} - p_{F,t}] - \frac{1}{\sigma}\mathbb{E}_t[\beta p_{F,t+1}^S + (1 - \beta)d_{F,t+1} - p_{F,t}^S], \\ c_{H,t} &= \mathbb{E}_t[c_{H,t+1}] + \frac{1}{\sigma}\mathbb{E}_t[p_{H,t+1} - p_{H,t}] - \frac{1}{\sigma}\mathbb{E}_t[\beta p_{F,t+1}^S + (1 - \beta)d_{F,t+1} - p_{F,t}^S], \\ c_{F,t} &= \mathbb{E}_t[c_{F,t+1}] + \frac{1}{\sigma}\mathbb{E}_t[p_{F,t+1} - p_{F,t}] - \frac{1}{\sigma}\mathbb{E}_t[\beta p_{H,t+1}^S + (1 - \beta)d_{H,t+1} - p_{H,t}^S]. \end{aligned}$$

Note that two of the four conditions are redundant.

Bond Euler. Equation (17) is log-linearized as follows.

$$\begin{aligned}
c_{H,t} &= \mathbb{E}_t [c_{H,t+1}] + \frac{1}{\sigma} \mathbb{E}_t [p_{H,t+1} - p_{H,t}] - \frac{1}{\sigma} \mathbb{E}_t [\beta p_{H,t+1}^B + (1-\beta)p_{t+1}^H - p_{H,t}^B], \\
c_{F,t} &= \mathbb{E}_t [c_{F,t+1}] + \frac{1}{\sigma} \mathbb{E}_t [p_{F,t+1} - p_{F,t}] - \frac{1}{\sigma} \mathbb{E}_t [\beta p_{F,t+1}^B + (1-\beta)p_{t+1}^F - p_{F,t}^B], \\
c_{H,t} &= \mathbb{E}_t [c_{H,t+1}] + \frac{1}{\sigma} \mathbb{E}_t [p_{H,t+1} - p_{H,t}] - \frac{1}{\sigma} \mathbb{E}_t [\beta p_{F,t+1}^B + (1-\beta)p_{t+1}^F - p_{F,t}^B], \\
c_{F,t} &= \mathbb{E}_t [c_{F,t+1}] + \frac{1}{\sigma} \mathbb{E}_t [p_{F,t+1} - p_{F,t}] - \frac{1}{\sigma} \mathbb{E}_t [\beta p_{H,t+1}^B + (1-\beta)p_{t+1}^H - p_{H,t}^B].
\end{aligned}$$

Note that two of the four conditions are redundant.

Production. Equation (5) is log-linearized as follows.

$$y_{H,t} = \widehat{\theta}_{H,t} + \kappa k_{H,t} + (1-\kappa)l_{H,t}, y_{F,t} = \widehat{\theta}_{F,t} + \kappa k_{F,t} + (1-\kappa)l_{F,t}.$$

Law of motion of capital. Equation (6) is log-linearized as follows.

$$k_{H,t+1} = (1-\delta)k_{H,t} + \delta(\widehat{\chi}_{H,t} + i_{H,t}), k_{F,t+1} = (1-\delta)k_{F,t} + \delta(\widehat{\chi}_{F,t} + i_{F,t}).$$

Budget constraint. Equation (4) is log-linearized as follows.

$$\begin{aligned}
(1-\Lambda)(c_{H,t} + p_{H,t}) &= (1-\kappa)(l_{H,t} + w_{H,t}) + (\kappa-\Lambda)(Sd_{H,t} + (1-S)d_{F,t}) + b(p_t^H - p_t^F), \\
(1-\Lambda)(c_{F,t} + p_{F,t}) &= (1-\kappa)(l_{F,t} + w_{F,t}) + (\kappa-\Lambda)(Sd_{F,t} + (1-S)d_{H,t}) + b(p_t^F - p_t^H).
\end{aligned}$$

Resource constraint. Equation (9) is log-linearized as follows.

$$\begin{aligned}
(1-\Lambda)ac_{H,t}^H + (1-\Lambda)(1-a)c_{H,t}^F + \Lambda a_I i_{H,t}^H + \Lambda(1-a_I)i_{H,t}^F &= y_{H,t}, \\
(1-\Lambda)(1-a)c_{F,t}^H + a(1-\Lambda)c_{F,t}^F + \Lambda a_I i_{F,t}^F + \Lambda(1-a_I)i_{F,t}^H &= y_{F,t}.
\end{aligned}$$

It should be noted that these conditions are redundant if budget constraints are included in the conditions due to Warlas's Law.

Terms of trade. Up to the first order, the zero-order portfolio satisfies the condition that the ratio of home to foreign marginal utilities of aggregate consumption ($C_{H,t}^{-\sigma}/C_{F,t}^{-\sigma}$) is equated to the consumption-based real exchange rate ($P_{H,t}/P_{F,t}$) and the log-linearized condition is given by

$$-\sigma(c_{H,t} - c_{F,t}) = p_{H,t} - p_{F,t} \Leftrightarrow p_t^H - p_t^F = -\frac{\sigma}{2a-1}(c_{H,t} - c_{F,t}).$$

Real corporate profits, equity and bond prices. Equations (23), (24), and (25) are log-linearized as follows.

$$\pi_{H,t} = p_t^H + y_{H,t} - p_{H,t}, \widehat{p}_{H,t}^S = p_{H,t}^S - p_{H,t}, \widehat{p}_{H,t}^B = p_{H,t}^B - p_{H,t}.$$

D Simulated Macro-Financial Volatility in G7 Countries

The following tables show the full results of the macro-financial volatility of G7 countries under four scenarios, which are the dataset for Tables 2 and 3 in Subsection 5.2. The volatility is measured as the standard deviation, and the unit is the percent.

Table A1: Macro-financial volatility in G7 countries

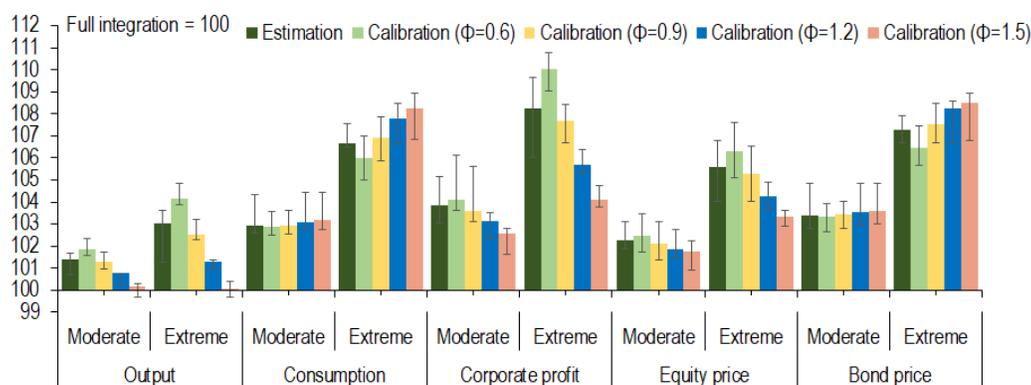
United States	Output	Consumption	Corporate profit	Equity price	Bond price
Full integration	1.99	1.53	1.83	2.04	1.12
Moderate fragmentation	2.02	1.57	1.89	2.08	1.16
Extreme fragmentation	2.05	1.63	1.98	2.15	1.21
Autarky	2.10	1.70	2.10	2.25	1.27
Japan	Output	Consumption	Corporate profit	Equity price	Bond price
Full integration	1.60	1.05	1.49	1.49	0.80
Moderate fragmentation	1.63	1.10	1.57	1.54	0.84
Extreme fragmentation	1.63	1.12	1.60	1.56	0.86
Autarky	1.65	1.16	1.65	1.59	0.89
Germany	Output	Consumption	Corporate profit	Equity price	Bond price
Full integration	1.43	0.88	1.28	1.37	0.68
Moderate fragmentation	1.44	0.89	1.32	1.39	0.70
Extreme fragmentation	1.44	0.93	1.35	1.42	0.73
Autarky	1.46	1.03	1.46	1.47	0.80
United Kingdom	Output	Consumption	Corporate profit	Equity price	Bond price
Full integration	2.51	1.83	2.12	2.39	1.32
Moderate fragmentation	2.55	1.91	2.23	2.48	1.38
Extreme fragmentation	2.61	2.00	2.36	2.59	1.45
Autarky	2.78	2.30	2.78	2.94	1.70
France	Output	Consumption	Corporate profit	Equity price	Bond price
Full integration	1.51	1.04	1.38	1.46	0.79
Moderate fragmentation	1.53	1.07	1.43	1.49	0.82
Extreme fragmentation	1.56	1.12	1.51	1.56	0.86
Autarky	1.60	1.18	1.60	1.62	0.91
Italy	Output	Consumption	Corporate profit	Equity price	Bond price
Full integration	2.15	1.49	1.86	1.99	1.10
Moderate fragmentation	2.18	1.53	1.93	2.03	1.14
Extreme fragmentation	2.23	1.59	2.04	2.12	1.18
Autarky	2.37	1.76	2.37	2.34	1.32
Canada	Output	Consumption	Corporate profit	Equity price	Bond price
Full integration	1.66	1.03	1.49	1.71	0.89
Moderate fragmentation	1.66	1.06	1.54	1.73	0.92
Extreme fragmentation	1.65	1.08	1.52	1.74	0.94
Autarky	1.68	1.22	1.68	1.81	1.06

E Robustness

E.1 Elasticity of Substitution between Home and Foreign Goods

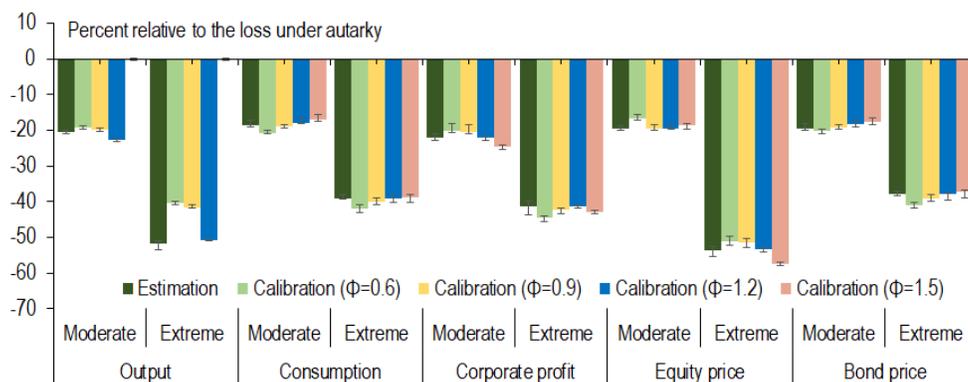
This appendix examines the robustness of the results in Section 5.2 concerning the elasticity of substitution in consumption and investment between home and foreign goods (ϕ, ϕ_I). Specifically, we simulate the model with four sets of parameters: $\phi = \phi_I = \{0.6, 0.9, 1.2, 1.5\}$.⁴⁸ We then compare the computed macro-financial volatility and loss of diversification benefit for G7 countries with those in Figures 2 and 3. Figure A1 shows that the impact of the changes in these parameters (ϕ, ϕ_I) on the estimates of macro-financial volatility is moderate. More importantly, Figure A1 demonstrates that the impact of the changes in the parameters on the estimates of the loss of diversification benefit is marginal. This implies that ϕ and ϕ_I barely affect the percent changes in diversification benefit while they moderately affect the size of the benefit.

Figure A1: Macro-financial volatility in G7 countries



Note: Bars show the median volatility (standard deviation) of the variables in the home country under fragmentation scenarios. Whiskers indicate the interquartile range of the effect across the G7 countries.

Figure A2: Loss of diversification benefit in G7 countries



Note: Bars show the median of loss of diversification benefit under fragmentation scenarios. Whiskers indicate the interquartile range of the effect across the G7 countries.

⁴⁸The other estimated parameter, σ , is re-estimated.

E.2 Local Spending Bias in Consumption and Investment

This appendix examines the robustness of the results in Section 5.2 concerning the dataset for calibrating local spending bias in consumption and investment (a, a_I). Specifically, we calibrate the parameters based on the export ratios and the export partner shares instead of the import and import partner shares. This is because the symmetry assumption in the model implies that a and a_I are the local spending bias in the foreign country and determine the home country's export ratio. We apply the calculation formula in Section 4. Table A2 shows the calibrated parameters based on the export ratios and the export partner shares under four scenarios, and the table indicates that the calibrated parameters exhibit little changes from Table 6.⁴⁹

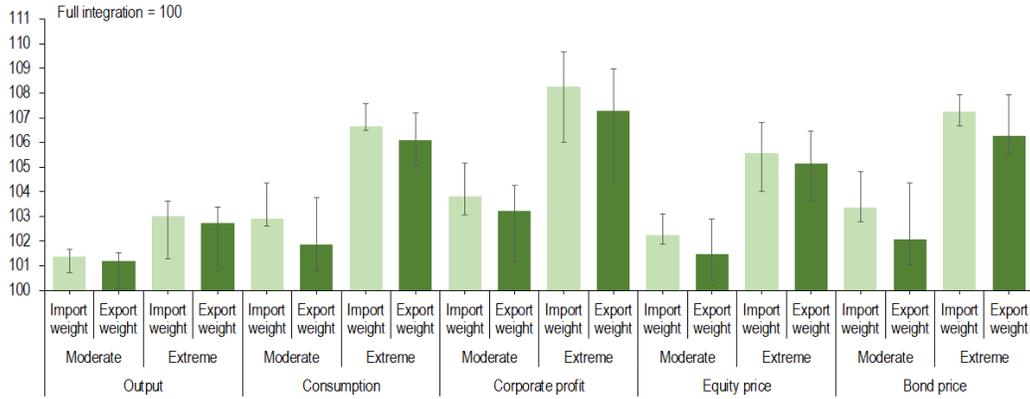
Table A2: Local spending bias in consumption and investment under four scenarios

Country	Full integration	Moderate fragmentation	Extreme fragmentation	Autarky
United States	0.90	0.91	0.94	1.00
Japan	0.87	0.91	0.93	1.00
Germany	0.66	0.68	0.70	1.00
United Kingdom	0.75	0.78	0.79	1.00
France	0.74	0.77	0.79	1.00
Italy	0.75	0.77	0.79	1.00
Canada	0.68	0.70	0.71	1.00

Figure A3 compares the estimates of the macro-financial volatility under the parameters in Table A2 with those in Table 6. The figure indicates that the impact of the changes in these parameters (a, a_I) on estimates of the macro-financial volatility is small. Similarly, Figure A4 compares the estimates of the loss of diversification benefit under the parameters in Table A2 with those in Table 6 and indicates that the impact of the changes in the parameters on the estimates is tiny. They imply the robustness of the results concerning the dataset for calibrating local spending bias.

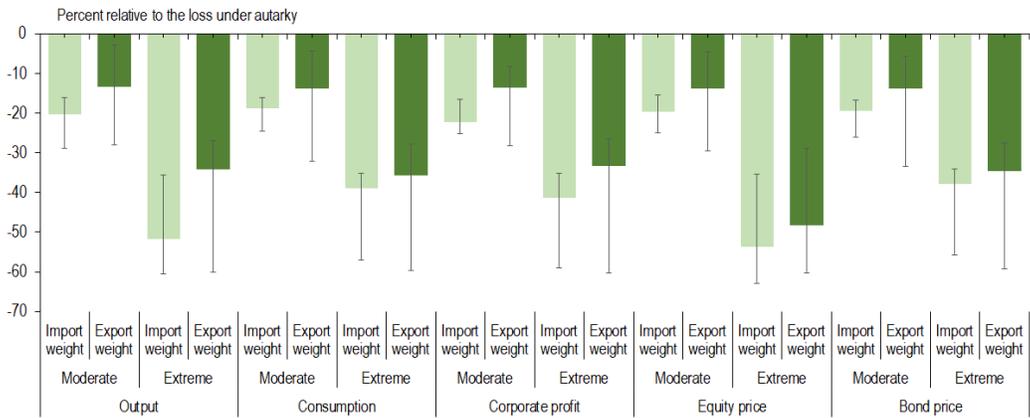
⁴⁹The export ratios are calculated based on the dataset by the United Nations “The National Accounts Main Aggregates Database,” and the dataset of bilateral export partner share is obtained from World Bank, “World Integrated Trade Solution.”

Figure A3: Macro-financial volatility in G7 countries



Note: Bars show the median volatility (standard deviation) of the variables in the home country under fragmentation scenarios. Whiskers indicate the interquartile range of the effect across the G7 countries.

Figure A4: Loss of diversification benefit in G7 countries



Note: Bars show the median of loss of diversification benefit under fragmentation scenarios. Whiskers indicate the interquartile range of the effect across the G7 countries.



PUBLICATIONS

**Geoeconomic Fragmentation and International Diversification
Benefits** Working Paper No. WP/2024/048