

A Formal Model of Crisis-Led Integration with a Queryable Simulation Interface

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Abstract

The model formalises crisis-led integration in the European Union as a dynamic outcome of crisis pressure, interdependence, domestic crisis-resolution capacity, sovereignty pressure, political mobilisation, supranational identification, and institutional adjustment. The central claim is that crisis intensity and crisis distribution jointly shape institutional change. Symmetric crises create common pressure for integration and generate stair-like increases in supranational authority. Asymmetric crises create weaker and slower adjustment because crisis dispersion lowers the speed with which aggregate demand becomes institutional change. The formalisation permits systematic queries across crisis symmetry, degrees of asymmetry, domestic capacity, mobilisation, identification, and sovereignty-sensitive policy fields.

Keywords: European integration; crisis; formal model; simulation; politicisation; sovereignty

AI usage disclosure. The author used OpenAI models in the Codex environment to support equation development, model auditing, simulation verification, and language editing. All modelling choices, interpretations, and responsibility for the article remain with the author.

1. Introduction

Crises occupy a central position in European integration theory because they reveal the limits of existing governance arrangements. They raise the cost of relying on national instruments, expose cross-border interdependence, and create pressure for institutional innovation at the European level. The recurrent observation that Europe advances through crisis requires a precise account of the political and functional conditions under which this pressure becomes integration.

The model represents integration as a bounded stock that changes over discrete periods. At each period, countries experience crisis pressure, absorb part of that pressure through domestic instruments, evaluate the sovereignty costs of further delegation, and participate in an institutional aggregation process. Integration advances when aggregate demand for integration is positive and when the institutional system can translate that demand into actual change. This specification makes the crisis mechanism explicit enough to compare counterfactual trajectories under common and asymmetric shocks.

The key theoretical move is to distinguish the intensity of a crisis from its distribution. A severe crisis can generate limited integration when costs are concentrated among a small group of member states. A more symmetric crisis creates common exposure and faster political translation. Crisis-led integration therefore depends on the symmetry of exposure, the capacity of member states to respond domestically, the degree of politicisation, the level of supranational identification, and the sovereignty sensitivity of the affected field.

The contribution is conceptual and methodological. Conceptually, the model specifies how functional pressure, domestic capacity, sovereignty costs, mobilisation, identification, and institutional rules interact over time. Methodologically, the formalisation permits controlled comparisons that are difficult to express verbally: the same shock can be made more symmetric or asymmetric, domestic capacity can be increased, mobilisation can be strengthened, identification can be varied, and the affected field can be made more or less sovereignty-sensitive.

The simulations use a deliberately restricted specification centred on exogenous crisis pressure and political translation. Under this calibration, symmetric crises produce stair-like increases in integration. The impulse associated with each crisis window is temporary, and the level of integration stabilises until a new shock occurs. Highly asymmetric crises produce smaller and slower increases. Domestic reaction capacity and sovereignty-sensitive policy fields dampen integration. EU identification increases integration by weakening the anti-integration force of mobilisation. Crisis-induced mobilisation has a more modest effect in the reported calibration, which is visible in endpoint comparisons and modest graphical separation.

The model is positioned at the intersection of neofunctionalism, intergovernmentalism, historical institutionalism, and postfunctionalist integration theory. These approaches explain different components of crisis-led integration: functional spillovers, bargaining among governments, path-dependent institutional constraints, and politicised resistance to delegation. The model links these components in a dynamic specification

in which crisis pressure generates demand for integration, while domestic capacity, sovereignty sensitivity, mobilisation, identification, and institutional rules condition political translation.

The functional side of the model draws on classic neofunctionalist arguments about spillover, interdependence, and incremental institutional change (Haas 1958; Lindberg 1963; Schmitter 1970). It also follows later work that treats crises as moments in which incomplete integration can generate demand for further institutional development (Schmitter and Lefkofridi 2015; Jones, Kelemen and Meunier 2016, 2021; Nicoli 2019, 2020). The model separates crisis intensity from crisis distribution because a shock can be severe without being politically common. This distinction connects crisis-led integration to the empirical difference between symmetric shocks, asymmetric shocks, and policy-specific spillovers.

The political-translation side of the model links liberal intergovernmentalism and postfunctionalism. Governments aggregate domestic preferences under constraints shaped by exposure, fiscal capacity, party competition, and public mobilisation (Moravcsik 1998, 2018; Hooghe and Marks 2009; Schimmelfennig 2014, 2018). Legitimacy and politicisation matter because functional pressure can generate resistance to delegation when the affected field is sovereignty-sensitive. The model operationalises this mechanism through status-quo pressure, mobilisation, and supranational identification. Mobilisation raises the political cost of delegation when crisis pressure becomes sovereignty-salient; identification reduces this cost when the crisis is experienced as a shared European problem.

The policy-field component is grounded in the literature on core state powers and the movement from market integration to fiscal, social, health, defence, and industrial-policy capacities (Genschel and Jachtenfuchs 2016, 2018; Kuhn and Nicoli 2020; Kelemen and McNamara 2022). This literature motivates the sovereignty-sensitivity parameter. Delegation in regulatory fields is modelled as less politically intrusive than delegation in taxation, fiscal capacity, defence, migration, or democratic control. The same crisis intensity can therefore produce different integration paths depending on the institutional field in which the shock occurs.

Recent empirical work supports the model's conditioning mechanisms. Public support for EU fiscal capacity and unemployment-risk sharing varies with policy design, deservingness, identity, and crisis context (Beetsma et al. 2022; Burgoon et al. 2022; Bremer et al. 2024; Nicoli, Kuhn and Burgoon 2020). Work on medicines procurement, defence cooperation, energy security, and joint public procurement shows that crisis response increasingly concerns European public goods across heterogeneous policy fields (Beetsma et al. 2021; Burgoon, Van der Duin and Nicoli 2023; Nicoli 2023; Beetsma and Nicoli 2024). These findings motivate the model's distinction between general integration pressure and field-specific sovereignty pressure.

The modelling strategy follows the logic of formal and simulation-based mechanism clarification, using simulated counterfactual variations to isolate the contribution of each theoretical channel (Axelrod 1997; Epstein 2008). In EU integration research, this strategy is useful because several mechanisms operate simultaneously: interdependence creates pressure, domestic capacity absorbs part of the shock, politicisation affects sovereignty

costs, and institutions determine adjustment speed. The model therefore provides a disciplined representation of how functional pressure becomes institutional adaptation under political constraints.

2. General Theory

The model starts from a simple mechanism. Crisis pressure raises the cost of remaining at the national level. Interdependence increases the likelihood that national responses are insufficient, because shocks travel across borders, unilateral decisions impose externalities, and policy areas become functionally connected. These functional pressures create incentives for deeper cooperation and, potentially, for additional supranational authority.

Political translation is the second part of the mechanism. Member states may experience a functional need for integration and still face strong sovereignty costs. Delegation affects policy domains unequally. Integration in market-regulatory fields is usually less sovereignty-sensitive than integration in fiscal, security, migration, or democratic-control domains. The model therefore treats the policy field as part of preference formation.

Domestic reaction capacity is the third part of the mechanism. States with larger fiscal and administrative resources can absorb a larger share of the shock through national instruments. Such capacity reduces the pressure for supranational solutions. At the same time, integration and interdependence reduce the unilateral toolbox available to national governments. Domestic capacity is therefore constrained by the institutional setting in which the crisis occurs.

Mobilisation and identification provide the sociopolitical channel. Crises activate publics and parties because they expose mismatches between pressure and institutional response. Mobilisation can raise the salience of sovereignty and increase resistance to delegation. Supranational identification can offset this effect because citizens who perceive benefits from integration, or who experience the crisis as a shared European event, are less likely to interpret delegation as a loss of control.

Institutional rules shape the final translation of national demands into realised integration. The model distinguishes three aggregation rules. The weighted-majority rule aggregates country demands through political weights. The QMV threshold approximation adds the Council's double-threshold logic, requiring a sufficiently broad coalition of member states and population before positive or negative aggregate demand is transmitted. Unanimity gives blocking power to the least supportive member state when preferences are mixed. Crisis symmetry matters because common exposure reduces political dispersion and accelerates adjustment, while asymmetric exposure increases bargaining frictions and slows institutional movement.

These mechanisms yield four expectations. First, symmetric crises should produce larger and faster integration than asymmetric crises. Second, greater domestic reaction capacity should dampen the integration response. Third, stronger supranational identification should weaken mobilisation-based resistance; its system-level effect

remains conditional on aggregation thresholds and feedback. Fourth, crises in high-sovereignty fields should produce weaker integration than crises in lower-sovereignty fields.

3. Parameters and Formal Model

Table 1 defines the model quantities before the equations are introduced. Baseline and scenario-specific values appear in Appendix A. The model contains eleven behavioural parameters. Crisis exposure, country identification, sovereignty predisposition, national reaction capacity, political weights, population, and bilateral exposure can be populated with observed data.

Table 1. Model parameters and inputs.

Natural-language name	Concise definition	Role in the model	Notation	Equations
Crisis-pressure translation	Conversion of unresolved crisis pressure into integration pressure.	Scales functional pressure before domestic political resistance is applied.	α^{CP}	6
Ecological interdependence	Strength of cross-border crisis transmission.	Scales the weighted effect of foreign shocks.	I^e	4
Domestic reaction capacity	Effectiveness of the residual national policy toolbox.	Subtracts crisis pressure that countries can absorb nationally.	C^d	6
Supranational democratic control	Democratic legitimacy available at EU level.	Reduces resistance to delegation.	D	10
Output legitimacy	Political reassurance produced by existing integration.	Reduces status-quo pressure as integration delivers benefits.	L	10
Integration-linked identification	Rate at which existing integration raises EU identification.	Adds an integration-indexed increment to country identification.	η^I	9
Exposure-homogeneity identification	Rate at which similar national exposure raises EU identification.	Adds an increment that grows as exogenous-shock dispersion falls.	η^S	9
Policy-field sovereignty	Proximity of the affected field to core state powers.	Raises sovereignty pressure and scales political mobilisation.	p	7-8, 10
Baseline mobilisation	Ordinary political activation surrounding authority in the field.	Sets mobilisation before crisis-induced activation.	m_0	8
Crisis-induced mobilisation	Responsiveness to the pressure-adjustment mismatch.	Raises mobilisation when institutional movement diverges from crisis pressure.	κ	8
EU resolution effectiveness	Effectiveness of existing EU instruments in absorbing a shock.	Attenuates direct crisis exposure in proportion to existing integration.	x	2
Initial integration	Integration stock at the beginning of the simulation.	Anchors the simulated path.	I_0	1 (initial condition)
Crisis exposure	Country-period intensity of the external shock.	Supplies direct crisis input and the identification-homogeneity term.	$CP^{ex}(c,t)$	2, 4, 9
EU identification	Country attachment to the European Union.	Moderates mobilisation-based resistance and evolves between periods.	$E_-(c,t)$	9-10

Sovereignty predisposition	Country propensity to defend national control.	Scales resistance in sovereignty-sensitive fields; held fixed in reported runs.	s_c	10
National fiscal capacity	Country allocation of fiscal-economic crisis capacity.	Distributes domestic reaction capacity across countries.	F_c	5-6
Bilateral exposure	Country c's exposure to pressure in country k.	Determines the network through which shocks propagate.	w_(c,k)	3
Political weight	Country influence in institutional aggregation.	Weights demand under weighted aggregation and QMV.	omega^pol_c	12-13
Population share	Country share of the EU population.	Determines whether the QMV population threshold is met.	pi_c	13
Membership size	Number of member states in the system.	Affects QMV thresholds and adjustment speed.	C	13, 15
Relative crisis asymmetry	Dispersion relative to mean absolute unresolved pressure.	Reduces adjustment speed continuously as pressure becomes more uneven.	A_t	15

3.1 Setup and model quantities

Integration is a bounded stock of supranational authority. The lower bound denotes the absence of authority in the relevant domain; the upper bound denotes the maximum admitted by the scale. Bounding the stock prevents simulated shocks from producing institutionally meaningless values.

$$I_t \in [0,1] \quad (1)$$

Ecological interdependence measures how strongly crisis pressure crosses national borders. Domestic reaction capacity measures how effectively member states can absorb pressure with national instruments. Supranational democratic control captures the legitimacy supplied by EU-level accountability, while output legitimacy captures the reassurance produced by the benefits of existing integration. Each construct enters the model once, so its name corresponds directly to its function in the equations.

EU identification is a bounded country-level stock. Its initial value is observed, while its subsequent path responds to existing integration and to the similarity of exogenous crisis exposure across countries. Sovereignty predisposition remains fixed over the simulation horizon, so the dynamic comparison isolates identification.

3.2 Crisis pressure, spillovers, and domestic absorption

Existing integration attenuates the direct shock before it generates demand for new authority. The attenuation is multiplicative because institutional capacity changes the effective magnitude of exposure: it has no independent effect when the shock is zero and removes a larger absolute amount when exposure is high.

$$CP_{c,t}^{\text{eff}} = CP_{c,t}^{\text{ex}} \max \{0, 1 - x I_t\} \quad (2)$$

Cross-border spillovers are proportional to the weighted effective pressure experienced by other countries. Multiplication by ecological interdependence scales the intensity of transmission, while the bilateral network determines where pressure travels.

$$CP_{c,t}^{spill} = \sum_{k \neq c} w_{c,k} CP_{k,t}^{eff} \quad (3)$$

Total crisis pressure adds direct exposure, propagated exposure, and unresolved pressure inherited from the preceding period. Additivity permits distinct sources of functional demand to accumulate. The residual term is reduced by the previous institutional change, giving reform a problem-solving effect, while the maximum operator prevents reform from creating negative crisis pressure. Here, Delta I at t equals I at t minus I at t minus one; Delta I at zero is zero; and unresolved pressure before the first period is zero.

$$\begin{aligned} Q_{c,t} &= CP_{c,t}^{eff} + I^e CP_{c,t}^{spill} + U_{c,t} \\ U_{c,t} &= \max(0, Q_{c,t-1} - \Delta I_{t-1}) \end{aligned} \quad (4)$$

National reaction capacity is allocated according to economic size and inverse debt burden. Placing debt in the denominator gives more capacity to countries with lower debt, conditional on size, and avoids negative fiscal-space values when debt exceeds annual GDP. Normalisation keeps the country weights summing to one.

$$F_c = \frac{\frac{g_c}{b_c}}{\sum_h \frac{g_h}{b_h}} \quad (5)$$

The residual national toolbox is larger when less authority has already been transferred. The product $(1-I_t)F_c$ therefore scales country capacity by the institutional room for autonomous action. Subtraction is appropriate because national absorption satisfies part of the functional demand that might otherwise require EU action.

$$P_{c,t} = \alpha^{CP} Q_{c,t} - C^d (1 - I_t) F_c \quad (6)$$

3.3 Mobilisation, sovereignty, and country demand

Policy fields differ in their proximity to core state powers. The effective sovereignty sensitivity of the field increases with the latest institutional change. Multiplication by $(1+\Delta I_t)$ makes rapid delegation temporarily more salient without introducing a separate additive source of resistance.

$$p_t = p(1 + \Delta I_t) \quad (7)$$

Mobilisation contains a baseline component and a short-run response to the mismatch between integration pressure and realised institutional movement. The absolute value permits mobilisation when adjustment is either insufficient or unusually rapid. The full bracket is multiplied by policy-field sovereignty because political activation is more consequential in core-state domains.

$$M_{c,t} = [m_0 + \kappa |\Delta_{It} - P_{c,t}|] p_t \quad (8)$$

EU identification is updated before it enters the following period. The first additive term links identification to the existing integration stock. The second links it to the homogeneity of exogenous exposure: lower cross-country dispersion generates a larger increment. After this update, values are bounded to the 0-1 interval. Because the homogeneity term depends on dispersion rather than crisis intensity, uniformly zero exposure also produces a positive increment.

$$E_{c,t+1} = E_{c,t} + \eta^I I_t + \eta^S h_t \quad (9)$$

$$h_t = 1 - \text{sd}(\text{CP}_t^{\text{ex}})$$

Status-quo pressure combines fixed country sovereignty predisposition, democratic control, mobilisation, current-period identification, and output legitimacy. Products are used where one quantity conditions another: sovereignty sensitivity raises resistance among sovereignty-minded countries, while mobilisation generates more resistance where EU identification is low. Democratic control and perceived benefits enter negatively because they lower the political cost of delegation. The lower bound preserves status-quo pressure as a blocking force.

$$H_{c,t} = \max(0, A_{c,t}^S + B_{c,t}^M) \quad (10)$$

$$A_{c,t}^S = s_c p_t - D$$

$$B_{c,t}^M = M_{c,t} (1 - E_{c,t}) - L I_t$$

Country demand is the difference between functional pressure and resistance to delegation. Retaining the signed difference allows the model to represent both integration and disintegration within the bounded stock.

$$G_{c,t} = P_{c,t} - H_{c,t} \quad (11)$$

3.4 Aggregation and institutional adjustment

Under weighted aggregation, national demands are summed using normalised political weights. This is a continuous aggregation rule rather than a legal majority threshold: it represents the direction and intensity of politically weighted demand.

$$G_t^W = \sum_c \omega_c^{\text{pol}} G_{c,t} \quad (12)$$

The QMV option is a threshold approximation. Let S with a plus superscript denote countries with positive demand, S with a minus superscript countries with negative demand, and q_C the larger of 0.55 and $15/C$. Positive or negative demand is transmitted only when the corresponding coalition clears q_C and represents at least 65 per cent of the population. The implementation does not reproduce the four-state blocking-minority exception; the label therefore distinguishes the approximation from the complete legal rule. In Equation 13, the indicator function equals one when its condition is met and zero otherwise; the superscript r denotes either the positive or negative coalition.

$$\begin{aligned}
W_t^r &= \sum_{c \in S_t^r} \omega_c^{\text{pol}} G_{c,t} \\
\Pi_t^r &= \sum_{c \in S_t^r} \pi_c, \pi^* = 0.65 \\
A_t^r &= 1 \left\{ \frac{|S_t^r|}{C} \geq q_C \right\} \times 1 \{ \Pi_t^r \geq \pi^* \} \\
T_t^r &= A_t^r W_t^r \\
G_t^{\text{QMV}} &= T_t^+ + T_t^-
\end{aligned} \tag{13}$$

Under unanimity, collective demand follows a sign-consensus rule. The weakest supporter determines positive movement, the least negative opponent determines disintegration, and mixed signs produce no change. This gives each country veto power over movement in either direction.

$$\begin{aligned}
U_t^+ &= 1 \{ \min_c G_{c,t} \geq 0 \} \min_c G_c, \\
U_t^- &= 1 \{ \max_c G_{c,t} \leq 0 \} \max_c G_c \\
G_t^U &= U_t^+ + U_t^-
\end{aligned} \tag{14}$$

Institutional adjustment speed depends on membership size, the voting rule, and relative crisis asymmetry. Relative asymmetry compares the cross-country dispersion of unresolved pressure with its mean absolute magnitude. Dividing dispersion by the sum of mean pressure and dispersion bounds the measure between zero and one and makes it invariant to common rescaling. Relative asymmetry is set to zero when both mean pressure and dispersion are zero. The voting-rule factor equals two under weighted aggregation and QMV and one under unanimity. Multiplication by one minus relative asymmetry slows adjustment continuously without turning uneven exposure into an additional veto. Under unanimity, mixed national demand signs can still produce stasis through Equation 14.

$$\begin{aligned}
A_t &= \frac{\text{sd}(Q_t)}{\text{mean}(|Q_t|) + \text{sd}(Q_t)} \\
\lambda_t &= \frac{v_r}{C} (1 - A_t)
\end{aligned} \tag{15}$$

Realised integration equals the inherited stock plus the product of aggregate demand and adjustment speed. Multiplication is appropriate because λ is the share of politically aggregated demand translated into institutional change. The external bounds preserve the 0-1 interpretation of the stock.

$$I_{t+1} = I_t + \lambda_t G_t^r \quad (16)$$

4. Simulation Design

The simulations use one common calibration. Each parameter-family exercise changes one theoretical quantity at a time; the final postfunctionalist scenario deliberately combines field sovereignty and mobilisation. The baseline shock is 0.05 and occurs in periods 4-6, 14-16, and 24-26. Integration begins at 0.300. The baseline compares no crisis, a symmetric crisis affecting all twenty-seven countries, and an asymmetric crisis affecting three countries. The additional simulations vary interdependence, the number of affected countries, domestic reaction capacity, crisis-induced mobilisation, EU identification, the sovereignty sensitivity of the affected field, and the voting rule. EU identification evolves in the principal simulations; Appendix B holds it fixed as a sensitivity test. Sovereignty predisposition is fixed in both versions. Integration is bounded at one; sufficiently long or intense sequences under weighted aggregation or QMV can therefore reach the ceiling, after which additional pressure is no longer visible in the integration path.

GDP shares and inverse debt burdens determine national reaction-capacity weights. Political weights enter weighted aggregation, while population shares determine the QMV population threshold. Initial EU identification is the percentage feeling very or fairly attached to the European Union in Standard Eurobarometer 104.1, Autumn 2025, question QC1_3. Sovereignty predisposition uses hard-Eurosceptic vote shares derived from CHES. Luxembourg has no CHES 2024 entry and uses the global baseline value of 0.10. Bilateral spillover weights are uniform, leaving the exogenous shock distribution as the source of asymmetry.

Initial EU identification varies across countries and evolves through Equation 9. The integration-linked increment assumes that accumulated authority strengthens EU attachment. The exposure-homogeneity increment assumes that similar national shocks strengthen attachment; because it depends on dispersion rather than mean crisis intensity, it is also positive under uniformly zero exposure. Country sovereignty predispositions remain fixed, while sovereignty-related pressure still varies with policy-field sensitivity and mobilisation.

5. Simulation Results

Table 2 reports selected endpoints. The figures show the complete paths and distinguish all scenarios through greyscale shades and line types.

Table 2. Selected simulation endpoints under the common calibration.

Scenario	Exposure	Rule	Final integration	Change
Baseline	None	Weighted	0.297	-0.003
Baseline	Symmetric	Weighted	0.664	+0.364
Baseline	Asymmetric	Weighted	0.405	+0.105
High interdependence	Symmetric	Weighted	0.843	+0.543
High interdependence	Asymmetric	Weighted	0.416	+0.116
Very high domestic capacity	Asymmetric	Weighted	0.395	+0.095
Low initial EU identification	Asymmetric	Weighted	0.401	+0.101
Very high initial EU identification	Asymmetric	Weighted	0.407	+0.107
Low-sovereignty field	Asymmetric	Weighted	0.411	+0.111
Very high-sovereignty field	Asymmetric	Weighted	0.388	+0.088
QMV threshold approximation	Asymmetric	QMV	0.332	+0.032
Unanimity	Asymmetric	Unanimity	0.300	-0.000
Postfunctionalist	Symmetric	Weighted	0.655	+0.355
Postfunctionalist	Asymmetric	Weighted	0.376	+0.076

5.1 Symmetric and Asymmetric Crises

Figure 1 shows the central mechanism under dynamic identification. With no crisis, integration remains near its initial level, ending at 0.297. A symmetric crisis produces a stair-like path and ends at 0.664, a gain of 0.364. The asymmetric crisis ends at 0.405, a gain of 0.105. Common exposure preserves the full institutional adjustment rate, while concentrated exposure reduces it continuously.

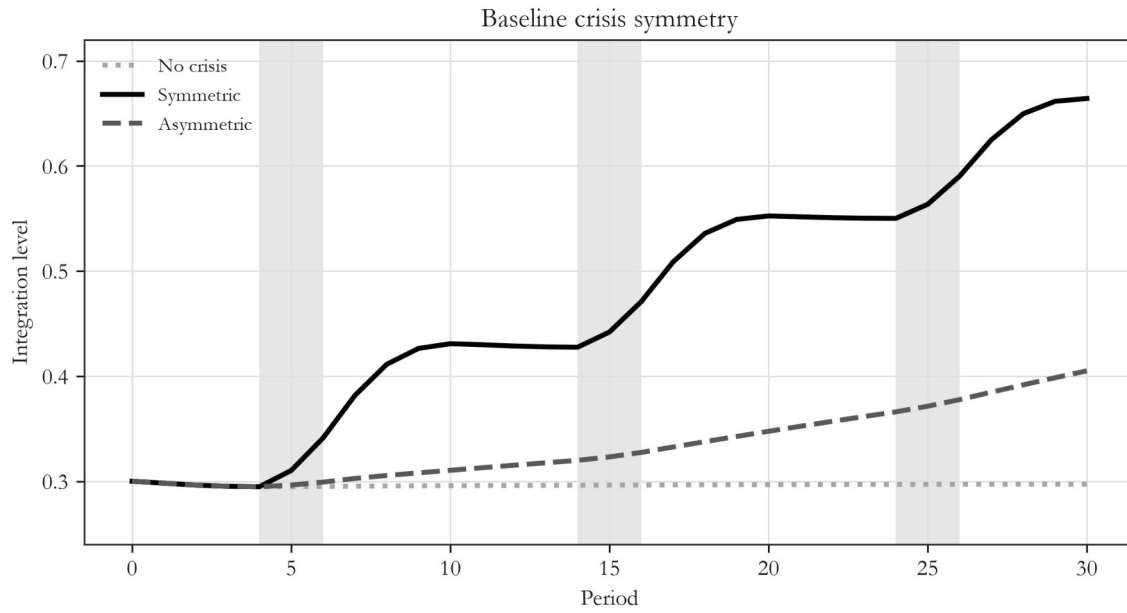


Figure 1. Baseline integration paths under no crisis, symmetric crisis, and asymmetric crisis.

5.2 Ecological Interdependence

Figure 2 varies ecological interdependence. Under symmetric exposure, the high-interdependence endpoint is 0.843, compared with 0.664 at low interdependence, because pressure propagates throughout the system. Under asymmetric exposure, the corresponding endpoints are 0.416 and 0.405.

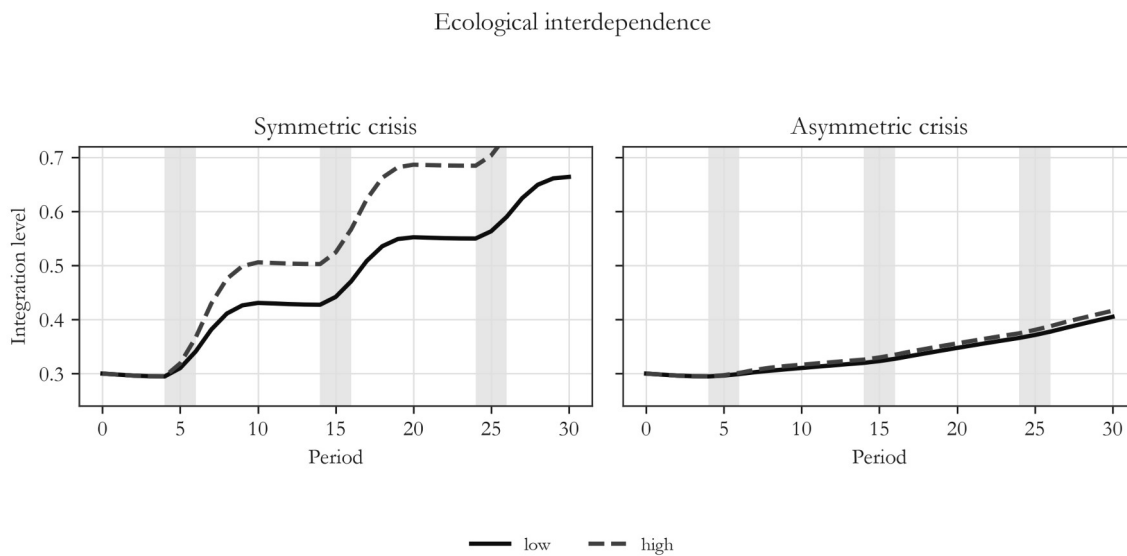


Figure 2. Ecological interdependence under symmetric and asymmetric crises.

5.3 Degree of Asymmetry

Figure 3 varies the number of directly affected countries. Integration ends at 0.405 when three countries are affected, 0.502 with six, 0.544 with nine, 0.602 with fifteen, 0.629 with twenty-one, and 0.664 when all twenty-seven are affected. The monotonic progression follows from broader demand and declining relative asymmetry.

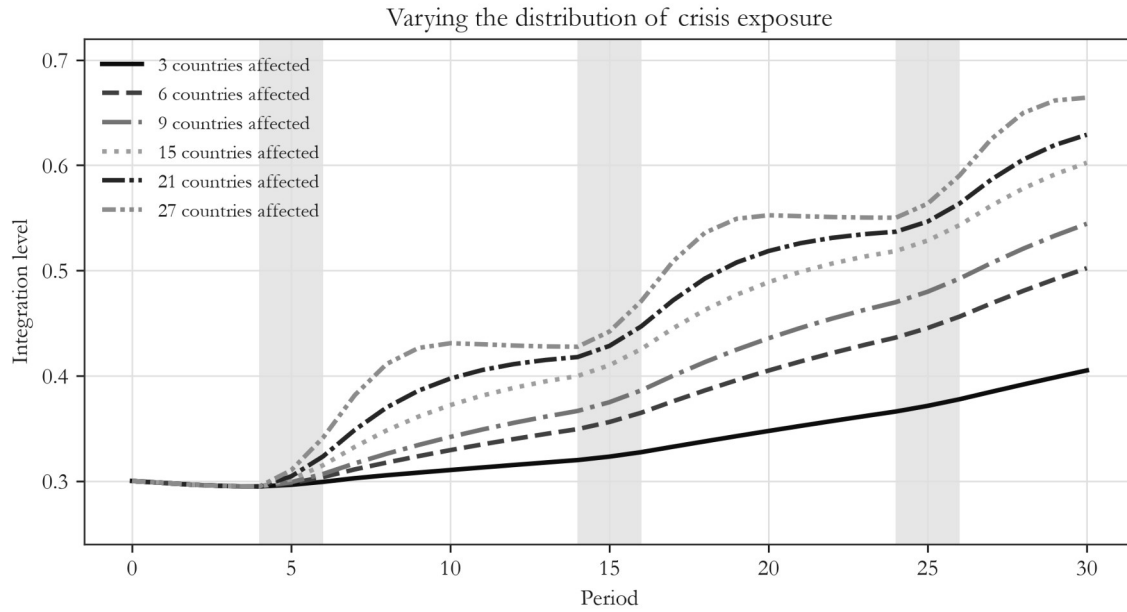


Figure 3. Integration paths as the number of directly affected member states increases.

5.4 Domestic Reaction Capacity

Figure 4 varies domestic reaction capacity. Stronger national capacity lowers supranational pressure. Under asymmetric exposure, final integration declines from 0.405 at low capacity to 0.395 at very high capacity.

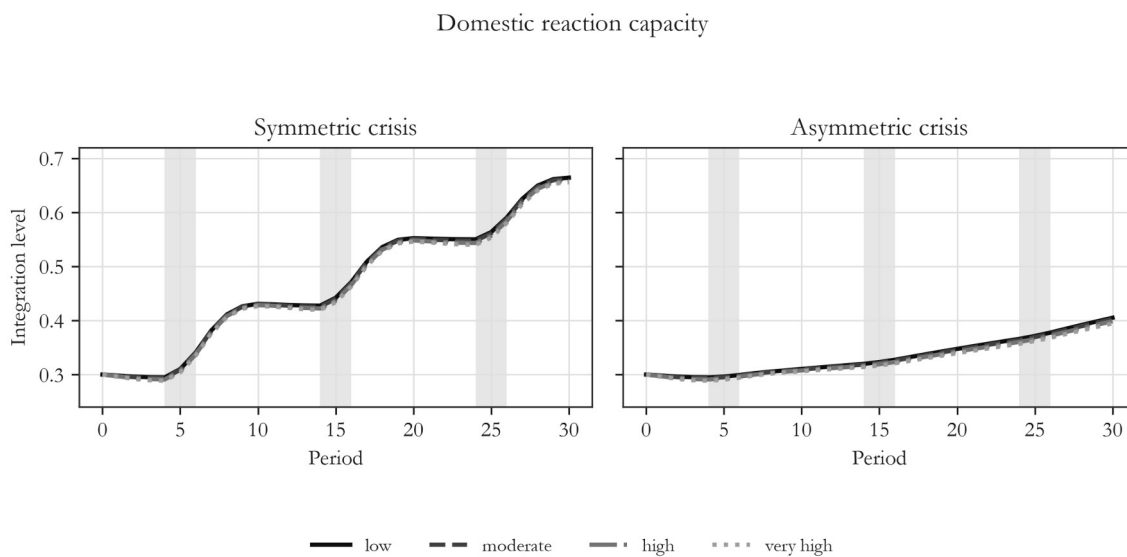


Figure 4. Domestic reaction capacity and the size of the integration response.

5.5 Short-Run Crisis-Induced Mobilisation

Figure 5 varies mobilisation responsiveness. Stronger mobilisation raises resistance to delegation and reduces integration, conditional on identification. In the asymmetric case, final integration declines from 0.406 under low mobilisation to 0.404 under very high mobilisation. Dynamic identification weakens this constraint over time.

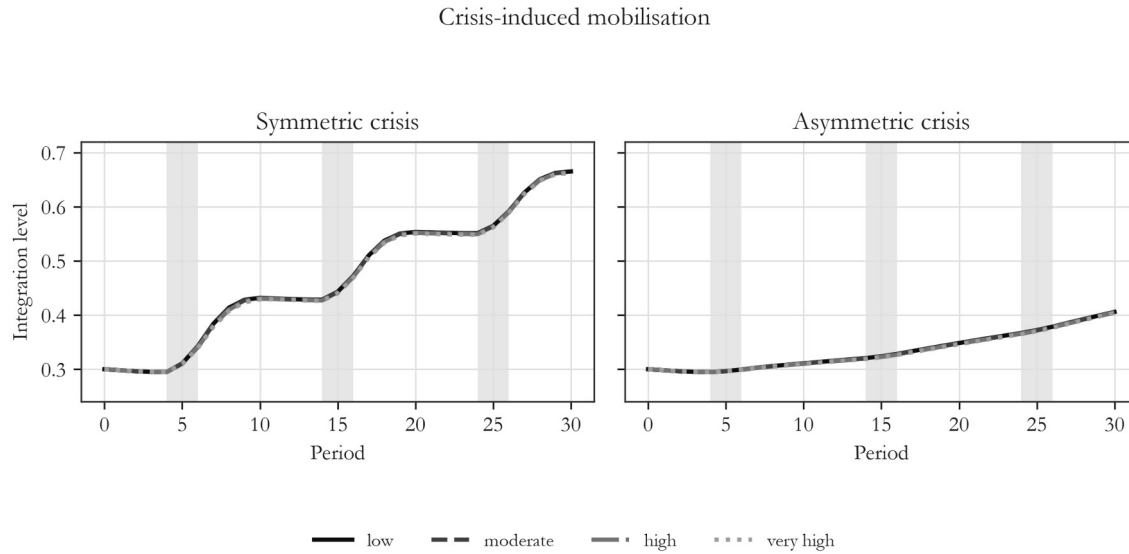


Figure 5. Short-run crisis-induced mobilisation and the political translation of crisis pressure.

5.6 EU Identification

Figure 6 varies initial EU identification. The baseline uses verified Eurobarometer country values; alternatives assign common low, high, and very high starting levels. In the asymmetric case, final integration rises from 0.401 under low initial identification to 0.407 under very high initial identification. Subsequent convergence towards the upper identity bound compresses persistent differences between starting levels.

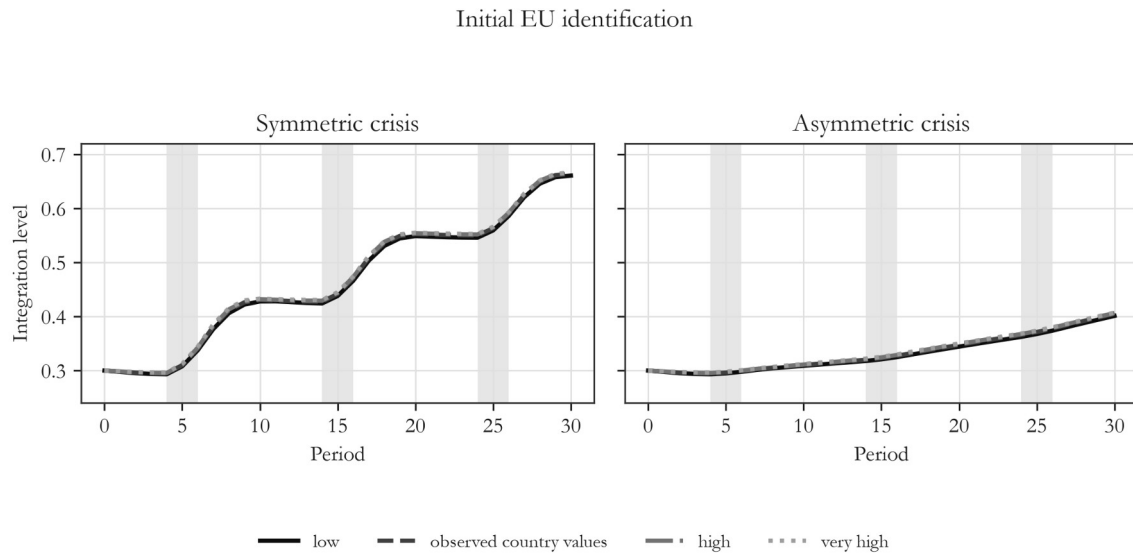


Figure 6. EU identification and the political acceptability of integration.

5.7 Sovereignty Sensitivity of the Affected Field

Figure 7 varies only policy-field sovereignty sensitivity. In the asymmetric case, final integration falls from 0.411 in a low-sovereignty field to 0.388 in a very high-sovereignty field.

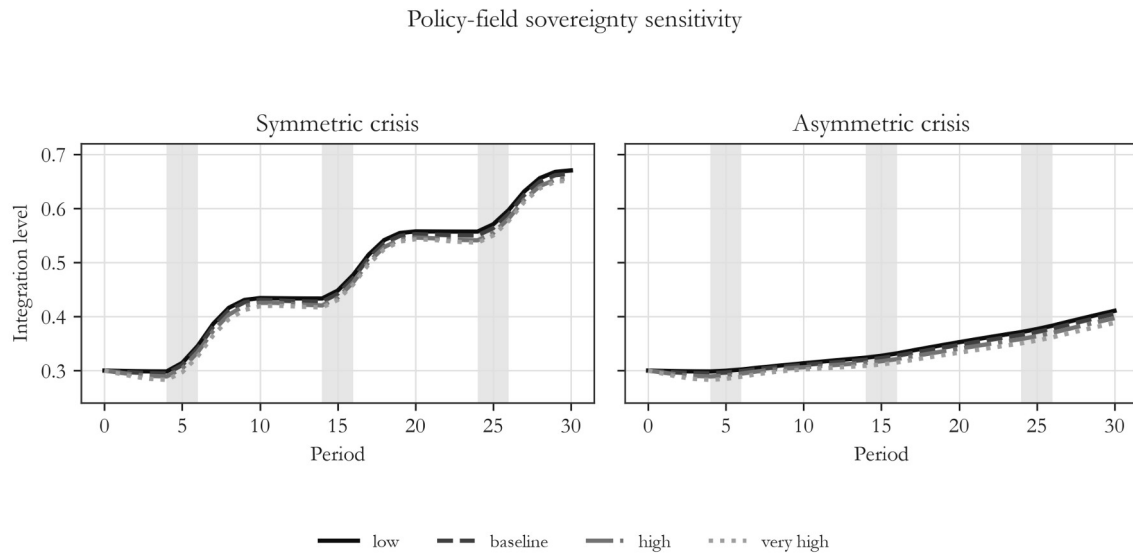


Figure 7. Sovereignty sensitivity of the affected policy field.

5.8 Voting Rule

Figure 8 compares weighted aggregation, the QMV threshold approximation, and unanimity. Under symmetric exposure, the three endpoints are 0.664, 0.664, and 0.613. Under asymmetric exposure, weighted aggregation ends at 0.405, QMV at 0.332, and unanimity at 0.300. QMV can transmit demand only after both coalition thresholds are met, while unanimity blocks movement whenever national demands have mixed signs.

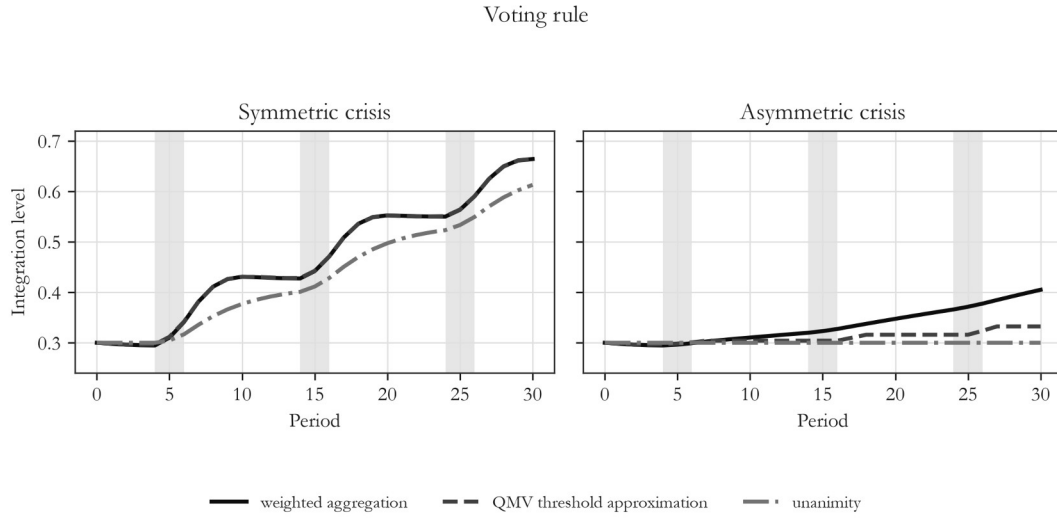


Figure 8. *Weighted aggregation, the QMV threshold approximation, and unanimity.*

5.9 Postfunctionalist Scenario

Figure 9 combines high mobilisation with a core-state field. The symmetric case ends at 0.655 and the asymmetric case at 0.376. Dynamic identification attenuates the mobilisation constraint relative to fixed identification; Appendix B reports the comparison.

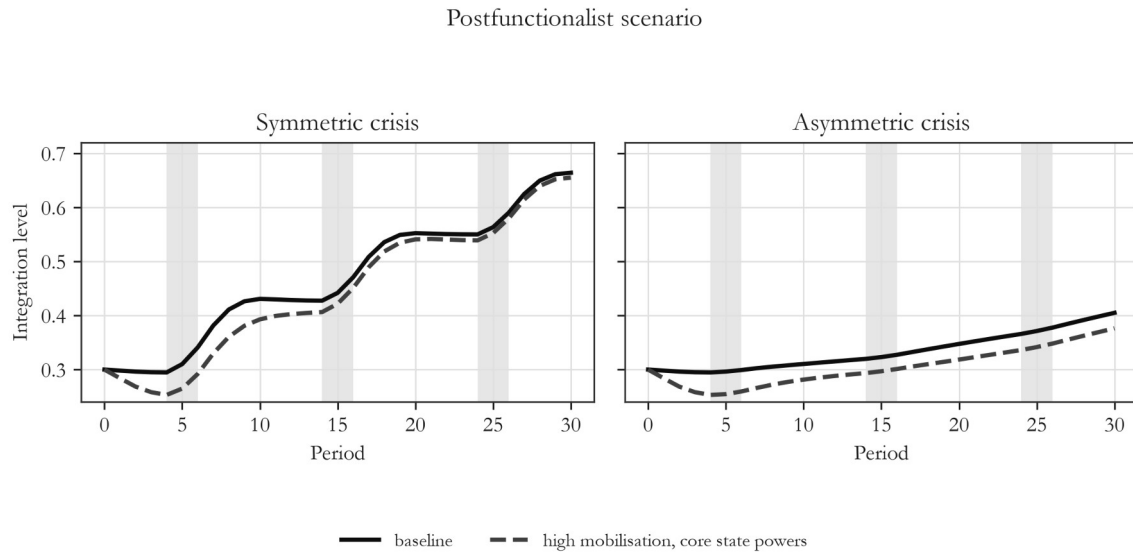


Figure 9. *Postfunctionalist scenario with high mobilisation and core-state sovereignty.*

6. Historical Crisis Application

Having examined stylised shocks, the historical application considers how country-specific crises from 1960 to 2024 translate through the same institutional adjustment rule. Crisis exposure is taken from the 60/40 composite index. Macroeconomic, exchange-rate, and sovereign-spread stress receive 60 per cent of the total weight;

mortality, energy and security, migration, and external-threat measures receive 40 per cent. Each country-year observation is scaled to the model's crisis range before entering as exogenous exposure.

The exercise begins with integration at 0.10 and EU crisis-resolution capacity at zero. Membership varies by year within the available country panel. EU identification evolves, sovereignty predispositions remain fixed, and integration reported for a year incorporates that year's crisis observation. Weighted aggregation, the QMV threshold approximation, and unanimity are evaluated separately. The crisis input, adjustment rule, and country-level source flags remain distinct from the controlled theoretical simulations reported above.

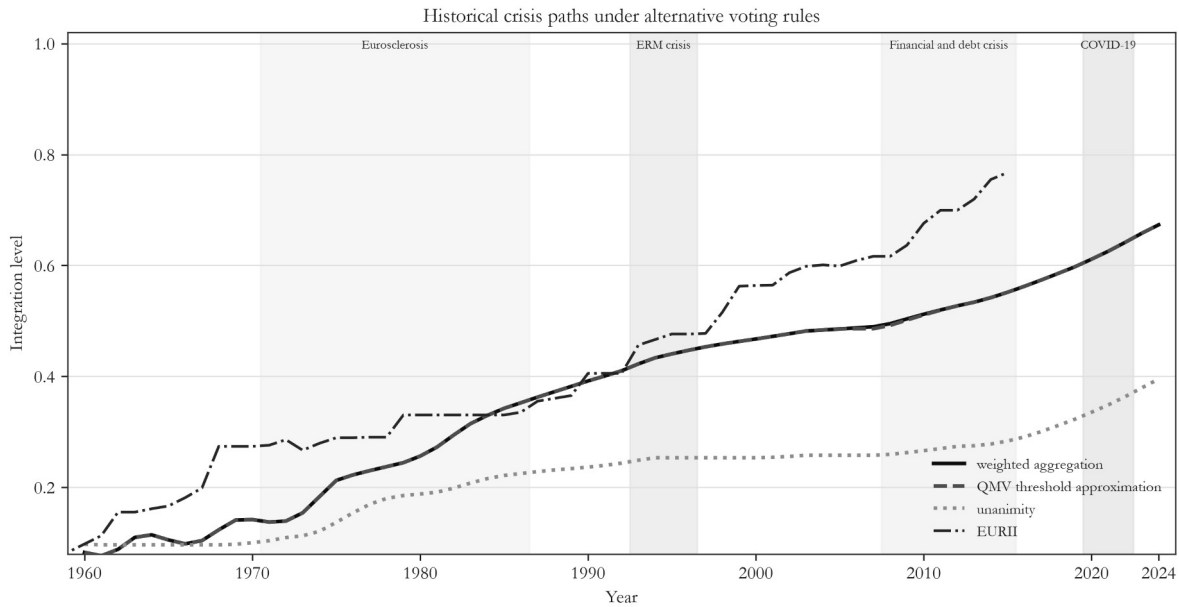


Figure 10. Historical crisis paths under alternative voting rules and the EURII benchmark.

Figure 10 reports exploratory paths. Weighted aggregation and the QMV approximation follow similar trajectories and end at 0.673 in 2024. Unanimity produces a slower path and ends at 0.395. The weighted path is close to EURII around 1990, but remains below the EURII benchmark in 2000 and 2015. EURII reaches 0.768 in 2015, compared with 0.552 for the weighted simulation. The difference is consistent with EURII's strong emphasis on institutional and economic integration, while the simulated stock also reflects political resistance, crisis asymmetry, and the pace of collective adjustment. The post-2020 increase is visible under all three voting rules.

The historical trajectories are experimental evidence rather than validation targets. The available panel omits the United Kingdom during its membership years and applies several contemporary country characteristics outside their observed historical periods. Missing crisis components sometimes enter as zero stress, with the affected observations retained in the source flags. These limitations can alter crisis means, dispersion, voting weights, and adjustment speed. Appendix C documents the historical specification and data status.

7. Conclusion and Limitations

Crisis-led integration follows from the interaction between functional pressure, national absorption, political resistance, and institutional adjustment. Common exposure creates broadly aligned national demands and preserves adjustment speed. Concentrated exposure generates weaker aggregate demand and greater relative asymmetry, producing smaller and slower changes without imposing an additional institutional veto. Domestic capacity, mobilisation, identification, sovereignty sensitivity, and voting thresholds condition the magnitude of this response. The historical application generates sustained integration under weighted aggregation and QMV and a slower path under unanimity, while its data limitations preclude validation claims.

The formalisation contributes a complex dynamic approach to European integration. Its architecture is comparable to complexity economics, agent-based modelling, and dynamic macroeconomic simulation in its emphasis on interdependence, feedback, constraints, and counterfactual trajectories. The analytical unit remains the member state and the equations are deliberately transparent to EU scholars. Representing each substantive mechanism with one parameter reduces the number of free behavioural quantities without suppressing the interaction among functionalist, intergovernmental, and postfunctionalist mechanisms.

Several limitations remain. Member states are the only strategic actors, leaving the Commission, European Parliament, European Central Bank, parties, organised interests, and subnational governments outside the bargaining process. Mobilisation compresses elite cueing, party competition, media framing, protest, and electoral threat into one response. The QMV option reproduces the state and population thresholds but omits the four-state blocking-minority exception and uses inherited Council weights to scale coalition demand. The bounded integration stock can also reach its upper limit under repeated intense shocks, particularly under weighted aggregation or QMV. Such saturation is a model outcome, but it compresses differences between high-pressure scenarios and should be reported when longer horizons are used.

The empirical status of the inputs is uneven. Country size, debt burden, population, political weight, EU identification, and sovereignty predisposition draw on observed information, while crisis translation, domestic absorption, mobilisation, ecological interdependence, and resolution effectiveness remain calibrated assumptions. The historical application retains explicit source and missingness flags and remains exploratory because its membership and country-year institutional inputs are incomplete.

Measuring integration is inherently difficult. A single bounded stock compresses authority, capacity, territorial coverage, and political legitimisation into one quantity. EURII provides a valuable institutional-economic benchmark, but its emphasis on market, monetary, and related governance integration can imply a higher level than measures that also require fiscal scale, defence capacity, redistribution, enforcement, and democratic authority. Validation should therefore compare simulated paths with several conceptually distinct integration indicators.

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Appendix A. Calibration

Table A1 reports the behavioural calibration used in the theoretical simulations. Each theoretical mechanism enters through a single substantively named parameter. Table A2 records the quantities varied across simulation families; all unlisted quantities retain the baseline values in Table A1.

Table A1. Baseline behavioural calibration

Quantity	Notation	Value
Initial integration	I_0	0.300000
Policy-field sovereignty	p	0.224948
Crisis-pressure translation	α^{CP}	5.036229
Baseline mobilisation	m_0	0.200000
Crisis-induced mobilisation	κ	0.674924
EU resolution effectiveness	x	0.540015
Ecological interdependence	I^e	0.021013
Domestic reaction capacity	C^d	0.026042
Supranational democratic control	D	0.013500
Output legitimacy	L	0.040000
Shock intensity	CP^{ex}	0.050000
Integration-linked identification	η^I	0.014164
Exposure-homogeneity identification	η^S	0.013965

Table A2. Scenario variations

Simulation family	Values
Crisis distribution	Symmetric: 27 affected; asymmetric baseline: 3 affected; degree-of-asymmetry series: 3, 6, 9, 15, 21, 27 affected.
Ecological interdependence	$I^e = 0.02$ and 0.60 .
Domestic reaction capacity	$C^d = 0.026, 0.174, 0.434, 0.694$.
Crisis-induced mobilisation	$\kappa = 0.20, 0.50, 0.90, 1.30$.
EU identification	Low 0.40; baseline observed country values; high 0.70; very high 0.85.
Policy-field sovereignty	$p = 0.12, 0.224948, 0.36, 0.50$.
Voting rule	Weighted aggregation; QMV threshold approximation; unanimity.
Postfunctionalist	$p = 0.50$; $m_0 = 0.90$; $\kappa = 1.30$.
Identity treatment	Dynamic in the principal simulations; fixed at initial values in Appendix B. Sovereignty predisposition is fixed in both.
Asymmetry adjustment	Bounded relative dispersion A_t ; no additional sensitivity coefficient.

Appendix B. Identity Dynamics Sensitivity

The principal simulations update EU identification according to Equation 9 while holding country sovereignty predispositions fixed. The sensitivity analysis holds identification at its Eurobarometer starting value. The fixed treatment reproduces the preceding specification to machine precision and changes no other model quantity.

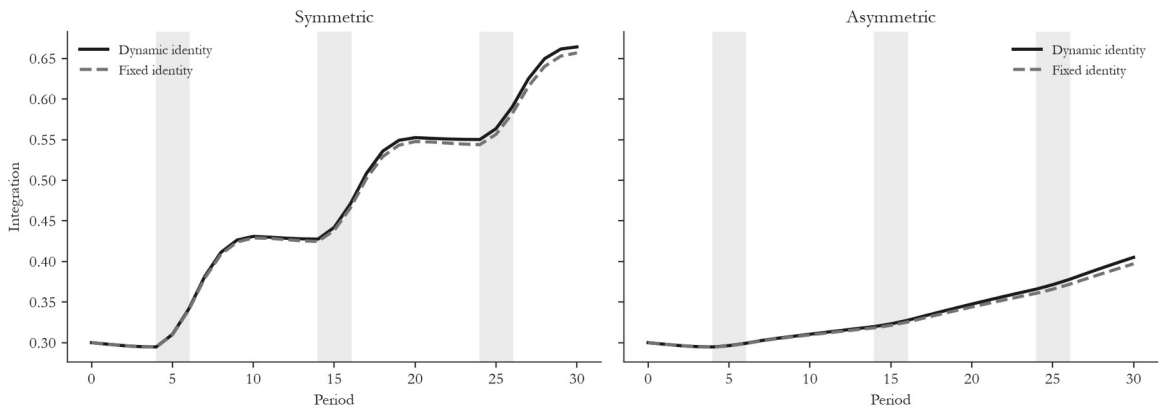


Figure B1. Integration under dynamic and fixed EU identification.

Exposure	Dynamic final	Fixed final	Difference	Largest path difference
None	0.297	0.295	+0.002	0.002
Symmetric	0.664	0.657	+0.007	0.010
Asymmetric	0.405	0.397	+0.008	0.008

Dynamic identification raises integration under weighted aggregation in the three baseline exposure patterns. Across all fifty-three reported calibrations, the largest endpoint difference is 0.065. In the asymmetric postfunctionalist simulation, dynamic identification produces an endpoint of 0.376, compared with 0.311 under fixed identification.

The accumulation rule reaches the upper identity bound rapidly. In the no-crisis baseline, the period-30 mean is 0.997 and twenty-five countries reach the ceiling; under a symmetric crisis, all twenty-seven do. This convergence follows from the assumed positive integration-linked increment and the positive homogeneity increment even when exposure is uniformly zero. The sensitivity therefore identifies how strongly the principal results depend on this accumulation law.

Appendix C. Historical Inputs and Data Status

The historical crisis input is constructed at the country-year level for 1960-2024. Macroeconomic stress combines inflation, unemployment, and growth relative to country-specific five-year baselines. Exchange-rate stress uses national-currency movement against the dollar before 1971 and against the ECU thereafter, with zero internal exchange-rate volatility after euro adoption. Sovereign stress is the positive national yield spread over Germany. Mortality, migration, energy and security, and external-threat measures provide the non-economic block. World Bank indicators, Eurostat series, national statistical sources, and Global Macro Database fallbacks supply the underlying observations.

Each component is normalised to a 0-100 scale across member-country-years. The model divides the resulting country-year score by 100 and multiplies it by the crisis scale of 0.05. The baseline weighting is reported in Table C1. Source and missingness flags remain attached to each country-year. One or more weighted components are substituted in 883/964 member-years (91.6%), chiefly because energy data are unavailable in all 883; asylum-based migration data are unavailable in 575 (59.6%). Raw-series gaps cover 15 unemployment, 6 growth, 2 exchange-rate, and 25 sovereign-yield member-years. Components entering as zero remain flagged and are not treated as observed absence of stress.

Block	Component	Weight
Macroeconomic and financial	Macroeconomic stress	20%
Macroeconomic and financial	Exchange-rate stress	20%
Macroeconomic and financial	Sovereign-spread stress	20%
Non-economic and crisis-specific	Mortality stress	10%
Non-economic and crisis-specific	Energy and security stress	10%
Non-economic and crisis-specific	Net-migration stress	10%
Non-economic and crisis-specific	External-security threat	10%

Table C1. Baseline weighting of the historical crisis intensity index.

Integration begins at 0.10 at the start of 1960, and resolution capacity begins at zero. The end-of-year integration value incorporates the crisis observation for that year, including 2024. Averaged bilateral spillovers, dynamic EU identification, fixed sovereignty predispositions, and the bounded relative-asymmetry adjustment rule match the theoretical specification. The QMV series uses weighted aggregation while the available panel contains fewer than fifteen members.

The country panel contains the current EU27. It therefore omits the United Kingdom during 1973-2020 and does not reproduce the historical membership universe. Contemporary GDP shares, debt burdens, political weights, population shares, EU identification, and sovereignty predispositions are also used outside their observed years. The historical paths consequently illustrate how the recorded crisis sequence operates within the model; they cannot establish correspondence between predicted and observed integration until the membership panel and country-year institutional inputs are reconstructed.