The Natural Limit of Monetary Independence

Preliminary and incomplete: estimates remain subject to revision, and errors may remain.

Evangelos D. Stravelas*

November 2026

Abstract

The relation between exchange-rate stability and monetary independence weakens steadily as the regions of an economy diverge. Sorting country-years into groups by regional fragmentation orders the strength of that relation without exception, from the classical trade-off in the least fragmented group to none in the most fragmented group, and the ordering survives the removal of fixed differences between economies and of shocks common to all economies in a year. The relation operates through capital mobility: with closed capital accounts exchange-rate stability and monetary independence show no relation, and the capital-mobility margin weakens as fragmentation rises. A threshold in fragmentation separates a regime with a strong relation from a regime with a weak one, and the weak regime shows attenuation, not reversal. The classical trilemma is the low-fragmentation limit of a relation whose slope falls toward zero as regions diverge.

JEL codes: F33, F41, E52, C23.

Keywords: monetary independence; exchange-rate stability; regional fragmentation; capital mobility; threshold estimation; trilemma.

*e.stravelas@gmail.com. Replication code provided upon acceptance. All errors are the author's own.

1. Introduction

The conditional slope of monetary independence on exchange-rate stability falls toward zero as regional fragmentation rises. In 58 economies over 1974–2020, a unit increase in exchange-rate stability (ERS) is associated with a decline in monetary independence (MI) of 0.49 (s.e. 0.04) in the least fragmented fifth of country-years and of 0.01 (s.e. 0.04) in the most fragmented fifth; fragmentation F is the cross-regional standard deviation of output gaps, and the two quintile medians are 0.48 and 5.19 percentage points. The ordering is monotone across the five quintiles (Figure 1), survives economy fixed effects, and has the form of the attenuation that Proposition 2.1 derives for the optimal weight $m(F)$ on the domestic natural rate.

The research question is how much monetary independence an economy forgoes for exchange-rate stability when its regions diverge. The estimand is the slope of MI on ERS, conditional on capital openness, economy and year, as a function of F; it is a reduced-form conditional slope, and the paper makes no causal claim about F. Lucas (1973) identifies the dependence of the output response to nominal demand on the variance of nominal demand from a cross-section of 18 economies. The same design identifies here the dependence of the ERS–MI slope on regional dispersion from 58 economies, with economy and year fixed effects removing composition and the global cycle.

The identifying variation is within economy and within year: 61 percent of the variance of F lies within economies, as do 48 percent of the variance of ERS and 63 percent of the variance of MI. The identifying assumption is that, conditional on economy and year effects, controls, capital openness and its interactions, F_{it} is uncorrelated with the unobserved determinants of the slope. The most credible threat is composition: low-F country-years concentrate in OECD economies with open

capital accounts (OECD share 0.76 and mean KAOPEN 0.78 in the lowest quintile; 0.21 and 0.50 in the highest), and the euro-area corner (ERS = 1, MI = 0) holds 13 percent of country-years. The response is the design: fixed effects, capital-openness interactions, euro-area exclusion and wild-cluster inference. Instruments for F built from the Regional Authority Index and legal origin carry first-stage F-statistics of 0.41 and 0.99 and bear no weight in the estimates.

Three results follow, each stated against the benchmark of -0.43 of Aizenman, Chinn, and Ito (2010). The trade-off is present at low F in all 16 estimators (coefficients from -0.51 to -0.12) and equals the benchmark in pooled estimators: -0.42 (s.e. 0.06) in the bottom decile of F; with fixed effects and controls it is -0.19 to -0.26. The slope attenuates with F and operates through capital mobility: the stacked trend contrast across quintiles is $+0.456$ (s.e. 0.176; Holm-adjusted $p = 0.048$), ERS$\times$KAOPEN is -0.222 (s.e. 0.072; wild-cluster $p = 0.006$), and each point of F attenuates that margin by 0.024 (s.e. 0.010; wild-cluster $p = 0.070$). A threshold in F at 1.70 points separates ERS coefficients of -0.190 (s.e. 0.048) and -0.058 (s.e. 0.029); the slope stays negative above it, so the threshold marks attenuation and no zero crossing.

Four predictions of Section 2 fail the data. The linear interaction ERS$\times F$ is $+0.0044$ (s.e. 0.0057), below the 0.016 that the design detects with 80 percent power; the logarithmic form is $+0.058$ (s.e. 0.025). Observed policy support thickens with F: hull volume rises from 0.046 to 0.093 across quintiles (permutation $p = 0.002$), where Hypothesis 2.3 predicts contraction. Mean MI is 0.34 below the threshold and 0.41 above it, where Hypothesis 2.2 predicts a reduction. The threshold is no higher under inflation targeting (-2.5 points; one-sided $p = 0.79$).

Aizenman, Chinn, and Ito (2010) estimate one slope for all country-years; the slope here equals their -0.43 at the bottom decile of F in pooled estimates and is -0.01 in

the top quintile. Klein and Shambaugh (2015) establish that partial capital-account openness yields an intermediate trilemma position; the ERS×KAOPEN interaction is linear in openness, with an ERS effect of −0.009 (s.e. 0.035) at KAOPEN = 0 and −0.231 (s.e. 0.052) at KAOPEN = 1. Rey (2015) establishes that the global financial cycle turns the trilemma into a dilemma; year fixed effects absorb that common cycle, and the quintile ordering holds within years and within economies. Obstfeld, Shambaugh, and Taylor (2005) trace the trade-off across four monetary regimes from 1870 to 2000; the coefficient here moves from +0.150 (s.e. 0.055) in 1973–79 to −0.210 (s.e. 0.079) in 2000–09 and tracks capital openness (rank correlation −0.76), not F (−0.02).

2. The Structural Limit

Heterogeneous regional trade exposure increases the output-stabilization cost of exchange-rate movements in an economy where regions face structurally distinct equilibrium interest rates. A national monetary authority setting a uniform nominal rate i_t cannot close regional output-gap deviations without inducing exchange-rate volatility that loads heterogeneously on regional demand. As spatial fragmentation rises, the cross-sectional welfare cost of exchange-rate fluctuations increases quadratically, driving the optimal policy rule toward foreign-rate tracking. The result characterizes the chosen policy; it does not characterize the feasible policy set.

Environment. A continuum of regions $i \in [0, 1]$ face the static open-economy demand equation

$$y_{it} = -\sigma(i_t - r^*_{it}) + \omega_i q_t, \qquad \sigma > 0, \tag{1}$$

where y_{it} is the regional output gap, r^*_{it} is the regional natural rate, $\omega_i \in (0, 1)$

is regional trade openness, and q_t is the exchange-rate movement entering current regional demand. The exchange-rate impact relation is

$$q_t = -\lambda^{-1}(i_t - i_t^*) + \varepsilon_t, \qquad \lambda > 0, \tag{2}$$

where i_t^* is the foreign base rate and ε_t is an exogenous shock with mean zero. Equation (2) is a maintained impact relation; it is not derived from uncovered interest parity.*

Regional structure. Let $r_{it}^* = \bar{r}_t^* + u_{it}^r$ and $\omega_i = \bar{\omega} + \xi_i$, where $\int_0^1 u_{it}^r \, di = \int_0^1 \xi_i \, di = 0$,

$$F \;\equiv\; \sqrt{\mathrm{Var}_i[r_{it}^*]} \;\geq\; 0, \qquad \mathrm{Var}_i(\xi_i) = \chi^2 F^2, \qquad \mathrm{Cov}_i(u_{it}^r, \xi_i) = 0. \tag{3}$$

The admissible fragmentation domain is $\mathcal{F} = [0, \bar{F}]$, where $\bar{F} \equiv \chi^{-1} \min\{\bar{\omega}/a, (1 - \bar{\omega})/b\}$ for bounded support $z_i \equiv \xi_i/(\chi F) \in [-a, b]$; this preserves $\omega_i \in [0, 1]$ and implies $\chi^2 F^2 \leq \bar{\omega}(1 - \bar{\omega})$.

Spatial transmission. Integration and subtraction give

$$\bar{y}_t = -\sigma(i_t - \bar{r}_t^*) + \bar{\omega}\, q_t, \qquad \tilde{y}_{it} \equiv y_{it} - \bar{y}_t = \sigma u_{it}^r + \xi_i q_t. \tag{4}$$

The common interest-rate term $-\sigma i_t$ cancels in the regional deviation. The exchange-rate channel $\xi_i q_t$ does not cancel when trade openness is heterogeneous.

Lemma 2.1 (Spatial Dispersion under the Static Specialization)**.** *Under*

*The structural impossibility of simultaneously coordinating expectations, transmitting policy, and stabilizing outcomes uniformly across heterogeneous regions is derived from information capacity constraints and nonlinear aggregation in Stravelas (2026); the static specialization here is a bounded-support embedding of that environment.

orthogonality $\mathrm{Cov}_i(u^r_{it}, \xi_i) = 0$,

$$\mathrm{Var}_i(y_{it}) = F^2\big(\sigma^2\sigma_r^2 + \chi^2 q_t^2\big)\,. \tag{5}$$

The policy derivatives of regional dispersion satisfy

$$\frac{\partial\,\mathrm{Var}_i(y_{it})}{\partial i_t} = -\frac{2\chi^2F^2}{\lambda}\,q_t, \qquad \frac{\partial^2\,\mathrm{Var}_i(y_{it})}{\partial i_t^2} = \frac{2\chi^2F^2}{\lambda^2} > 0. \tag{6}$$

Positive exposure dispersion makes regional variance strictly convex in i_t. *The variance-minimizing rate satisfies* $i_t = i_t^* + \lambda\varepsilon_t$; *at that rate the floor reduces to* $F^2\sigma^2\sigma_r^2$, *which is strictly positive whenever* $F > 0$.

Proof. Squaring $\tilde{y}_{it} = \sigma u^r_{it} + \xi_i q_t$ and integrating eliminates the cross term by orthogonality, giving (5). Substituting $q_t = -\lambda^{-1}(i_t - i_t^*) + \varepsilon_t$ and differentiating gives (6). ■

2.1. Optimal Policy Attenuation

At $F = 0$, heterogeneity in trade exposure is zero and the exchange-rate channel contributes no cross-sectional dispersion; the first-order policy problem is the classical aggregate stabilization problem. For $F > 0$, regional dispersion grows quadratically in the exchange-rate movement q_t, introducing a welfare penalty on policy deviations from the foreign rate. The unique optimal policy rule assigns monotonically decreasing weight to the domestic natural rate as exposure dispersion rises.

Proposition 2.1 (Optimal Foreign-Rate Weight)**.** *In the static specialization with* $\varepsilon_t = 0$, *the authority minimizes*

$$\mathcal{L}(i_t) = \theta\left[\big\{\sigma(i_t - \bar{r}_t^*) + (\bar{\omega}/\lambda)(i_t - i_t^*)\big\}^2 + \frac{\chi^2F^2}{\lambda^2}(i_t - i_t^*)^2\right]. \tag{7}$$

The unique optimal interest rate is

$$i_t = m(F)\,\bar{r}_t^* + [1 - m(F)]\,i_t^*, \qquad m(F) = \frac{\kappa\sigma\lambda^2}{\kappa^2\lambda^2 + \chi^2 F^2}, \qquad \kappa \equiv \sigma + \frac{\bar{\omega}}{\lambda}. \tag{8}$$

The domestic policy response $m(F)$ satisfies:

(i) $m(0) \in (0,1)$*: positive domestic response at zero fragmentation.*

(ii) $m'(F) < 0$ *for all* $F > 0$*: strictly decreasing on* $\mathcal{F} = (0, \bar{F}]$*.*

(iii) $m(\bar{F}) > 0$*: bounded away from zero on the admissible domain; the bounded support of trade shares implies* $m(F) \geq \kappa\sigma\lambda^2/(\kappa^2\lambda^2 + \bar{\omega}(1-\bar{\omega})) > 0$*.*

(iv) The optimal rate equals the foreign rate only when $\bar{r}_t^* = i_t^*$*.*

The Aizenman-Chinn-Ito adding-up constraint[†]

$$\mathrm{MI}_{it} \approx \alpha - \theta_1\,\mathrm{ERS}_{it} - \theta_2\,\mathrm{KAOPEN}_{it}, \quad \theta_1, \theta_2 > 0, \tag{9}$$

describes the data in the low-fragmentation regime; the three empirical designs test how this relationship changes with F_{it}*.*

Proof. The welfare objective (7) follows from squaring the aggregate demand equation, adding the regional dispersion from Lemma 2.1, and dropping the constant natural-rate-variance term. The second derivative $\mathcal{L}''(i_t) = 2\theta(\kappa^2 + \chi^2 F^2/\lambda^2) > 0$ establishes strict convexity; the unique minimizer follows from the first-order condition. Differentiating $m(F) = A/(B + CF^2)$ with $A = \kappa\sigma\lambda^2$, $B = \kappa^2\lambda^2$, $C = \chi^2$

[†]Mundell (1963) and Fleming (1962) derive the classical exchange-rate constraint from IS-LM-BP foundations under perfect capital mobility. Aizenman, Chinn, and Ito (2010) operationalize it as the adding-up constraint with $\hat{\theta}_1 \approx -0.40$ to -0.43. In the static specialization at $F = 0$, the optimal policy response $m(0)$ characterizes the sensitivity of the domestic rate to domestic natural-rate shocks; its empirical projection onto the (ERS, MI) dimension is what the ACI framework measures. The present paper estimates how that projection changes with F.

gives $m'(F) = -2ACF/(B + CF^2)^2 < 0$ for $F > 0$. Substituting $C\bar{F}^2 \leq \bar{\omega}(1 - \bar{\omega})$ gives the lower bound. At the foreign rate, $\mathcal{L}'(i_t^*) = -2\theta\kappa\sigma(\bar{r}_t^* - i_t^*) \neq 0$ whenever targets differ. ■

Remark 2.1 (Attenuation versus Collapse). Proposition 2.1 establishes strict attenuation of the domestic policy response as F rises. It does not establish a finite threshold above which interior policy responses cease to exist: the response $m(F)$ remains strictly positive on every admissible $F \in \mathcal{F}$. The three empirical designs in Sections 4–5 test the attenuation prediction: a positive interaction coefficient $\hat{\beta}_3 > 0$ in the interaction model, an above-threshold ERS coefficient indistinguishable from the below-threshold coefficient at the zero baseline, and contraction of the observed policy support as F rises.

2.2. Three Testable Implications

Hypothesis 2.1 (Attenuating Trade-off)**.** The marginal effect $\partial\,\mathrm{MI}/\partial\,\mathrm{ERS}$ is strictly increasing in F on the relevant parameter range; the interaction $\mathrm{ERS}_{it} \times F_{it}$ carries a positive coefficient $\hat{\beta}_3 > 0$, and the marginal effect at $\bar{F}$ is strictly less negative than the marginal effect at $F = 0$.

Hypothesis 2.2 (Threshold Compression)**.** A finite threshold $F^* > 0$ exists above which the ERS and KAOPEN coefficients are jointly attenuated toward zero and mean MI is substantially reduced relative to the below-threshold regime; below F^*, the ACI constraint (9) describes the data.

Hypothesis 2.3 (Contracting Observed Policy Support)**.** The volume of the convex hull of observed $(\mathrm{ERS}_{it}, \mathrm{KAOPEN}_{it}, \mathrm{MI}_{it})$ triples in $[0, 1]^3$ falls strictly monotonically with F_{it}: realized policy configurations concentrate as fragmentation rises.

Hypothesis 2.1 tests the weakening: the linearization degrades continuously as F rises. Hypothesis 2.2 locates the boundary: it estimates $\hat{F}^*$, the empirical frontier within which the linearization holds. Hypothesis 2.3 provides non-parametric geometric confirmation independent of any regression structure. Together the three tests characterize the attenuation mechanism from three independent empirical designs, consistently with Proposition 2.1 and Lemma 2.1.

Remark 2.2 (Theoretical Attenuation and Empirical Threshold). Corollary 2.1 establishes that the spatial variance floor grows with F and modifies the classical affine trade-off surface; its exact projection onto the (ERS, MI) dimension is the subject of ongoing theoretical work. The specific values $\hat{F}^*$, $\hat{\theta}_1$, $\hat{\psi}_1$, and $\hat{\beta}_3$ are empirical estimates from the data; they are subject to revision as the panel extends. The empirical threshold model detects a conditional-relationship break; it characterizes the data, not a structural impossibility boundary.

3. Measurement and Data

Regional fragmentation is the cross-regional dispersion of output gaps, the trilemma indices are the Aizenman–Chinn–Ito indexes, and the estimation sample is the set of 58 economies with at least three sub-national output units.

3.1. The Fragmentation Index

Lemma 2.1 gives the cross-regional standard deviation of output gaps as $\mathrm{sd}_i(y_{it}) = F\,(\sigma^2\sigma_r^2 + \chi^2 q_t^2)^{1/2}$: at a given exchange-rate movement, the dispersion of regional output gaps is proportional to F, with a factor common to all regions of the economy

in year t. The empirical index is therefore

$$F_{it} \;=\; 100 \times \mathrm{sd}_r\!\left(y^{\mathrm{gap}}_{rit}\right), \tag{10}$$

the sample standard deviation, across the $R_{it} \geq 3$ regional units r of economy i in year t, of the regional output gap, in percentage points of log output. Thresholds and scale parameters below are stated on the scale of F_{it}.

The output gap of each regional unit is the cycle of the unobserved-components model of Harvey (1989): log real regional output decomposes into a stochastic trend and a trigonometric cycle, estimated by maximum likelihood with the Kalman filter, with no Phillips curve or other structural restriction on the cycle. F_{it} and the continuous controls are winsorized at the 1st and 99th within-economy percentiles, and country-years with fewer than three regional units are set to missing.

The two-component index adds the dispersion of regional inflation,

$$F^{(2)}_{it} \;=\; 100 \times \left[\tfrac{1}{2}\left(\left\{\mathrm{sd}_r(\pi_{rit})/\kappa_0\right\}^2 + \mathrm{sd}_r\!\left(y^{\mathrm{gap}}_{rit}\right)^2\right)\right]^{1/2}, \qquad \kappa_0 = 0.10, \tag{11}$$

with inflation in decimal units and output gaps in log units. Regional consumer prices exist for 15 economies, 14 of them in the estimation sample (310 country-years); $F^{(2)}$ therefore serves as a check on that subsample (Appendix C), and F_{it} is the index of every other estimate.

3.2. Trilemma Indices and Controls

ERS and MI are the Aizenman–Chinn–Ito trilemma indexes (Aizenman, Chinn, and Ito, 2010) on the unit interval, available through 2020. ERS rises with the stability of the exchange rate against the base country. MI $= (1-\rho)/2$, where ρ is the annual

correlation of the domestic short-term interest rate with the base-country rate; a unit change in MI equals a change of two in ρ. KAOPEN is the Chinn–Ito capital-account openness index (Chinn and Ito, 2008), normalized to the unit interval. The sum ERS + MI + KAOPEN has mean 1.54 (s.d. 0.43) in the estimation sample.

Controls X_{it} are log real GDP per capita, the logarithm of one plus CPI inflation, trade openness (percent of GDP), central bank independence (Garriga, 2016), foreign-exchange reserves (percent of GDP), and dummies for interstate war, civil war, inflation crisis, euro-area membership and exchange-rate-regime reclassification. Year fixed effects absorb the global financial crisis and the pandemic.

3.3. Sources, Coverage and Sample

Of the 58 economies in the estimation sample, ARDECO, the Annual Regional Database of the European Commission, supplies 16 at the NUTS-2 level; DOSE (Wenz et al., 2023) supplies 35; direct correspondence with national statistical authorities and central banks supplies five (Canada, Guatemala, India, Korea and Thailand); and national regional accounts supply two (Japan and South Africa). Where an authority published successive vintages on different bases, the vintages are joined by backchaining, following the precise guidance of the authority concerned. Not every economy has regional output, and fewer have regional prices: the panel holds regional output for 61 of its 85 economies and regional consumer prices for 15.

The panel covers 85 economies over 1973–2022. Of these, 81 have ERS and MI (the United States is the base country; Argentina, Bangladesh and Serbia have no ERS or MI), 61 have regional output, and 58 have at least three regional units (Lithuania, Malta and Slovenia have fewer); all 58 have capital openness and the controls. The estimation sample has 1,794 country-years over 1974–2020. The sample without controls, used for the quintile, economy-level and hull estimates, has 1,818

Table 1. Estimation Sample: Observations and Summary Statistics

	Full sample	OECD	Non-OECD
Country-years	1,794	936	858
Economies	58	25	33
Years	1974–2020	1974–2020	1974–2020
Regional fragmentation F (pp), mean (s.d.)	2.58 (4.28)	1.63 (2.83)	3.61 (5.24)
F: 10th, 50th, 90th percentile	0.47, 1.45, 5.11	0.37, 1.01, 3.03	0.70, 2.35, 6.73
Exchange-rate stability (ERS), mean (s.d.)	0.531 (0.296)	0.561 (0.305)	0.498 (0.283)
Monetary independence (MI), mean (s.d.)	0.371 (0.224)	0.284 (0.221)	0.466 (0.185)
Capital openness (KAOPEN), mean (s.d.)	0.639 (0.359)	0.795 (0.288)	0.469 (0.351)
ERS + MI + KAOPEN, mean (s.d.)	1.541 (0.432)	1.640 (0.371)	1.433 (0.467)
Euro-area share of country-years	0.148	0.269	0.016
Inflation-targeting share of country-years	0.285	0.264	0.309

Notes: F is the cross-regional standard deviation of output gaps in percentage points (equation (10)). ERS, MI and KAOPEN are unit-interval indexes. The OECD sample is the 25 OECD economies with regional output; the United States is the base country and Iceland and Luxembourg have no sub-national series.

country-years over 1973–2020. The sample reaches the 1970s: 327 country-years of the estimation sample precede 1990, from 32 economies (220 country-years from 20 OECD economies and 107 from 12 non-OECD economies). Observed values of capital openness (670 country-years) and central bank independence (635) for non-OECD economies before 1990, carried in an auxiliary sheet of the source workbook, fill blanks of the main panel and coincide with it wherever both exist; no value is imputed, interpolated or filled. Table 1 reports the sample, and Appendix B lists all 85 economies with their sources, region counts and years.

4. Identification and Estimation

The estimand is the slope $\partial\,\mathrm{MI}/\partial\,\mathrm{ERS}$ as a function of F, conditional on KAOPEN, economy and year.

4.1. Identifying Variation and Assumption

The identifying variation is the within-economy and within-year covariation of MI, ERS and F: 61 percent of the variance of F_{it}, 48 percent of the variance of ERS and 63 percent of the variance of MI lie within economies. Year effects absorb every shock common to all economies in a year, the global financial cycle of Rey (2015) among them.

Assumption 4.1 (Conditional independence of fragmentation)**.** Conditional on α_i, λ_t, X_{it} and KAOPEN_{it}, F_{it} is uncorrelated with the unobserved determinants of the ERS–MI slope.

Assumption 4.1 is substantive. Two threats bear on it. Composition: country-years with low F concentrate in OECD economies with open capital accounts and euro-area membership, and the euro-area corner (ERS = 1, MI = 0) holds 13 percent of country-years. Reverse causation: Frankel and Rose (1998) establish that trade integration and business-cycle synchronization respond to currency arrangements, and regional dispersion may respond to the exchange-rate regime in the same way. The design answers composition with economy fixed effects, capital-openness interactions and a variant that drops euro-area rows. No design answers reverse causation: the instruments of Section 4.6 carry no first stage. The estimates are reduced-form conditional slopes for the 58 economies with sub-national output accounts over 1974–2020, and they carry no causal reading of F.

4.2. Quintile Design

Country-years are ranked by F_{it} and split into five equal-count quintiles q. Within each quintile,

$$\mathrm{MI}_{it} \;=\; a_q + b_q\,\mathrm{ERS}_{it} + c_q\,\mathrm{KAOPEN}_{it} + \varepsilon_{it}, \qquad F_{it} \in \text{quintile } q, \tag{12}$$

estimated by pooled OLS, with economy fixed effects, and by pooled OLS with euro-area rows excluded. The trend of $\hat{b}_q$ in the median F of the quintile is summarized by the Spearman rank correlation, with an economy-cluster bootstrap that resamples economies and rebuilds the quintiles in each of 500 draws, and by a stacked model with economy and year fixed effects and controls whose trend contrast $\sum_q (q-3)\hat{b}_q$ tests monotone attenuation. The design follows Lucas (1973), who orders country-specific slopes by the variance of nominal demand; the groups here are quintiles of the dispersion variable.

4.3. Interaction Models and the Shape of the Slope

The interaction model is

$$\begin{aligned}\mathrm{MI}_{it} \;&= \beta_1\,\mathrm{ERS}_{it} + \beta_2\,\mathrm{KAOPEN}_{it} + \beta_3\,\mathrm{ERS}_{it}F_{it} + \beta_4\,\mathrm{KAOPEN}_{it}F_{it} \\ &\quad + \beta_5\,\mathrm{ERS}_{it}\mathrm{KAOPEN}_{it} + \beta_6\,\mathrm{ERS}_{it}\mathrm{KAOPEN}_{it}F_{it} + \gamma F_{it} + \delta' X_{it} + \alpha_i + \lambda_t + \varepsilon_{it}.\end{aligned} \tag{13}$$

The marginal effect of ERS is $\beta_1 + \beta_5\,\mathrm{KAOPEN} + \beta_3 F + \beta_6\,\mathrm{KAOPEN}\,F$. Table 5 reports six specifications: (1) ERS and KAOPEN only; (2) adds F and its interactions with ERS and KAOPEN (β_3, β_4, γ), where Hypothesis 2.1 is $\beta_3 > 0$; (3) the same with $\ln F$ in place of F; (4) adds ERS×KAOPEN (β_5) to column (1); (5) equation (13) in full; (6) equation (13) with $\ln F$ in place of F.

Proposition 2.1 gives $m(F) = m(0)/\{1 + (F/F_0)^2\}$ with $m(0) = \sigma/\kappa$ and $F_0 = \kappa\lambda/\chi$. The maintained reduced form for the slope is $\theta(F) = \theta_0/\{1 + (F/F_0)^2\}$. F_0 is identified from the cross-section of slopes as the dispersion at which the slope equals half its low-fragmentation value θ_0. The form is fitted on the micro data by profiling over a grid of F_0 with economy and year fixed effects and controls, for the ERS margin and for the ERS×KAOPEN margin; the null of no attenuation is $F_0 \to \infty$, and the share of bootstrap draws that select it is the test statistic.

4.4. Threshold Model

Hypothesis 2.2 is tested through the panel threshold model of Hansen (1999):

$$\mathrm{MI}_{it} = \begin{cases} \theta_1 \,\mathrm{ERS}_{it} + \theta_2 \,\mathrm{KAOPEN}_{it} + \delta_1' X_{it} + \alpha_i + \lambda_t + \varepsilon_{it}, & F_{it} \le \gamma, \\ \psi_1 \,\mathrm{ERS}_{it} + \psi_2 \,\mathrm{KAOPEN}_{it} + \delta_2' X_{it} + \alpha_i + \lambda_t + \varepsilon_{it}, & F_{it} > \gamma, \end{cases} \tag{14}$$

with economy and year effects common to both regimes. Panel A of Table 7 lets every coefficient be regime-specific; Panel B lets only the ERS and KAOPEN coefficients differ. The threshold γ minimizes the concentrated sum of squares over the 5th to 95th percentile of F_{it} with at least five percent of country-years and five economies on each side. The sup-LR statistic is compared with a wild-cluster bootstrap (Rademacher weights by economy, regressors held fixed, 500 draws) under the null of no threshold, and the confidence interval inverts the LR profile at the 95 percent critical value of Hansen (1999).

4.5. Observed Policy Support and Adding-Up

Within each year, country-years are split into F quintiles, and the convex hull of the observed $(\mathrm{ERS}, \mathrm{KAOPEN}, \mathrm{MI})$ triples in the unit cube is computed by Quickhull

(Barber, Dobkin, and Huhdanpaa, 1996) and averaged across years. The test statistic is the slope of mean volume on the quintile, against a permutation null that shuffles quintile labels within year (500 draws), in both directions. Hull volume measures observed support, not the feasible policy set; the centroids report where the support sits. The adding-up sum ERS + MI + KAOPEN is tested for equal dispersion across pooled F quintiles by the Brown–Forsythe statistic (Brown and Forsythe, 1974) and, across economies, by the rank correlation between the within-economy standard deviation of the sum and mean F.

4.6. Instruments

The Regional Authority Index (Hooghe et al., 2016) and legal origin (La Porta et al., 1999) are constitutional and legal determinants of regional structure that predate the sample. Their interactions with ERS and KAOPEN instrument $\mathrm{ERS}_{it}F_{it}$ and $\mathrm{KAOPEN}_{it}F_{it}$ in the capital model; the first-stage F-statistic, the Anderson–Rubin test (Anderson and Rubin, 1949) and the overidentification test report whether they carry information about the interactions.

4.7. Inference

Standard errors are clustered by economy (58 clusters; 25 and 33 in the two subsamples), because shocks to the ERS–MI relation are serially correlated within economy. Wild-cluster restricted-bootstrap p-values (Cameron, Gelbach, and Miller, 2008) accompany the interaction terms and the threshold; two-way clustering by economy and year changes the standard errors of the three headline interactions by less than ten percent; and the minimum effect detectable at 80 percent power and five percent size is 2.8 standard errors. Economy-specific slopes use Newey–West standard errors (Newey and West, 1987). Holm adjustments (Holm, 1979) apply within two

families: the four predictions of Section 2 and five further tests.

5. Results

The estimand throughout is the conditional slope of MI on ERS as a function of F; standard errors are clustered by economy, and Table 10 collects the adjusted p-values of the tests that Section 2 states and of five further tests.

5.1. The Classical Trade-off at Low Fragmentation

The coefficient on ERS is negative in every specification and sample (Table 2). In the full sample it is -0.299 (s.e. 0.047) in pooled OLS and -0.110 (s.e. 0.029) with economy and year fixed effects, controls and the euro-area dummy; the benchmark of Aizenman, Chinn, and Ito (2010) is -0.43. The average country-year has F of 2.6 points, and the slope depends on F. In the bottom decile of F ($F \leq 0.47$ points) the pooled coefficient is -0.422 (s.e. 0.060), which equals the benchmark ($p = 0.89$), and the fixed-effects coefficients lie between -0.19 and -0.26.

The pooled benchmark depends on the euro-area corner. Euro-area members hold ERS $= 1$ and MI $= 0$ in 13 percent of country-years; with those rows dropped, the pooled coefficient in the lowest F quintile is -0.178 (s.e. 0.057), which differs from the benchmark ($p < 0.001$). Across the 16 estimators of the low-F slope (Table 15), the coefficient lies between -0.51 and -0.12, is negative at the two percent level in every case, and is equivalent to -0.43 within a margin of 0.10 in none. The trade-off therefore exists at low F in every specification; its classical magnitude holds in the pooled estimators that retain the euro-area corner and not in the estimators with fixed effects or without the corner.

Table 2. Coefficient on Exchange-Rate Stability: From the Pooled Benchmark to Fixed Effects

	Full sample	OECD	Non-OECD	Full sample, $F \leq$ 10th percentile
Pooled OLS	−0.299***	−0.466***	−0.090**	−0.422***
	(0.047)	(0.028)	(0.043)	(0.060)
+ economy fixed effects	−0.244***	−0.379***	−0.101**	−0.234**
	(0.043)	(0.045)	(0.041)	(0.089)
+ year fixed effects	−0.229***	−0.357***	−0.097**	−0.263**
	(0.039)	(0.045)	(0.042)	(0.099)
+ continuous controls	−0.200***	−0.278***	−0.095**	−0.231**
	(0.032)	(0.050)	(0.037)	(0.097)
+ dummies, including euro area	−0.110***	−0.182***	−0.060*	−0.189
	(0.029)	(0.048)	(0.034)	(0.120)
Pooled OLS, euro-area rows dropped	−0.084**	−0.226***	−0.057	−0.200***
	(0.039)	(0.056)	(0.034)	(0.052)
Two-way fixed effects and controls, euro-area rows dropped	−0.065**	−0.061	−0.058*	−0.212
	(0.027)	(0.053)	(0.034)	(0.146)
Country-years, rows 1–5	1,794	936	858	180
Economies, rows 1–5	58	25	33	25
Country-years, rows 6–7	1,528	684	844	161

Notes: Dependent variable: monetary independence (MI). Every specification includes KAOPEN. Standard errors in parentheses, clustered by economy. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$. The Aizenman–Chinn–Ito benchmark is −0.43. Continuous controls and dummies are those of Section 3.2.

5.2. Attenuation across Fragmentation Quintiles

The coefficient on ERS rises monotonically with F across the five quintiles (Figure 1, Table 3). In pooled OLS the quintile coefficients are −0.492 (s.e. 0.040), −0.453 (0.059), −0.369 (0.044), −0.193 (0.071) and −0.011 (0.040), at median F of 0.48, 0.90, 1.47, 2.50 and 5.19 points. With economy fixed effects they are −0.367, −0.276, −0.251, −0.139 and −0.036. The Spearman rank correlation between the coefficient and median F is +1.00 in both estimators (bootstrap 95 percent intervals 0.70 to 1.00 and 0.30 to 1.00), and the bootstrap p-values for the null of no attenuation are below 0.001 and 0.006 (Table 4).

The slope of the quintile coefficients on median F is +0.104 per point (bootstrap 95 percent interval 0.069 to 0.133) in pooled OLS and +0.065 (0.031 to 0.099) with

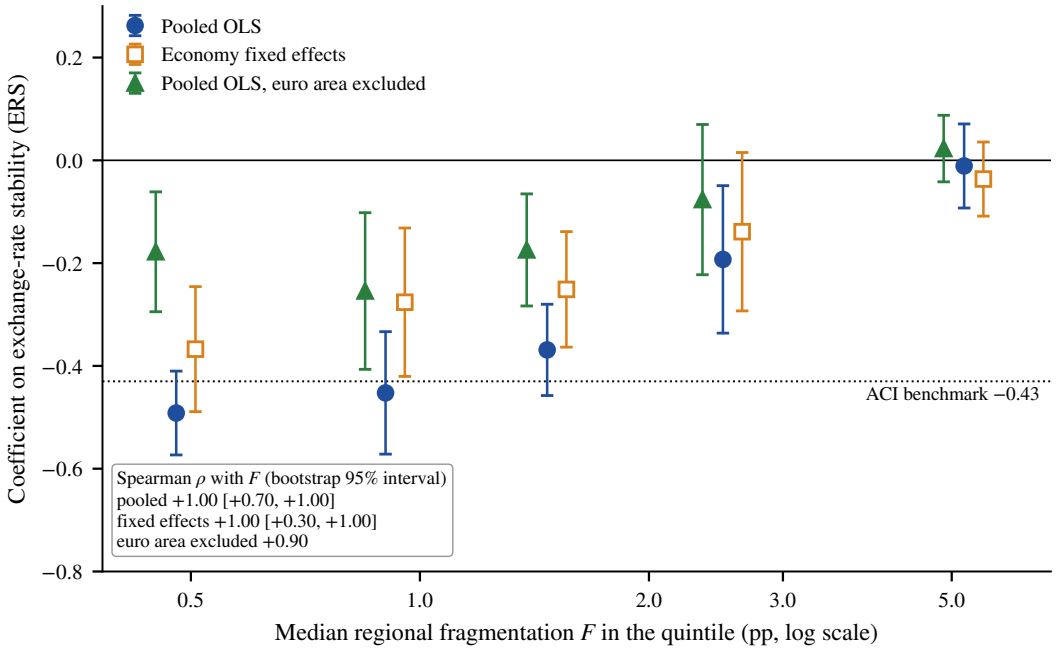


Figure 1. The coefficient on exchange-rate stability by quintile of regional fragmentation, full sample. Each marker is the coefficient on ERS from a regression of MI on ERS and KAOPEN within an equal-count quintile of F (pooled OLS, economy fixed effects, and pooled OLS without euro-area rows); bars are 95 percent confidence intervals from standard errors clustered by economy. The dotted line is the Aizenman–Chinn–Ito benchmark.

fixed effects. The stacked model with economy and year fixed effects and controls gives a trend contrast of +0.456 (s.e. 0.176, $p = 0.012$), and equality of the five slopes is rejected at $p = 0.097$. Dropping euro-area rows leaves the ordering: the coefficients are −0.178, −0.254, −0.174, −0.076 and +0.023 (Spearman +0.90, exact $p = 0.037$). In the OECD sample the pooled ordering has Spearman +0.70 (bootstrap $p = 0.036$), with coefficients from −0.51 to −0.32; in the non-OECD sample it has +0.90 ($p = 0.056$), with coefficients from −0.12 to +0.01 (Appendix Table 12, Figure 4). Levels are lower outside the OECD, where mean KAOPEN is 0.47 against 0.80.

The quintiles differ in composition: the OECD share falls from 0.76 to 0.21 and mean KAOPEN from 0.78 to 0.50. Economy fixed effects hold composition fixed, and the interaction models of Section 5.3 separate F from capital openness.

Table 3. Coefficient on Exchange-Rate Stability by Quintile of F: Full Sample

F quintile	Median F (pp)	Country-years	Economies	OECD share	Euro-area share	Mean KAOPEN	Coefficient on ERS		
							Pooled OLS	Economy FE	Pooled, no euro area
1	0.48	364	37	0.76	0.22	0.78	-0.492^{***} (0.040)	-0.367^{***} (0.060)	-0.178^{***} (0.057)
2	0.90	363	44	0.67	0.25	0.71	-0.453^{***} (0.059)	-0.276^{***} (0.071)	-0.254^{***} (0.076)
3	1.47	364	50	0.59	0.16	0.64	-0.369^{***} (0.044)	-0.251^{***} (0.056)	-0.174^{***} (0.054)
4	2.50	363	51	0.36	0.09	0.54	-0.193^{***} (0.071)	-0.139^{*} (0.077)	-0.076 (0.073)
5	5.19	364	40	0.21	0.02	0.50	-0.011 (0.040)	-0.036 (0.036)	0.023 (0.032)

Notes: Each row is a regression of MI on ERS and KAOPEN within an equal-count quintile of F (equation (12)). Standard errors in parentheses, clustered by economy; stars from the t distribution with $G-1$ degrees of freedom. $^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.10$.

Table 4. Monotone Attenuation: Rank Correlation and Stacked Trend Contrast

	Spearman ρ (bootstrap p)		Stacked model, economy and year FE		
	Pooled	Economy FE	Equal slopes (p)	Trend contrast (s.e.)	Trend p
Full sample	+1.00 (0.000)	+1.00 (0.006)	0.097	+0.456 (0.176)	0.012
OECD	+0.70 (0.036)	+0.60 (0.292)	0.023	+0.511 (0.210)	0.023
Non-OECD	+0.90 (0.056)	+0.80 (0.088)	0.263	+0.272 (0.198)	0.180

Notes: Spearman rank correlation between the five quintile coefficients and quintile median F; the bracketed value is the economy-cluster bootstrap p-value for the null of no attenuation (500 draws). The stacked model interacts ERS with the quintile and includes economy and year fixed effects and controls; the trend contrast is $\sum_q (q-3)\hat{b}_q$.

5.3. Interaction Models and the Capital-Mobility Margin

The linear interaction of ERS with F is +0.0044 (s.e. 0.0057; wild-cluster $p = 0.50$) in the full sample (Table 5, column 2). The design detects an interaction of 0.016 per point with 80 percent power, 3.7 times the point estimate. The marginal effect of ERS at mean capital openness is -0.124 (s.e. 0.036) at the 10th percentile of F and -0.103 (s.e. 0.028) at the 90th, and the linear form puts the zero crossing at $F = 28$ points, beyond the 99th percentile of F (18.5 points). Hypothesis 2.1 in its linear

form is not supported. F has a long right tail (mean 2.6, median 1.5, maximum 72.4 points); the logarithmic form (column 3) weights the bulk of the distribution. It gives an interaction of +0.058 (s.e. 0.025, $p = 0.027$) and marginal effects of −0.195 (s.e. 0.053), −0.131 (0.032) and −0.058 (0.030) at the 10th, 50th and 90th percentiles of F: attenuation of about seven tenths across the bulk of the distribution.

The slope operates through capital mobility. In column 4, the ERS×KAOPEN coefficient is −0.222 (s.e. 0.072; wild-cluster $p = 0.006$; Holm $p = 0.030$). The marginal effect of ERS is −0.009 (s.e. 0.035) at KAOPEN = 0 and −0.231 (s.e. 0.052) at KAOPEN = 1: with closed capital accounts, exchange-rate stability and monetary independence show no relation, and at full openness the slope equals 54 percent of the benchmark. Fragmentation attenuates the capital-mobility margin (column 5): the triple interaction ERS×KAOPEN×F is +0.0241 (s.e. 0.0104; $p = 0.024$; wild-cluster $p = 0.070$). At full openness the marginal effect of ERS is −0.271 (s.e. 0.053) at the 10th percentile of F and −0.214 (s.e. 0.046) at the 90th; the logarithmic form (column 6) gives −0.315 (s.e. 0.067) and −0.148 (s.e. 0.055), with a triple interaction of +0.069 (s.e. 0.058). In the OECD sample the triple interaction is −0.024 (s.e. 0.033); in the non-OECD sample it is +0.027 (s.e. 0.011; wild-cluster $p = 0.058$) (Appendix Tables 13 and 14). Dropping economies with fewer than five regional units leaves the three headline interactions unchanged (+0.0048, −0.241 and +0.0262).

5.4. The Shape of the Slope

The reduced form $\theta_0/\{1 + (F/F_0)^2\}$ fits the ERS×KAOPEN margin with $\hat{F}_0 = 4.96$ points and $\hat{\theta}_0 = -0.271$ (s.e. 0.059) in the full sample (Table 6): at roughly the 90th percentile of F (5.11 points), the open-account slope equals half its low-fragmentation value. Only 3 percent of bootstrap draws select no attenuation. In the non-OECD sample $\hat{F}_0 = 2.65$ points (95 percent interval 1.15 to 23.4; 1 percent of draws without

Table 5. Interaction Models: Full Sample

	(1) Slopes	(2) Linear F	(3) Log F	(4) Capital	(5) Capital, linear F	(6) Capital, log F
ERS	-0.110^{***}	-0.126^{***}	-0.152^{***}	-0.009	0.041	-0.009
	(0.029)	(0.038)	(0.038)	(0.035)	(0.050)	(0.055)
KAOPEN	-0.117^{***}	-0.152^{***}	-0.144^{***}	-0.008	0.002	-0.020
	(0.031)	(0.035)	(0.032)	(0.049)	(0.056)	(0.057)
F (pp)		-0.0073^{**}			-0.0005	
		(0.0029)			(0.0043)	
$\ln F$			-0.0690^{***}			-0.0422^{*}
			(0.0154)			(0.0246)
ERS $\times F$		0.0044			-0.0116	
		(0.0057)			(0.0089)	
ERS $\times \ln F$			0.0577**			0.0016
			(0.0254)			(0.0423)
KAOPEN $\times F$		0.0099**			-0.0013	
		(0.0041)			(0.0068)	
KAOPEN $\times \ln F$			0.0552***			0.0210
			(0.0192)			(0.0397)
ERS $\times$ KAOPEN				-0.222^{***}	-0.318^{***}	-0.254^{***}
				(0.072)	(0.078)	(0.079)
ERS $\times$ KAOPEN $\times F$					0.0241**	
					(0.0104)	
ERS $\times$ KAOPEN $\times \ln F$						0.0686
						(0.0584)
Marginal effect of ERS at F = 10th percentile, KAOPEN = mean	-0.110^{***}	-0.124^{***}	-0.195^{***}	-0.151^{***}	-0.161^{***}	-0.205^{***}
	(0.029)	(0.036)	(0.053)	(0.031)	(0.036)	(0.050)
at F = 90th percentile, KAOPEN = mean	-0.110^{***}	-0.103^{***}	-0.058^{*}	-0.151^{***}	-0.143^{***}	-0.097^{***}
	(0.029)	(0.028)	(0.030)	(0.031)	(0.028)	(0.032)
Marginal effect of ERS at F = 10th percentile, KAOPEN = 1				-0.231^{***}	-0.271^{***}	-0.315^{***}
				(0.052)	(0.053)	(0.067)
at F = 90th percentile, KAOPEN = 1				-0.231^{***}	-0.214^{***}	-0.148^{***}
				(0.052)	(0.046)	(0.055)
Wild-cluster bootstrap p, headline interaction	–	0.499	–	0.006	0.070	–
Country-years	1,794	1,794	1,794	1,794	1,794	1,794
Economies	58	58	58	58	58	58
Within R^2	0.187	0.194	0.203	0.195	0.204	0.210

Notes: Dependent variable: MI. All columns include economy and year fixed effects and the controls of Section 3.2. Standard errors in parentheses, clustered by economy. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$. Marginal effects are evaluated at the stated percentile of F (10th: 0.47 points; 90th: 5.11 points) and at mean KAOPEN (0.64) or at KAOPEN = 1. The wild-cluster bootstrap uses Rademacher weights by economy (500 draws) and tests the interaction named in the row label of the headline term: ERS$\times F$ in column 2, ERS$\times$KAOPEN in column 4, ERS$\times$KAOPEN$\times F$ in column 5.

attenuation). For the ERS margin alone the full-sample estimate is $\hat{F}_0 = 6.12$ points, with 14 percent of draws selecting no attenuation and a confidence set unbounded above. The reduction in the sum of squares relative to a constant slope is 0.24 percent for ERS and 1.37 percent for ERS$\times$KAOPEN. The scale parameter $F_0 = \kappa\lambda/\chi$ is therefore bounded below and, for the capital-mobility margin, finite.

Table 6. The Shape of the Slope in F: $\theta(F) = \theta_0/\{1 + (F/F_0)^2\}$

Margin	Sample	$\hat{\theta}_0$ (s.e.)	$\hat{F}_0$ (pp)	95% interval for F_0	Bootstrap share without attenuation	SSR gain over constant (%)
ERS	Full	−0.132 (0.036)	6.12	[3.27, ∞]	0.14	0.24
	OECD	−0.190 (0.049)	14.09	[1.35, ∞]	0.08	0.11
	Non-OECD	−0.085 (0.052)	3.27	[0.50, ∞]	0.29	0.16
ERS × KAOPEN	Full	−0.271 (0.059)	4.96	[3.27, ∞]	0.03	1.37
	OECD	−0.242 (0.116)	14.09	[0.50, ∞]	0.08	0.15
	Non-OECD	−0.331 (0.091)	2.65	[1.15, 23.4]	0.01	2.76

Notes: Fitted on the micro data with economy and year fixed effects and controls, by profiling over a grid of F_0. The interval for F_0 inverts the SSR profile; ∞ marks an unbounded upper limit. The bootstrap resamples economies (500 draws); the share is the fraction of draws in which the best fit has no attenuation. SSR gain: percentage reduction in the sum of squares relative to a constant slope.

5.5. The Threshold

A threshold at $\hat{\gamma} = 1.70$ points (95 percent interval 1.59 to 3.23) splits the full sample into 1,008 country-years below and 786 above (Table 7, Panel A). The sup-LR statistic is 68.8 against a bootstrap 5 percent critical value of 45.3 ($p < 0.01$). The ERS coefficient is −0.190 (s.e. 0.048) below the threshold and −0.058 (s.e. 0.029) above it (equality rejected at $p = 0.016$), and the KAOPEN coefficient is −0.227 (s.e. 0.039) below and −0.018 (s.e. 0.033) above. Both coefficients attenuate toward zero; the ERS coefficient stays negative above the threshold, so the threshold marks attenuation and no zero crossing. The non-OECD sample has $\hat{\gamma} = 2.65$ points ($p < 0.01$; ERS −0.114 to −0.024), the OECD sample $\hat{\gamma} = 1.07$ ($p = 0.058$; −0.296 to −0.089), and the full sample without euro-area rows $\hat{\gamma} = 3.17$ ($p < 0.01$; −0.075 to −0.023). The threshold is located in the within-economy component of F ($\hat{\gamma} = 2.49$, $p = 0.022$) and, less sharply, in the between-economy component ($p = 0.086$); shuffling F within economies rejects the null of no threshold in 4 percent of draws.

Mean MI is 0.34 below the threshold and 0.41 above it. The second clause of Hypothesis 2.2, a reduction of mean MI above the threshold, is not supported; high-F

Table 7. Panel Threshold Models in F

	Full sample	OECD	Non-OECD	Full, no euro area	Inflation targeting	No inflation targeting
Panel A. All coefficients regime-specific (equation (14))						
Threshold $\hat{\gamma}$ (pp)	1.70	1.07	2.65	3.17	1.05	3.23
95% interval	[1.59, 3.23]	[0.92, 1.29]	[2.48, 3.47]	[1.67, 3.73]	[0.91, 2.37]	[2.69, 3.73]
Sup-LR statistic	68.8	45.2	54.1	54.2	26.5	74.6
Bootstrap 5% critical value	45.9	46.4	42.0	43.3	34.0	53.7
Wild-cluster bootstrap p	0.000	0.058	0.000	0.000	0.248	0.002
ERS, $F \leq \hat{\gamma}$	-0.190^{***}	-0.296^{***}	-0.114^{***}	-0.075^{**}	-0.154	-0.126^{***}
	(0.048)	(0.055)	(0.043)	(0.034)	(0.106)	(0.040)
ERS, $F > \hat{\gamma}$	-0.058^{**}	-0.089^{*}	-0.024	-0.023	-0.041	-0.036
	(0.029)	(0.051)	(0.033)	(0.029)	(0.158)	(0.036)
KAOPEN, $F \leq \hat{\gamma}$	-0.227^{***}	-0.172^{***}	-0.148^{***}	-0.116^{***}	-0.240^{**}	-0.171^{***}
	(0.039)	(0.056)	(0.039)	(0.036)	(0.092)	(0.046)
KAOPEN, $F > \hat{\gamma}$	-0.018	-0.111	0.010	0.024	0.094	-0.018
	(0.033)	(0.068)	(0.039)	(0.038)	(0.089)	(0.050)
Equal ERS coefficients, Wald p	0.016	0.002	0.094	0.216	0.341	0.075
Country-years below / above	1,008 / 786	498 / 438	475 / 383	1,139 / 389	222 / 290	967 / 315
Mean MI below / above	0.34 / 0.41	0.28 / 0.29	0.46 / 0.48	0.42 / 0.46	0.41 / 0.41	0.32 / 0.46
Panel B. Only ERS and KAOPEN regime-specific						
Threshold $\hat{\gamma}$ (pp)	3.62	0.93	3.63	3.59	1.10	3.62
95% interval	[3.05, 4.34]	[0.26, 1.08]	[0.99, 4.28]	[2.80, 4.31]	[0.28, 4.74]	[3.06, 5.27]
Sup-LR statistic	17.7	15.0	15.0	17.1	5.9	21.1
Bootstrap 5% critical value	23.3	21.9	19.1	23.1	18.4	28.9
Wild-cluster bootstrap p	0.162	0.216	0.176	0.200	0.748	0.196
ERS, $F \leq \hat{\gamma}$	-0.105^{***}	-0.255^{***}	-0.053	-0.055^{*}	0.014	-0.094^{**}
	(0.034)	(0.064)	(0.040)	(0.032)	(0.125)	(0.038)
ERS, $F > \hat{\gamma}$	-0.116^{***}	-0.140^{***}	-0.082^{**}	-0.080^{**}	-0.233	-0.118^{***}
	(0.037)	(0.041)	(0.041)	(0.036)	(0.156)	(0.043)
KAOPEN, $F \leq \hat{\gamma}$	-0.139^{***}	-0.051	-0.120^{***}	-0.105^{***}	-0.031	-0.158^{***}
	(0.034)	(0.063)	(0.028)	(0.032)	(0.083)	(0.044)
KAOPEN, $F > \hat{\gamma}$	-0.056	-0.158^{***}	-0.005	-0.011	0.037	-0.051
	(0.041)	(0.058)	(0.043)	(0.040)	(0.080)	(0.055)
Equal ERS coefficients, Wald p	0.816	0.018	0.545	0.572	0.025	0.616
Country-years below / above	1,467 / 327	416 / 520	596 / 262	1,198 / 330	240 / 272	1,009 / 273
Mean MI below / above	0.35 / 0.46	0.28 / 0.29	0.46 / 0.49	0.42 / 0.46	0.41 / 0.41	0.33 / 0.46

Notes: Dependent variable: MI. Economy and year fixed effects common to both regimes. The threshold minimizes the concentrated sum of squares over the 5th to 95th percentile of F; the 95 percent interval inverts the LR profile; the bootstrap is wild-cluster with Rademacher weights (500 draws). Standard errors clustered by economy. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

economies are mostly non-OECD economies with closed capital accounts and mean MI of 0.47 against 0.28 in the OECD. Allowing only the ERS and KAOPEN coefficients to differ by regime (Panel B) detects no threshold ($\hat{\gamma} = 3.62$, $p = 0.162$): the break of equation (14) involves the whole conditional relation, including the coefficients on controls.

Table 8. Observed Policy Support and the Adding-Up Sum

Panel A. Hull of (ERS, KAOPEN, MI) by F quintile within year

Quintile	Median F (pp)	Mean annual volume (s.e.)	Mean trace of covariance	Centroid		
				ERS	KAOPEN	MI
1	0.48	0.046 (0.006)	0.195	0.555	0.783	0.316
2	0.90	0.064 (0.008)	0.254	0.552	0.692	0.345
3	1.40	0.063 (0.006)	0.261	0.531	0.641	0.357
4	2.34	0.080 (0.008)	0.274	0.508	0.565	0.389
5	4.95	0.093 (0.009)	0.241	0.523	0.534	0.443

Panel B. Adding-up sum ERS + MI + KAOPEN by pooled F quintile (full sample)

Quintile	Median F (pp)	Country-years	Mean of sum	S.d. of sum	S.d. within economy
1	0.48	364	1.664	0.375	0.282
2	0.90	363	1.593	0.369	0.266
3	1.47	364	1.501	0.407	0.291
4	2.50	363	1.435	0.477	0.336
5	5.19	364	1.480	0.491	0.354

Notes: Panel A: Quickhull volume of the hull of observed (ERS, KAOPEN, MI) triples in the unit cube, computed within year by F quintile and averaged over 41 years; centroids are means of the three indices. Panel B: pooled F quintiles of the full sample; the last column is the mean within-economy standard deviation of the sum.

5.6. Observed Policy Support and Adding-Up

Observed policy support thickens with F (Table 8, Panel A). Mean annual hull volume rises from 0.046 (s.e. 0.006) in the lowest F quintile to 0.093 (s.e. 0.009) in the highest; the slope on the quintile is +0.011, the permutation p-value for a fall is 1.000 and for a rise 0.002. Hypothesis 2.3 is rejected with the sign reversed. The centroid moves from MI = 0.32 and KAOPEN = 0.78 in the lowest quintile to MI = 0.44 and KAOPEN = 0.53 in the highest, with ERS roughly unchanged (0.55 to 0.52): highly fragmented economies occupy more of the policy cube, at higher MI and lower openness.

The adding-up sum ERS + MI + KAOPEN has a standard deviation of 0.375 in the lowest quintile and 0.491 in the highest (Panel B), and equal dispersion across quintiles is rejected (Brown–Forsythe $p < 0.001$). Across economies, the rank correlation between the within-economy dispersion of the sum and mean F is +0.27 ($p = 0.096$; 39 economies).

Table 9. The Coefficient on Exchange-Rate Stability by Period

Group	Period	Country-years	Economies	Mean F (pp)	Mean KAOPEN	Euro-area share	Coefficient on ERS
All economies	1973–1979	72	15	3.82	0.36	0.00	0.150** (0.055)
	1980–1989	270	32	2.65	0.46	0.00	−0.026 (0.066)
	1990–1999	386	50	3.06	0.57	0.03	−0.103** (0.040)
	2000–2009	519	56	2.84	0.70	0.21	−0.210*** (0.079)
	2010–2020	571	57	1.95	0.73	0.26	−0.105 (0.100)
OECD	1980–1989	179	20	1.85	0.59	0.00	−0.008 (0.087)
	1990–1999	207	22	1.82	0.78	0.05	−0.211*** (0.061)
	2000–2009	242	25	1.79	0.87	0.45	−0.109 (0.147)
	2010–2020	271	25	1.13	0.92	0.49	0.079 (0.175)
Non-OECD	1980–1989	91	12	4.22	0.22	0.00	−0.035 (0.096)
	1990–1999	179	28	4.50	0.33	0.00	−0.030 (0.051)
	2000–2009	277	31	3.76	0.56	0.00	−0.221** (0.090)
	2010–2020	300	32	2.68	0.55	0.05	−0.135 (0.115)

Notes: Regressions of MI on ERS and KAOPEN with economy fixed effects within each period and group; standard errors clustered by economy. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

5.7. Evolution over Time and Illustrative Economies

The slope has deepened with capital openness and not with F (Table 9, Figure 2). With economy fixed effects the coefficient on ERS is +0.150 (s.e. 0.055) in 1973–79, when mean KAOPEN is 0.36, then −0.026 (s.e. 0.066), −0.103 (0.040) and −0.210 (0.079) in 1980–89, 1990–99 and 2000–09, and −0.105 (s.e. 0.100) in 2010–20 at mean KAOPEN of 0.73. The rolling ten-year coefficient has rank correlation −0.76 with mean KAOPEN, −0.69 with the euro-area share and −0.02 with mean F.

Economy-specific slopes do not order by mean F: the rank correlation across 56 economies is +0.07 ($p = 0.61$). The economy slopes are imprecise, and the capital model predicts them: the leave-one-out prediction of Model 5 lies within 1.96 standard errors of the economy slope for 30 of 39 economies and for 17 of the 21 economies with standard error below 0.15. Figure 3 plots six economies chosen by rule (Appendix C): three with open capital accounts and three with restricted accounts. Bulgaria (−0.371, s.e. 0.115; KAOPEN 0.61), Italy to 1998 (−0.199, s.e. 0.097; 0.44) and Finland to 1998 (−0.269, s.e. 0.094; 0.76) carry negative slopes and

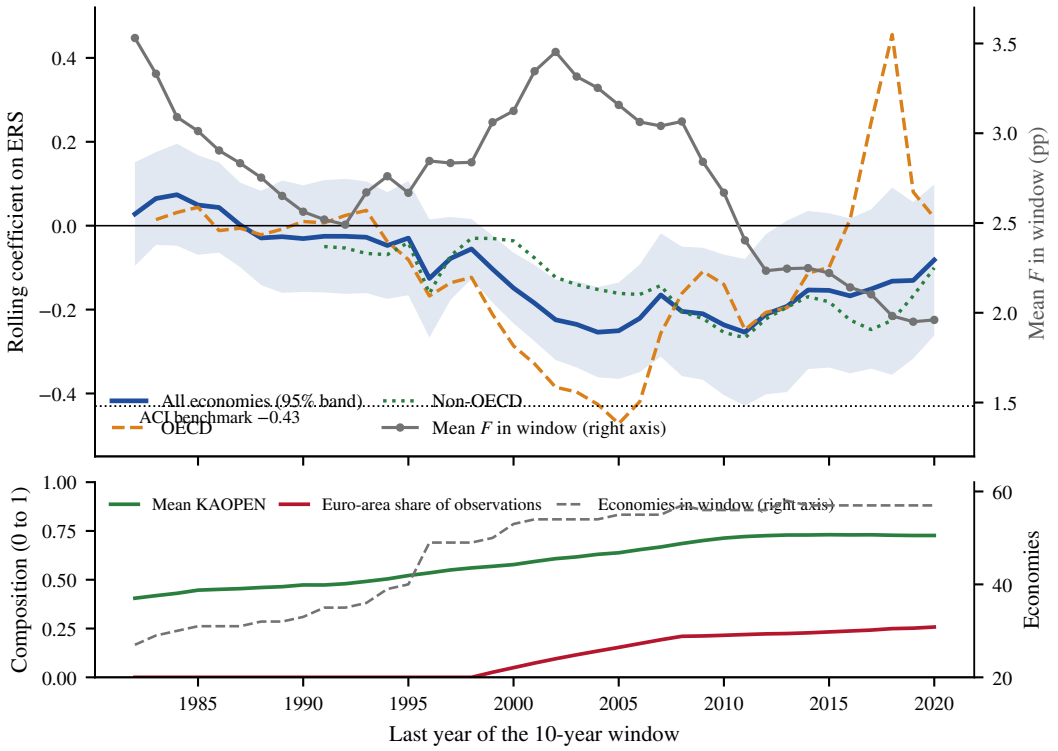


Figure 2. The rolling ten-year coefficient on exchange-rate stability, mean regional fragmentation, capital openness and euro-area share. Upper panel: coefficient on ERS from a regression of MI on ERS and KAOPEN with economy fixed effects in the ten-year window ending in the year shown (shaded band: 95 percent interval, all economies), with mean F in the window on the right axis. Lower panel: mean KAOPEN, euro-area share of observations and number of economies in the window.

open accounts. Brazil (−0.112, s.e. 0.106; KAOPEN 0.20), China (−0.077, s.e. 0.056; 0.14) and Türkiye (+0.096, s.e. 0.102; 0.25) carry slopes indistinguishable from zero and restricted accounts; the capital model predicts each within 1.5 standard errors. France before the euro (+0.161, s.e. 0.097) and Japan (+0.483, s.e. 0.290) carry positive slopes that the model misses ($z = +2.9$ and +2.6).

5.8. Inflation Targeting, Instruments and Multiple Testing

The threshold is no higher under inflation targeting. In the ERS and KAOPEN specification, the threshold is 1.10 points for inflation-targeting country-years and 3.62

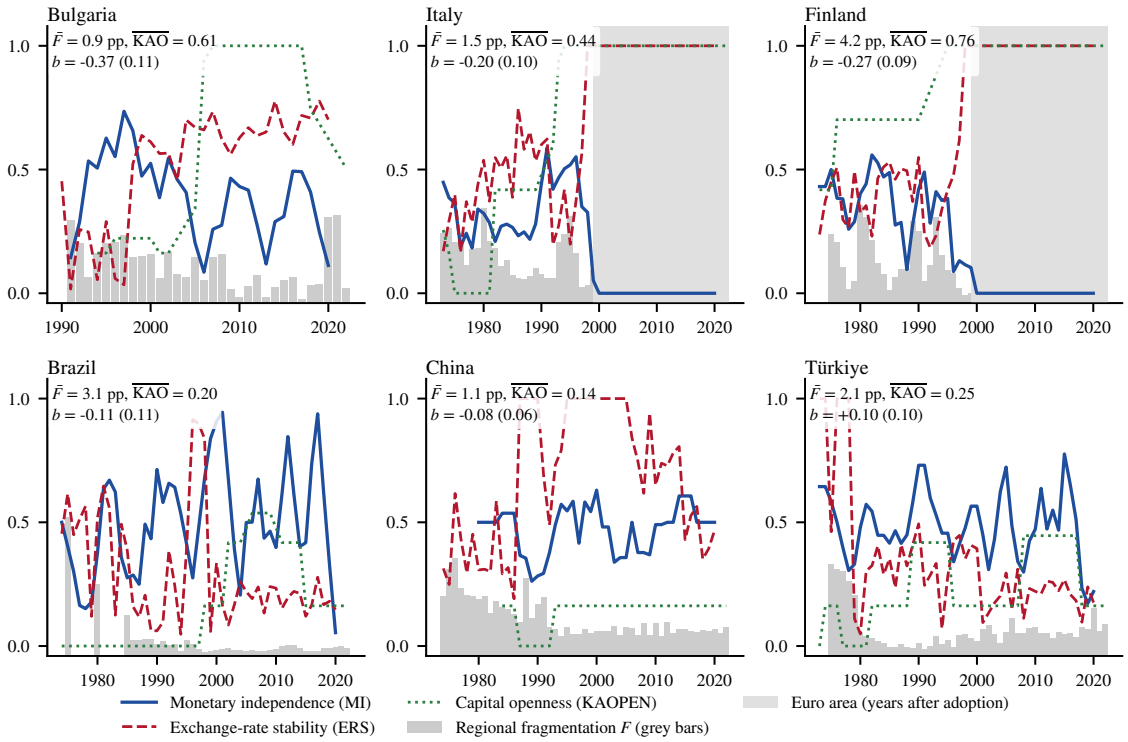


Figure 3. Monetary independence, exchange-rate stability, capital openness and regional fragmentation in six economies. Upper row: economies with open capital accounts (Bulgaria, Italy, Finland); lower row: economies with restricted accounts (Brazil, China, Türkiye). Each panel states mean F, mean KAOPEN and the economy slope b of MI on ERS (Newey–West standard error in parentheses; for Italy and Finland, the years before euro adoption). Grey bars: F (scale suppressed); grey shading: euro-area years.

for the others; the difference is −2.51 points (95 percent bootstrap interval −4.80 to +1.85; one-sided $p = 0.79$). With every coefficient regime-specific, inflation-targeting country-years show no threshold ($\hat{\gamma} = 1.05$, $p = 0.248$) and the others show one at 3.23 ($p = 0.002$) (Table 7). A threshold that inflation targeting delays is not found.

The instruments carry no first stage (Appendix Table 16). With Regional Authority Index interactions, the first-stage F-statistic for ERS×F is 0.41 and the IV estimate is +0.51 (s.e. 1.91); adding legal-origin interactions raises the statistic to 0.99, and the estimate is −0.018 (s.e. 0.058); the Anderson–Rubin p-values are 0.29 and 0.23 and 12 economies lack the index. The OLS estimates stand as reduced-form

Table 10. Tests and Holm-Adjusted p-Values

Test	Estimate	p	Holm p
Family A. Predictions of Section 2			
Hypothesis 1: ERS $\times F > 0$ (linear, full sample)	+0.0044 (0.0057)	0.250	0.749
Hypothesis 2: threshold in F (equation (14))	$\hat{\gamma} = 1.70$ pp	0.000	0.000
Hypothesis 3: hull volume falls with F	slope +0.011	1.000	1.000
Inflation-targeting threshold above non-targeting threshold	−2.51 pp	0.792	1.000
Family B. Additional tests			
ERS × KAOPEN < 0	−0.222 (0.072)	0.006	0.030
ERS × KAOPEN $\times F > 0$	+0.0241 (0.0104)	0.070	0.210
Quintile trend contrast > 0	+0.456 (0.176)	0.012	0.048
Within-economy adding-up dispersion rises with mean F	$\rho = +0.27$	0.096	0.210
Economy-specific slopes rise with mean F	$\rho = +0.07$	0.610	0.610

Notes: Family A: the predictions of Section 2 and the inflation-targeting delay. Family B: five further tests. Holm adjustment within family. One-sided p-values for directional predictions; the threshold test uses the wild-cluster bootstrap; the hull test uses the permutation p-value for a fall; the quintile trend is the stacked contrast of Table 4.

slopes.

Table 10 adjusts for multiple testing within two families. In Family A the threshold survives (Holm $p < 0.001$) and the linear interaction, the hull contraction and the inflation-targeting delay do not (Holm $p = 0.749$, 1.000 and 1.000). In Family B, ERS×KAOPEN (Holm $p = 0.030$) and the quintile trend (Holm $p = 0.048$) survive; the attenuation of the capital-mobility margin (Holm $p = 0.210$), the economy-level adding-up dispersion (0.210) and the economy-slope ordering (0.610) do not.

6. Conclusion

For an economy with an open capital account, the slope of monetary independence on exchange-rate stability equals its classical value at low regional fragmentation and falls toward zero as fragmentation rises; for an economy with a closed capital account the slope is zero at any fragmentation. The slope is −0.49 in the least fragmented

fifth of country-years and -0.01 in the most fragmented fifth.

In natural units, a rise of exchange-rate stability from 0.5 to 1.0 raises the correlation between the domestic and the base-country short-term interest rate by 0.49 at the bottom and by 0.01 at the top of the fragmentation distribution in the quintile estimates, and, for a fully open capital account, by 0.27 (s.e. 0.05) at the 10th and 0.21 (s.e. 0.05) at the 90th percentile of F in the capital model; the benchmark of Aizenman, Chinn, and Ito (2010) is 0.43. The threshold at 1.70 points marks where the ERS coefficient falls from -0.19 to -0.06; it is a boundary of attenuation and no impossibility boundary, in agreement with Remark 2.1.

The estimates are conditional slopes, and the instruments for F carry no first stage; the paper claims no causal effect of F. The linear interaction, the contraction of observed support, the reduction of mean MI above the threshold and the inflation-targeting delay of the threshold are not found. The 27 economies outside the sample lack sub-national output series; the results apply to economies with regional accounts, over 1974–2020, at annual frequency.

The classical trilemma slope is the low-fragmentation limit of a slope that falls toward zero as regions diverge. The cross-section of 58 economies identifies that limit and the scale F_0 at which the capital-mobility slope is halved, in the manner in which Lucas (1973) identifies the dependence of the output response on the variance of nominal demand.

A. Proof of Proposition 2.1 (Optimal Foreign-Rate Weight)

Welfare objective. Integration of regional squared output gaps gives

$$\theta \int_0^1 y_{it}^2 \, di = \theta\big[\bar{y}_t^2 + \mathrm{Var}_i(y_{it})\big] = \theta\left[\big\{\sigma(i_t - \bar{r}_t^*) + (\bar{\omega}/\lambda)(i_t - i_t^*)\big\}^2 + F^2\left(\sigma^2\sigma_r^2 + \frac{\chi^2}{\lambda^2}(i_t - i_t^*)^2\right)\right].$$

The constant term $\theta F^2\sigma^2\sigma_r^2$ does not depend on i_t and is dropped; the policy-relevant loss is

$$\mathcal{L}(i_t) = \theta\left[\big\{\sigma(i_t - \bar{r}_t^*) + (\bar{\omega}/\lambda)(i_t - i_t^*)\big\}^2 + \frac{\chi^2 F^2}{\lambda^2}(i_t - i_t^*)^2\right].$$

Strict convexity and unique minimizer. Differentiating twice:

$$\mathcal{L}''(i_t) = 2\theta\left(\kappa^2 + \frac{\chi^2 F^2}{\lambda^2}\right) > 0, \qquad \kappa \equiv \sigma + \frac{\bar{\omega}}{\lambda}.$$

Strict convexity implies a unique interior minimum. The first-order condition $\mathcal{L}'(i_t^{\mathrm{opt}}) = 0$ gives

$$\kappa\left[\sigma(i_t - \bar{r}_t^*) + \frac{\bar{\omega}}{\lambda}(i_t - i_t^*)\right] + \frac{\chi^2 F^2}{\lambda^2}(i_t - i_t^*) = 0.$$

Collecting i_t terms and solving yields the unique minimizer stated in equation (8) with $m(F) = \kappa\sigma\lambda^2/(\kappa^2\lambda^2 + \chi^2 F^2)$.

Strict monotonicity and lower bound. Differentiating $m(F)$ with $A \equiv \kappa\sigma\lambda^2$, $B \equiv \kappa^2\lambda^2$, $C \equiv \chi^2$:

$$m'(F) = -\frac{2ACF}{(B + CF^2)^2} < 0 \quad \forall F > 0.$$

The admissible-domain bound $C\bar{F}^2 = \chi^2\bar{F}^2 \leq \bar{\omega}(1-\bar{\omega})$ implies

$$m(\bar{F}) = \frac{A}{B + C\bar{F}^2} \geq \frac{\kappa\sigma\lambda^2}{\kappa^2\lambda^2 + \bar{\omega}(1-\bar{\omega})} > 0.$$

Interior optimum at every finite fragmentation level. At the foreign rate i_t^*, the first derivative is $\mathcal{L}'(i_t^*) = -2\theta\kappa\sigma(\bar{r}_t^* - i_t^*)$. A nonzero domestic–foreign target gap ($\bar{r}_t^* \neq i_t^*$) therefore makes the foreign rate a suboptimal policy; the minimizer $m(F)\bar{r}_t^* + [1 - m(F)]i_t^*$ lies strictly in the interior for every finite admissible F. ■

B. Data Construction and Sample

B.1 Variables

ERS, MI. Aizenman–Chinn–Ito trilemma indexes (Aizenman, Chinn, and Ito, 2010), unit interval, 1973–2020. ERS rises with exchange-rate stability against the base country; MI $= (1-\rho)/2$, with ρ the annual correlation of the short-term domestic and base-country interest rates.

KAOPEN. Chinn–Ito capital-account openness (Chinn and Ito, 2008), normalized to the unit interval, 1970–2022.

F**.** Equation (10): 100× the sample standard deviation across at least three regional units of the unobserved-components output gap (Harvey, 1989); winsorized within economy at the 1st and 99th percentiles.

$F^{(2)}$**.** Equation (11); available for 14 economies of the estimation sample.

Controls. Log real GDP per capita (WDI, constant 2015 USD); logarithm of one plus CPI inflation; trade openness (exports plus imports, percent of GDP); central bank independence (Garriga, 2016); foreign-exchange reserves (percent of GDP); continuous controls winsorized within economy at the 1st and 99th percentiles.

Dummies. Interstate or extra-state war; civil war; inflation crisis (a composite of the Reinhart–Rogoff, Bruno–Easterly and hyperinflation criteria); euro-area membership from the year of adoption; exchange-rate-regime reclassification (Ilzetzki–Reinhart–Rogoff coding through 2019 (Ilzetzki, Reinhart, and Rogoff, 2019), IMF AREAER events from 2020).

Instruments. Regional Authority Index (self-rule plus shared rule; Hooghe et al. 2016), 1950–2018; legal origin (La Porta et al., 1999).

Inflation targeting. One from the year of formal adoption of an inflation-targeting framework.

B.2 Regional Output Series

ARDECO supplies the 16 economies at the NUTS-2 level (Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, Greece, Hungary, Ireland, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden). DOSE (Wenz et al., 2023) supplies 35 economies. Direct correspondence with national statistical authorities and central banks supplies Canada (Statistics Canada), Guatemala (Banco de Guatemala), India (Ministry of Statistics and Programme Implementation), Korea (KOSIS) and Thailand (National Economic and Social Development Council). National regional accounts supply Japan (prefectural accounts, Cabinet Office) and South Africa (provincial accounts, Statistics South Africa). Where an authority published successive vintages on different bases, the vintages are joined by backchaining following the precise guidance of the authority concerned. Regional output exists for 61 of the 85 economies and regional consumer prices for 15; the remaining economies have no sub-national series, and no series is imputed.

B.3 The Eighty-Five Economies

Table 11. Economies, Status and Sources of Fragmentation

Economy	ISO	OECD	Status	Source of F	Regions	Years	Obs.
Argentina	ARG	0	No ERS or MI	–	–	–	–
Australia	AUS	1	In sample	DOSE	8	1976–2019	37

OECD: member of the 28-economy OECD sub-sample. Regions: median number of regional units in the country-years of the estimation sample. Years and observations refer to the estimation sample.

Table 11 (continued)

Economy	ISO	OECD	Status	Source of F	Regions	Years	Obs.
Austria	AUT	1	In sample	ARDECO NUTS-2	9	1980–2020	41
Bangladesh	BGD	0	No ERS or MI	–	–	–	–
Belgium	BEL	1	In sample	ARDECO NUTS-2	11	1980–2020	41
Bolivia	BOL	0	In sample	DOSE	9	1988–2019	32
Brazil	BRA	0	In sample	DOSE	27	1975–2020	36
Bulgaria	BGR	0	In sample	ARDECO NUTS-2	6	1994–2020	27
Canada	CAN	1	In sample	Statistics Canada (direct)	10	1979–2020	42
Chile	CHL	0	In sample	DOSE	13	1977–2020	44
China	CHN	0	In sample	DOSE	31	1984–2020	34
Colombia	COL	0	In sample	DOSE	32	1980–2020	41
Costa Rica	CRI	0	No sub-national output series	–	–	–	–
Croatia	HRV	0	In sample	ARDECO NUTS-2	4	1996–2014	19
Cyprus	CYP	0	No sub-national output series	–	–	–	–
Czechia	CZE	0	In sample	ARDECO NUTS-2	8	1996–2020	25
Denmark	DNK	1	In sample	ARDECO NUTS-2	5	1980–2020	41
Dominican Rep.	DOM	0	No sub-national output series	–	–	–	–
Ecuador	ECU	0	In sample	DOSE	24	1993–2020	19
Egypt	EGY	0	In sample	DOSE	26	1999–2017	12
El Salvador	SLV	0	No sub-national output series	–	–	–	–
Estonia	EST	0	In sample	DOSE	15	1996–2019	24
Finland	FIN	1	In sample	DOSE	5	1975–2020	46
France	FRA	1	In sample	DOSE	27	1973–2020	47
Germany	DEU	1	In sample	DOSE	36	1973–2020	47
Ghana	GHA	0	No sub-national output series	–	–	–	–
Greece	GRC	1	In sample	ARDECO NUTS-2	13	1980–2020	41
Guatemala	GTM	0	In sample	Banco de Guatemala (direct)	8	2013–2020	8
Honduras	HND	0	In sample	DOSE	16	1990–2004	15
Hong Kong	HKG	0	No sub-national output series	–	–	–	–
Hungary	HUN	0	In sample	ARDECO NUTS-2	8	1991–2020	30
Iceland	ISL	1	No sub-national output series	–	–	–	–
India	IND	0	In sample	MoSPI and CSO (direct)	29	1974–2020	47
Indonesia	IDN	0	In sample	DOSE	28	1983–2016	33
Ireland	IRL	1	In sample	ARDECO NUTS-2	3	1980–2020	41
Israel	ISR	0	No sub-national output series	–	–	–	–
Italy	ITA	1	In sample	DOSE	21	1973–2020	47

OECD: member of the 28-economy OECD sub-sample. Regions: median number of regional units in the country-years of the estimation sample. Years and observations refer to the estimation sample.

Table 11 (continued)

Economy	ISO	OECD	Status	Source of F	Regions	Years	Obs.
Jamaica	JAM	0	No sub-national output series	–	–	–	–
Japan	JPN	1	In sample	National regional accounts	47	1975–2020	46
Kazakhstan	KAZ	0	In sample	DOSE	14	2005–2019	15
Kenya	KEN	0	In sample	DOSE	40	1974–2020	34
Korea	KOR	1	In sample	KOSIS (direct)	16	1985–2020	36
Latvia	LVA	0	In sample	DOSE	5	2000–2018	19
Lithuania	LTU	0	Fewer than three regions	–	–	–	–
Luxembourg	LUX	1	No sub-national output series	–	–	–	–
Malaysia	MYS	0	In sample	DOSE	15	1980–2020	21
Malta	MLT	0	Fewer than three regions	–	–	–	–
Mexico	MEX	1	In sample	DOSE	32	2000–2019	20
Morocco	MAR	0	No sub-national output series	–	–	–	–
Netherlands	NLD	1	In sample	ARDECO NUTS-2	12	1981–2020	40
New Zealand	NZL	1	In sample	DOSE	15	2000–2019	20
Nicaragua	NIC	0	No sub-national output series	–	–	–	–
Nigeria	NGA	0	No sub-national output series	–	–	–	–
Norway	NOR	1	In sample	DOSE	14	1983–2019	27
Pakistan	PAK	0	In sample	DOSE	4	1982–2019	31
Panama	PAN	0	In sample	DOSE	9	1996–2019	24
Paraguay	PRY	0	In sample	DOSE	6	2001–2017	17
Peru	PER	0	In sample	DOSE	23	1974–2019	41
Philippines	PHL	0	In sample	DOSE	15	1975–2020	40
Poland	POL	1	In sample	ARDECO NUTS-2	17	1991–2020	26
Portugal	PRT	1	In sample	ARDECO NUTS-2	7	1980–2020	41
Romania	ROU	0	In sample	ARDECO NUTS-2	8	1994–2020	27
Russia	RUS	0	In sample	DOSE	82	1996–2020	24
Saudi Arabia	SAU	0	No sub-national output series	–	–	–	–
Serbia	SRB	0	No ERS or MI	–	–	–	–
Singapore	SGP	0	No sub-national output series	–	–	–	–
Slovakia	SVK	1	In sample	ARDECO NUTS-2	4	1996–2020	25
Slovenia	SVN	0	Fewer than three regions	–	–	–	–
South Africa	ZAF	0	In sample	National regional accounts	9	1996–2020	25
Spain	ESP	1	In sample	ARDECO NUTS-2	19	1980–2020	41
Sri Lanka	LKA	0	No sub-national output series	–	–	–	–

OECD: member of the 28-economy OECD sub-sample. Regions: median number of regional units in the country-years of the estimation sample. Years and observations refer to the estimation sample.

Table 11 (continued)

Economy	ISO	OECD	Status	Source of F	Regions	Years	Obs.
Sweden	SWE	1	In sample	ARDECO NUTS-2	8	1980–2020	41
Switzerland	CHE	1	In sample	DOSE	26	2008–2020	13
Tanzania	TZA	0	In sample	DOSE	20	1994–2019	20
Thailand	THA	0	In sample	NESDC (direct)	7	1995–2020	26
Trin. & Tob.	TTO	0	No sub-national output series	–	–	–	–
Türkiye	TUR	1	In sample	DOSE	26	1975–2020	46
Uganda	UGA	0	No sub-national output series	–	–	–	–
Ukraine	UKR	0	In sample	DOSE	25	1996–2020	21
United Kingdom	GBR	1	In sample	DOSE	12	1973–2020	43
United States	USA	1	Base country	–	–	–	–
Uruguay	URY	0	In sample	DOSE	5	2008–2014	7
Venezuela	VEN	0	No sub-national output series	–	–	–	–
Vietnam	VNM	0	In sample	DOSE	61	1996–2018	20
Zambia	ZMB	0	No sub-national output series	–	–	–	–

OECD: member of the 28-economy OECD sub-sample. Regions: median number of regional units in the country-years of the estimation sample. Years and observations refer to the estimation sample.

C. Additional Results

C.1 Quintiles by OECD Status

Table 12. Coefficient on Exchange-Rate Stability by Quintile of F: OECD and Non-OECD Economies

F quintile	Median F (pp)	Country-years	Economies	OECD share	Euro-area share	Mean KAOPEN	Coefficient on ERS		
							Pooled OLS	Economy FE	Pooled, no euro area
OECD economies									
1	0.37	189	20	1.00	0.19	0.84	−0.510***	−0.304**	−0.260***
							(0.050)	(0.115)	(0.079)
2	0.70	189	22	1.00	0.44	0.85	−0.545***	−0.460***	−0.365***
							(0.032)	(0.083)	(0.061)
3	1.02	188	23	1.00	0.34	0.83	−0.514***	−0.340***	−0.353***
							(0.045)	(0.079)	(0.088)
4	1.58	189	24	1.00	0.22	0.74	−0.405***	−0.253**	−0.170*
							(0.056)	(0.093)	(0.092)
5	3.09	189	22	1.00	0.15	0.69	−0.320***	−0.287**	−0.108
							(0.078)	(0.129)	(0.093)
Non-OECD economies									
1	0.72	175	19	0.00	0.01	0.50	−0.123*	−0.152	−0.085
							(0.064)	(0.104)	(0.053)
2	1.40	175	25	0.00	0.03	0.44	−0.246***	−0.235***	−0.189***
							(0.056)	(0.068)	(0.053)
3	2.35	174	28	0.00	0.03	0.46	−0.118	−0.090	−0.072
							(0.087)	(0.070)	(0.080)
4	3.69	175	24	0.00	0.01	0.46	−0.103	−0.020	−0.083
							(0.068)	(0.058)	(0.068)
5	6.75	175	25	0.00	0.00	0.45	0.006	−0.022	0.006
							(0.032)	(0.044)	(0.032)

Notes: As Table 3. Quintiles are formed within each subsample.

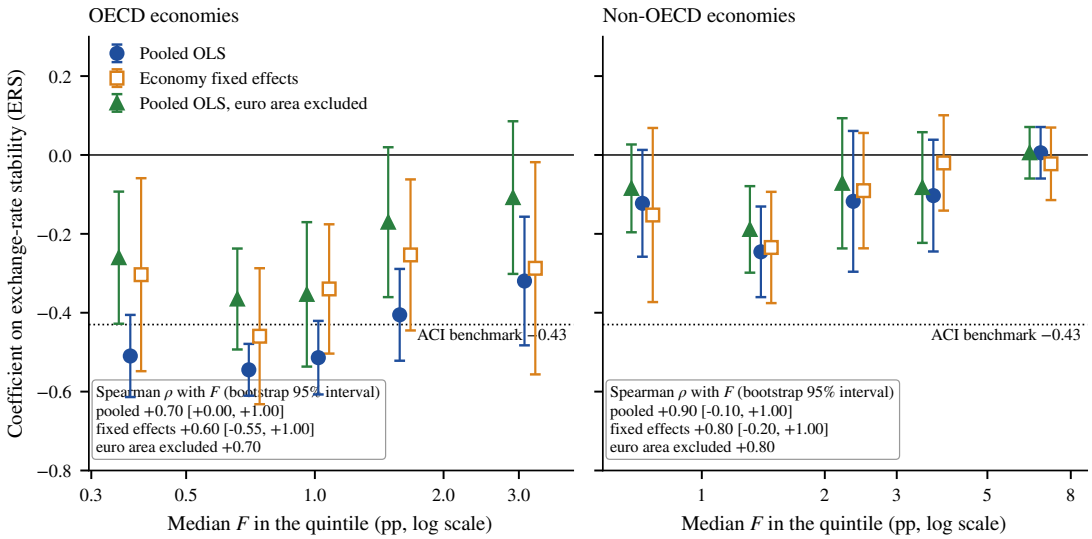


Figure 4. The coefficient on exchange-rate stability by quintile of F: OECD and non-OECD economies. Markers and bars as in Figure 1.

C.2 Interaction Models by Subsample

C.3 The Slope at Low Fragmentation

C.4 Instruments

C.5 The Two-Component Index

C.6 Illustrative Economies

Nineteen economies enter by ex ante rules on sample length, informativeness of the economy slope and real variation in ERS before euro adoption, with Brazil and China included by design. The economy slope b_i is the coefficient of MI on ERS (Newey–West standard error); the predicted slope is the leave-one-out prediction of Model 5 at the economy's mean F and mean KAOPEN; z is the standardized gap.

Table 13. Interaction Models: OECD Economies

	(1) Slopes	(2) Linear F	(3) Log F	(4) Capital	(5) Capital, linear F	(6) Capital, log F
ERS	−0.182***	−0.214***	−0.193***	−0.029	−0.100	−0.104
	(0.048)	(0.065)	(0.052)	(0.095)	(0.155)	(0.133)
KAOPEN	−0.125**	−0.155**	−0.129**	−0.017	−0.088	−0.066
	(0.057)	(0.062)	(0.055)	(0.109)	(0.134)	(0.119)
F (pp)		−0.0172*			−0.0231	
		(0.0094)			(0.0154)	
$\ln F$			−0.0679**			−0.0931*
			(0.0299)			(0.0506)
ERS $\times F$		0.0211			0.0288	
		(0.0149)			(0.0265)	
ERS $\times \ln F$			0.0661*			0.1130
			(0.0363)			(0.0804)
KAOPEN $\times F$		0.0159			0.0287	
		(0.0108)			(0.0213)	
KAOPEN $\times \ln F$			0.0267			0.0652
			(0.0362)			(0.0669)
ERS × KAOPEN				−0.232	−0.157	−0.148
				(0.140)	(0.196)	(0.169)
ERS × KAOPEN $\times F$					−0.0236	
					(0.0332)	
ERS × KAOPEN $\times \ln F$						−0.0709
						(0.0881)
Marginal effect of ERS at F = 10th percentile, KAOPEN = mean	−0.182***	−0.207***	−0.259***	−0.213***	−0.221***	−0.277***
	(0.048)	(0.062)	(0.076)	(0.051)	(0.061)	(0.076)
at F = 90th percentile, KAOPEN = mean	−0.182***	−0.150***	−0.120**	−0.213***	−0.195***	−0.158***
	(0.048)	(0.045)	(0.049)	(0.051)	(0.048)	(0.050)
Marginal effect of ERS at F = 10th percentile, KAOPEN = 1				−0.260***	−0.255***	−0.293***
				(0.070)	(0.079)	(0.091)
at F = 90th percentile, KAOPEN = 1				−0.260***	−0.242***	−0.205***
				(0.070)	(0.069)	(0.069)
Wild-cluster bootstrap p, headline interaction	–	0.210	–	0.170	0.501	–
Country-years	936	936	936	936	936	936
Economies	25	25	25	25	25	25
Within R^2	0.271	0.276	0.282	0.276	0.280	0.286

Notes: As Table 5.

Table 14. Interaction Models: Non-OECD Economies

	(1) Slopes	(2) Linear F	(3) Log F	(4) Capital	(5) Capital, linear F	(6) Capital, log F
ERS	−0.060*	−0.073	−0.095*	−0.025	0.041	0.022
	(0.034)	(0.047)	(0.053)	(0.042)	(0.061)	(0.072)
KAOPEN	−0.080***	−0.115***	−0.152***	−0.034	0.008	−0.012
	(0.028)	(0.031)	(0.035)	(0.059)	(0.066)	(0.084)
F (pp)		−0.0060*			0.0013	
		(0.0030)			(0.0042)	
$\ln F$			−0.0559**			−0.0202
			(0.0209)			(0.0299)
ERS $\times F$		0.0015			−0.0150	
		(0.0067)			(0.0093)	
ERS $\times \ln F$			0.0318			−0.0400
			(0.0327)			(0.0483)
KAOPEN $\times F$		0.0078*			−0.0053	
		(0.0042)			(0.0071)	
KAOPEN $\times \ln F$			0.0788***			0.0003
			(0.0278)			(0.0613)
ERS × KAOPEN				−0.100	−0.263**	−0.291**
				(0.099)	(0.110)	(0.138)
ERS × KAOPEN $\times F$					0.0273**	
					(0.0111)	
ERS × KAOPEN $\times \ln F$						0.1526
						(0.0965)
Marginal effect of ERS at F = 10th percentile, KAOPEN = mean	−0.060*	−0.071	−0.106	−0.072*	−0.084*	−0.126**
	(0.034)	(0.044)	(0.063)	(0.037)	(0.046)	(0.059)
at F = 90th percentile, KAOPEN = mean	−0.060*	−0.062*	−0.034	−0.072*	−0.097***	−0.054
	(0.034)	(0.035)	(0.035)	(0.037)	(0.035)	(0.033)
Marginal effect of ERS at F = 10th percentile, KAOPEN = 1				−0.125	−0.213**	−0.309**
				(0.078)	(0.082)	(0.118)
at F = 90th percentile, KAOPEN = 1				−0.125	−0.139**	−0.054
				(0.078)	(0.064)	(0.073)
Wild-cluster bootstrap p, headline interaction	–	0.802	–	0.329	0.058	–
Country-years	858	858	858	858	858	858
Economies	33	33	33	33	33	33
Within R^2	0.090	0.096	0.111	0.091	0.105	0.119

Notes: As Table 5.

Table 15. Sixteen Estimators of the Slope at Low Fragmentation

Estimator	Sample	Coefficient on ERS (s.e.)	p: equal to 0	p: equal to −0.43
Lowest F quintile, pooled OLS	Full	−0.492*** (0.040)	0.0000	0.1339
Lowest F quintile, economy FE	Full	−0.367*** (0.060)	0.0000	0.3019
Lowest F quintile, pooled, no euro area	Full	−0.178*** (0.057)	0.0039	0.0001
Lowest F quintile, pooled OLS	OECD	−0.510*** (0.050)	0.0000	0.1259
Lowest F quintile, economy FE	OECD	−0.304** (0.115)	0.0184	0.2880
Lowest F quintile, pooled, no euro area	OECD	−0.260*** (0.079)	0.0044	0.0475
Bottom decile of F, pooled OLS	Full	−0.422*** (0.060)	0.0000	0.8902
Bottom decile of F, pooled, no euro area	Full	−0.200*** (0.052)	0.0009	0.0002
Linear interaction model, effect at $F = 0$	Full	−0.126*** (0.038)	0.0017	0.0000
Linear interaction model, effect at 10th percentile of F	Full	−0.124*** (0.036)	0.0012	0.0000
Capital model, 10th percentile of F, KAOPEN = 1	Full	−0.271*** (0.053)	0.0000	0.0040
Capital model, $F = 0$, KAOPEN = 1	Full	−0.277*** (0.054)	0.0000	0.0067
Linear interaction model, effect at $F = 0$	OECD	−0.214*** (0.065)	0.0032	0.0031
Linear interaction model, effect at 10th percentile of F	OECD	−0.207*** (0.062)	0.0026	0.0013
Capital model, 10th percentile of F, KAOPEN = 1	OECD	−0.255*** (0.079)	0.0037	0.0379
Capital model, $F = 0$, KAOPEN = 1	OECD	−0.257*** (0.083)	0.0049	0.0485

Notes: Dependent variable: MI. Standard errors clustered by economy. The linear-model rows report the marginal effect of ERS at mean KAOPEN; the capital-model rows report it at KAOPEN = 1. The last column tests equality with the benchmark −0.43.

Table 16. Instrumental-Variable Estimates of the ERS×F Interaction

Specification	$\hat{\beta}$ on ERS ×F (s.e.)	First-stage F, ERS ×F	First-stage F, KAOPEN ×F	Anderson–Rubin p	Overidentification p	Country-years (economies)
OLS, sample with RAI	+0.021 (0.009)	–	–	–	–	1,473 (46)
IV, RAI instruments	+0.513 (1.907)	0.41	0.58	0.290	–	1,473 (46)
OLS, sample with RAI and legal origin	+0.020 (0.009)	–	–	–	–	1,269 (46)
IV, RAI and legal-origin instruments	−0.018 (0.058)	0.99	3.35	0.225	0.142	1,269 (46)

Notes: Instruments: ERS and KAOPEN interacted with the Regional Authority Index, and with legal-origin indicators in the second IV row. Economies without the index are dropped. The Anderson–Rubin test is robust to weak instruments.

Table 17. Coefficient on Exchange-Rate Stability by Tercile of $F^{(2)}$: Economies with Regional Prices

Tercile of $F^{(2)}$	Median $F^{(2)}$ (pp)	Country-years	Economies	Mean KAOPEN	Pooled OLS	Economy FE
1	2.69	104	9	0.74	0.118 (0.068)	0.064 (0.217)
2	4.78	103	13	0.65	−0.036 (0.095)	−0.071 (0.234)
3	11.18	103	12	0.41	−0.054 (0.046)	0.001 (0.046)

Notes: 14 economies with regional consumer prices (310 country-years); equation (11). Terciles are equal-count. Standard errors clustered by economy. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$. The subsample has no low-$F^{(2)}$ support: its lowest tercile has median $F^{(2)}$ above the full-sample median of F.

Table 18. Illustrative Economies: Slopes and Model Fit

Economy	Group	Years	Obs.	Mean F (pp)	Mean KAOPEN	Slope b_i (s.e.)	Predicted slope	z
Sweden	Advanced, own currency	1980–2020	41	0.41	0.89	−0.127 (0.314)	−0.235	+0.34
Czechia	Advanced, own currency	1996–2020	25	0.69	0.87	−0.152 (0.121)	−0.227	+0.59
Denmark	Advanced, own currency	1980–2020	41	0.70	0.87	−0.341 (0.344)	−0.229	−0.32
Japan	Advanced, own currency	1975–2020	46	0.98	0.95	+0.483 (0.290)	−0.273	+2.58
Canada	Advanced, own currency	1979–2020	42	1.00	1.00	−0.234 (0.238)	−0.263	+0.12
Australia	Advanced, own currency	1976–2019	37	1.32	0.83	−0.608 (0.454)	−0.210	−0.87
Korea	Advanced, own currency	1985–2020	36	2.56	0.50	−0.048 (0.142)	−0.114	+0.45
United Kingdom	Advanced, own currency	1973–2020	44	2.57	0.88	+0.333 (0.256)	−0.227	+2.16
Türkiye	OECD, own currency	1975–2020	46	2.10	0.25	+0.096 (0.102)	−0.050	+1.37
Poland	OECD, own currency	1991–2020	30	3.42	0.39	+0.230 (0.409)	−0.094	+0.79
France	Euro area, pre-adoption	1973–1998	26	1.18	0.55	+0.161 (0.097)	−0.137	+2.94
Italy	Euro area, pre-adoption	1973–1998	26	1.51	0.44	−0.199 (0.097)	−0.100	−0.98
Finland	Euro area, pre-adoption	1975–1998	24	4.16	0.76	−0.269 (0.094)	−0.171	−0.98
Bulgaria	Non-OECD	1994–2020	27	0.87	0.61	−0.371 (0.115)	−0.144	−1.90
China	Non-OECD	1984–2020	37	1.10	0.14	−0.077 (0.056)	−0.003	−1.10
Philippines	Non-OECD	1975–2020	46	2.22	0.33	−0.110 (0.147)	−0.068	−0.28
Chile	Non-OECD	1977–2020	44	2.46	0.43	+0.004 (0.100)	−0.108	+1.08
Brazil	Non-OECD	1975–2020	38	3.07	0.20	−0.112 (0.106)	−0.034	−0.71
Ukraine	Non-OECD	1996–2020	25	3.52	0.08	+0.089 (0.091)	−0.031	+1.23

Notes: Euro-area economies: years before adoption.

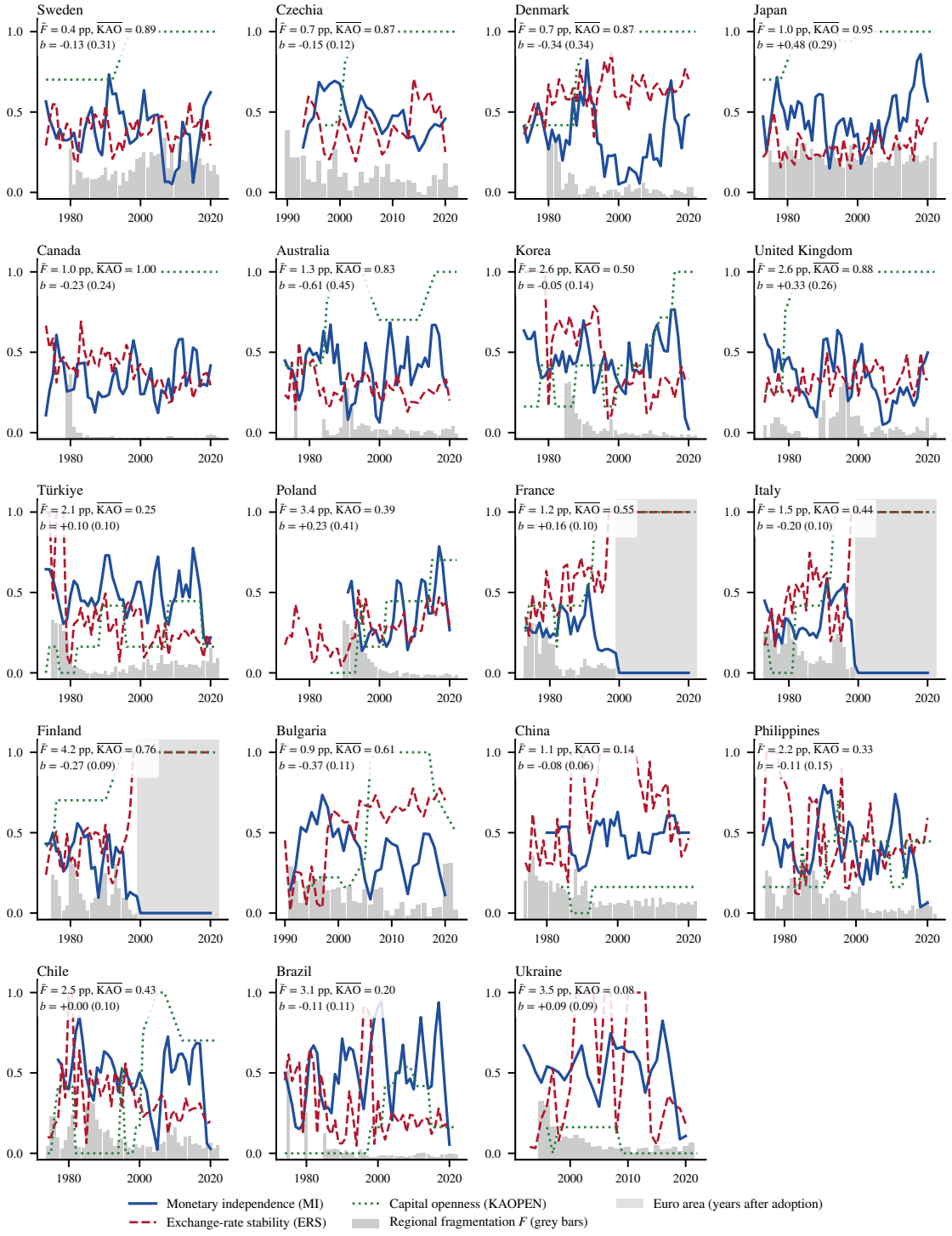


Figure 5. Monetary independence, exchange-rate stability, capital openness and regional fragmentation in the 19 illustrative economies. Notation as in Figure 3.

References

Aizenman, J., M. D. Chinn, and H. Ito (2010). The emerging global financial architecture. *Journal of International Money and Finance* 29(4): 615–641.

Anderson, T. W., and H. Rubin (1949). Estimation of the parameters of a single equation in a complete system of stochastic equations. *Annals of Mathematical Statistics* 20(1): 46–63.

Barber, C. B., D. P. Dobkin, and H. Huhdanpaa (1996). The Quickhull algorithm for convex hulls. *ACM Transactions on Mathematical Software* 22(4): 469–483.

Brown, M. B., and A. B. Forsythe (1974). Robust tests for the equality of variances. *Journal of the American Statistical Association* 69(346): 364–367.

Cameron, A. C., J. B. Gelbach, and D. L. Miller (2008). Bootstrap-based improvements for inference with clustered errors. *Review of Economics and Statistics* 90(4): 414–427.

Chinn, M. D., and H. Ito (2008). A new measure of financial openness. *Journal of Comparative Policy Analysis* 10(3): 309–322.

Fleming, J. M. (1962). Domestic financial policies under fixed and under floating exchange rates. *IMF Staff Papers* 9(3): 369–380.

Frankel, J. A., and A. K. Rose (1998). The endogeneity of the optimum currency area criteria. *Economic Journal* 108(449): 1009–1025.

Garriga, A. C. (2016). Central bank independence in the world. *International Interactions* 42(5): 849–868.

Hansen, B. E. (1999). Threshold effects in non-dynamic panels. *Journal of Econometrics* 93(2): 345–368.

Harvey, A. C. (1989). *Forecasting, Structural Time Series Models and the Kalman Filter*. Cambridge University Press.

Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics* 6(2): 65–70.

Hooghe, L., G. Marks, A. H. Schakel, S. Chapman Osterkatz, S. Niedzwiecki, and S. Shair-Rosenfield (2016). *Measuring Regional Authority, Vol. I*. Oxford University Press.

Ilzetzki, E., C. M. Reinhart, and K. S. Rogoff (2019). Exchange arrangements entering the twenty-first century: Which anchor will hold? *Quarterly Journal of Economics* 134(2): 599–646.

Klein, M. W., and J. C. Shambaugh (2015). Rounding the corners of the policy trilemma. *American Economic Journal: Macroeconomics* 7(4): 33–66.

La Porta, R., F. Lopez-de-Silanes, A. Shleifer, and R. Vishny (1999). The quality of government. *Journal of Law, Economics, and Organization* 15(1): 222–279.

Lucas, R. E., Jr. (1973). Some international evidence on output-inflation tradeoffs. *American Economic Review* 63(3): 326–334.

Mundell, R. A. (1963). Capital mobility and stabilization policy under fixed and flexible exchange rates. *Canadian Journal of Economics and Political Science* 29(4): 475–485.

Newey, W. K., and K. D. West (1987). A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica* 55(3): 703–708.

Obstfeld, M., J. C. Shambaugh, and A. M. Taylor (2005). The trilemma in history. *Review of Economics and Statistics* 87(3): 423–438.

Rey, H. (2015). Dilemma not trilemma. NBER Working Paper 21162.

Stravelas, E. D. (2026). The reach of monetary policy. *Working Paper*.

Wenz, L., R. D. Carr, N. Kögel, M. Kotz, and M. Kalkuhl (2023). DOSE—Global data set of reported sub-national economic output. *Scientific Data* 10: 425.