Online Appendix

Tobias Tober
tobias.tober@unige.ch
University of Geneva
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This appendix provides supporting information for the paper "*European Institutional Integration, Trade Unions, and Income Inequality*". Section 1 focuses on descriptive statistics and measurement details. Section 2 provides full model results, robustness tests, and diagnostics.

1 Descriptive Statistics

Table A1 contains descriptive statistics of the variables included in the main analysis. Figure A1 presents a correlation matrix of these variables. Figures A2–A4 show trends for union strength and top income inequality both across time and space. For union strength, light blue lines are added indicating the moving average of the five preceding years (as used in the regression analysis). Table A2 lists the institutional integration steps that were used to expand the integration index between 2005 and 2014, their respective index values, and the exempted countries.

Table A1: Descriptive statistics.

Variable	Obs	Mean	SD	Min	Max
Top 1% income share	526	7.87	1.97	3.25	13.09
Top 10% income share	526	29.23	3.71	21.97	39.21
Pre-fisc gini (100 multiply imputed datasets)	615	46.18	4.43	33.24	56.78
90-10 ratio	242	2.90	0.60	1.88	4.65
90-50 ratio	242	1.81	0.24	1.43	2.84
50-10 ratio	242	1.60	0.21	1.28	2.33
European institutional integration	900	46.97	33.62	0	101.4
Union strength	785	43.28	18.97	7.61	86.24
Bargaining level	839	3.40	1.14	1	5
Trade openness	900	72.90	50.47	9.60	374.15
GDP per capita (in thousands)	900	50.36	80.92	2.96	389.37
Employed (share of total population)	900	44.18	5.96	30.61	75.90
Years of schooling	900	8.75	2.36	1.80	13.55
Government ideology	846	3.03	0.85	0.09	4
Financial reforms	462	0.68	0.27	0.05	1
Female labor force participation	591	47.76	12.07	13.30	73.21
Top income tax rate	667	55.05	14.57	20	96.3

Note: Numbers are based on main panel consisting of 15 European countries.

Figure A1: Correlation matrix.

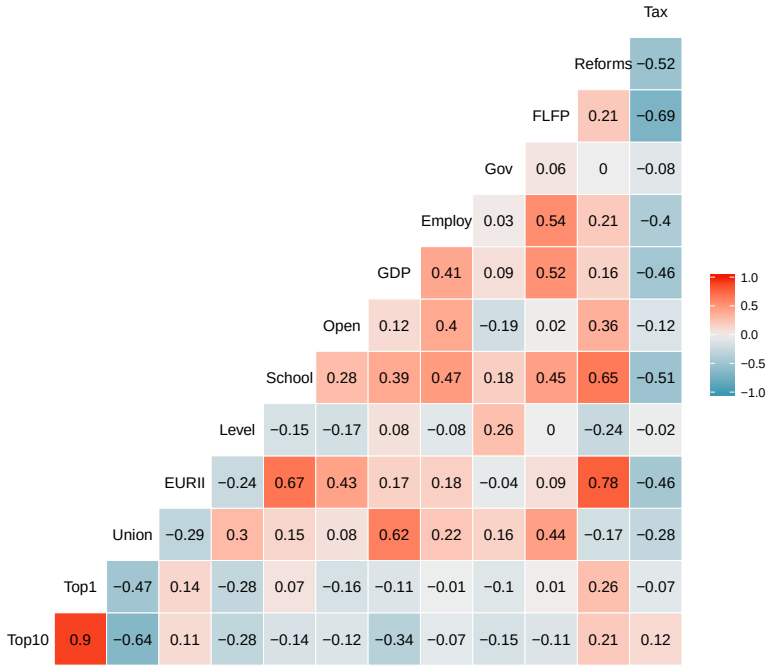


Figure A2: Trade union membership in 11 European and 5 non-European countries, 1950-2013. Light blue lines indicate moving average of five preceding years.

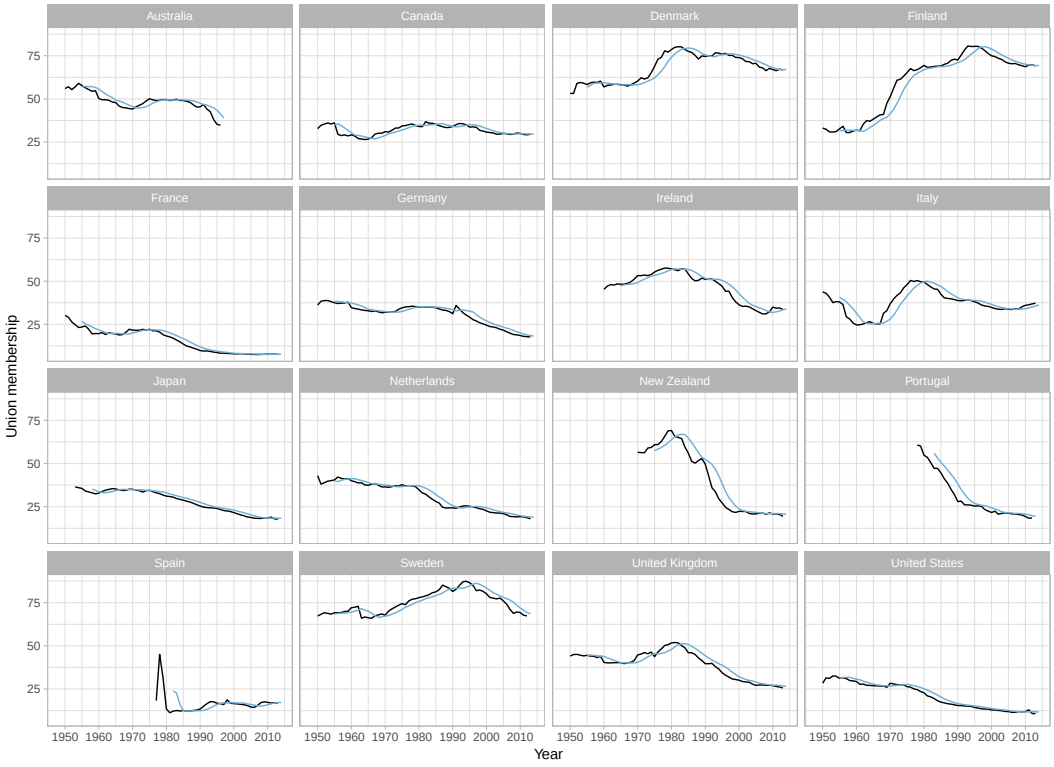


Figure A3: Top 10% income share in 11 European and 5 non-European countries, 1945-2014.

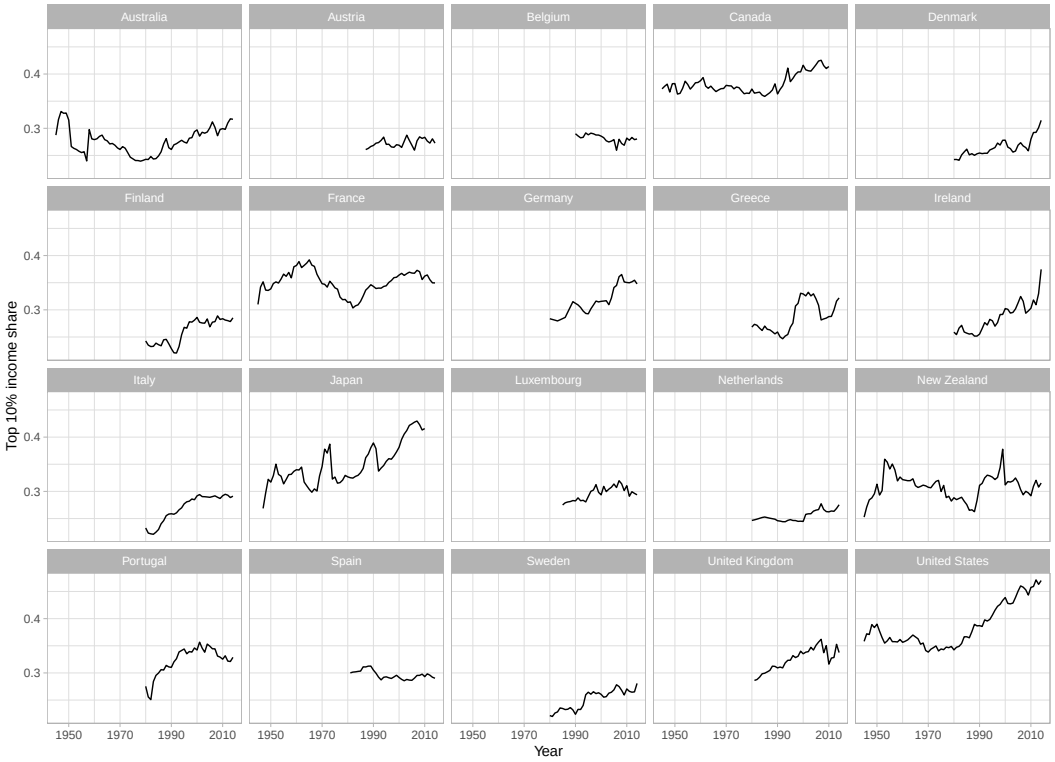


Figure A4: Top 1% income share in 11 European and 5 non-European countries, 1945-2014.

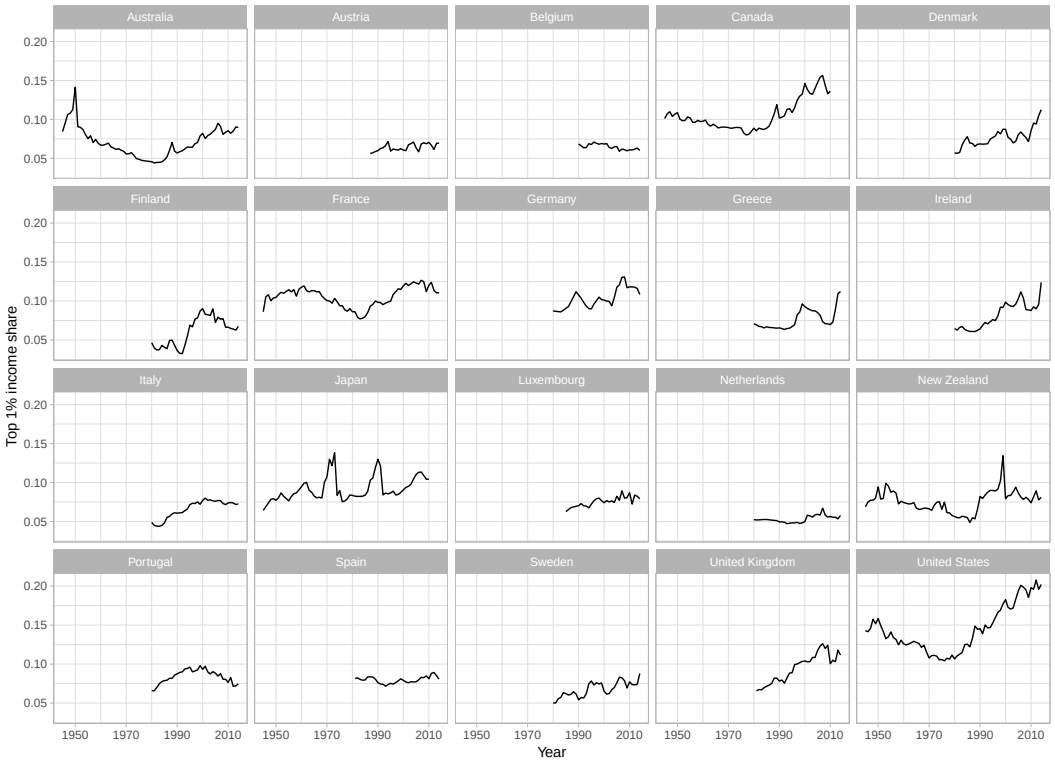


Table A2: Extension of European institutional integration index for the years 2005-2014.

Integration step	Value	Date	Exempted
Growth and Jobs (Reform of the Lisbon strategy)	0.05	01.02.05	
Weakening of the SGP	-0.25	01.03.05	
"Bolkenstein" directive on services in the internal market (2006/123/EC)	1.00	01.12.06	
CRD implementing the Second Basel Accord (Basel II)	0.25	01.01.07	
Payment Services Directive	0.50	01.12.07	
CRD II	0.25	01.09.09	
Treaty of Lisbon: allow for a simplified treaty revision procedure and passarelle clauses	0.50	01.12.09	
Eurogroup in the Treaty (Protocol) with permanent President (Lisbon Treaty)	0.25	01.12.09	Denmark, Sweden, United Kingdom
Treaty of Lisbon: EP expands its control of the EU budget, expands the role of national parliaments	0.25	01.12.09	
Treaty of Lisbon: co-decision is extended, Citizens' initiative established, EP on same footing as Council	0.25	01.12.09	
Establishment of the European Council as a legal entity in the Treaty with a permanent President	0.50	01.12.09	
EU 2020 Strategy / European Semester created	0.15	01.03.10	
Greek Loan Facility (GLF) is set up (bilateral emergency loans)	0.25	01.05.10	Denmark, Sweden, United Kingdom
Establishment of EFSM (EU-budget based fiscal backstop; small scale but QMV)	0.25	01.05.10	
Undertakings for the collective investment in transferable securities	0.05	01.07.10	
Establishment of EFSF (Intergovernmental (IG) fiscal backstop)	1.00	01.07.10	Denmark, Sweden, United Kingdom
Establishment of ESM (linked to Treaty, less IG, large scale fiscal backstop)	1.50	01.09.10	Denmark, Sweden, United Kingdom
European System of Financial Supervirors: ESRB (macro)	0.75	01.12.10	
European System of Financial Supervisors: EBA, ESMA, EIOPA	0.50	01.01.11	
Europlus pact	0.10	01.03.11	Sweden, United Kingdom
Macroeconomic Imbalance Procedure (instituted by the "Six-Pack")	1.00	01.12.11	
Stregthening of the SGP (Six-pack)	0.50	01.12.11	
Directive on national fiscal frameworks (Six-pack)	0.25	01.12.11	
"Fiscal compact": IG Treaty on Stability, Coordination and Governance (TSGC)	1.00	01.01.13	Sweden, United Kingdom
"Two-pack": far reaching fiscal surveillance	0.50	01.05.13	Denmark, Sweden, United Kingdom
CRD IV/CRR (implementing Basel III)	0.50	01.07.13	
EC President candidates to be indicated ahead of the EP elections by EP groups (Lisbon treaty)	0.10	01.05.14	
Deposit Guarantee Scheme Directive - DGSD	0.50	01.06.14	
SEPA	0.50	01.08.14	
Single Supervisory Mechanism	2.00	01.11.14	Denmark, Sweden, United Kingdom
Limited ESM Direct Bank Recapitalisation (DBR)	0.25	01.11.14	Denmark, Sweden, United Kingdom
SSM accountability (to EP & Council)	0.20	01.11.14	Denmark, Sweden, United Kingdom

2 Model Details, Robustness, and Diagnostics

Model details. Table A3 supplements Table 1 in the main text by presenting full results for the included control variables.

Table A3: Discroll-Kraay FE estimation of the impact of union strength, European institutional integration, and their interaction on top income inequality, 1955– 2014. Control variables.

	Model 1 Top 10%	Model 2 Top 10%	Model 3 Top 10%	Model 4 Top 10%	Model 5 Top 1%	Model 6 Top 1%	Model 7 Top 1%	Model 8 Top 1%
Bargaining level	−.109	−.153	−.111	−.076	−.058	−.112*	−.069	−.072
	(.101)	(.077)	(.083)	(.092)	(.084)	(.034)	(.072)	(.042)
Trade openness	.003	.009	.020*	.003	−.000	.009	.008*	.005
	(.006)	(.007)	(.005)	(.013)	(.003)	(.006)	(.004)	(.012)
GDP per capita	−.014*	−.041*	−.022*	−.041*	−.008	−.037*	−.014*	−.037*
	(.003)	(.005)	(.004)	(.006)	(.004)	(.005)	(.004)	(.006)
Share employed	−.017	.011	−.128*	.019	.005	.111*	−.055	.128*
	(.020)	(.046)	(.042)	(.030)	(.016)	(.022)	(.031)	(.045)
Years of schooling	−.324	−1.144*	−.358	−1.431	.222	−.384	.111	−.601
	(.527)	(.559)	(.624)	(.750)	(.205)	(.537)	(.256)	(.720)
Government	.186	.132	.151	.098	.142	.154	.088	.129*
	(.176)	(.149)	(.117)	(.109)	(.094)	(.079)	(.058)	(.054)
Female LFP		−.091*		−.123*		−.092*		−.116*
		(.014)		(.017)		(.021)		(.030)
Financial reforms		3.485*		2.357*		1.745*		.954
		(.996)		(.807)		(.664)		(.580)
Top tax rate		−.023		−.021*		.003		.005
		(.015)		(.010)		(.008)		(.007)
Time trend	−.204	−.256			−.078	−.101		
	(.114)	(.256)			(.068)	(.170)		
Time trend squared	.003*	.005			.001	.002		
	(.001)	(.003)			(.001)	(.002)		
Observations	424	262	424	262	459	274	459	274
Within R^2	.586	.641	.700	.758	.573	.722	.609	.772

* Zero outside the confidence interval.

Table A4: Discroll-Kraay FE estimation of impact of interaction between union strength and European institutional integration on top income inequality. Robustness tests.

	Top 10% income share		Top 1% income share	
	Interaction		Interaction	
Robustness test	Beta	SE	Beta	SE
(1) Non-European countries	.001*	.000	.001*	.000
(2) Pre-2005 years	.001*	.000	.001*	.000
(3) Non-overlapping averages	.002*	.000	.001*	.000
(4) KOF economic index	.002*	.001	.002*	.000

* Zero outside the confidence interval. Models include the constitutive terms of the interaction and the long series of control variables. The models use linear and squared time trends. The results remain substantially unchanged when year fixed effects are used instead.

Robustness tests. Table A4 summarizes the results of the robustness tests. The estimates are based on the long series of controls. Presented are only the parameter estimates and standard errors of the interaction term. Four specifications are tested. First, I add five non-European countries (Australia, Canada, Japan, New Zealand, and the US) that exhibit zero level of institutional integration. Second, I limit the observation period to the original timeframe of the integration index. Third, I replace the moving average of union strength (based on five preceding years) by non-overlapping, lagged five-year averages. Fourth, I add the economic dimension of the KOF index of globalization as an alternative to trade openness.

Diagnostics. As discussed in the main text, Hainmueller, Mummolo, and Xu (2019) explain that the classical linear multiplicative interaction model relies on two assumptions, which are usually overlooked and—as their replication results show—often violated. First, the standard model assumes a linear interaction effect (LIE) that changes at a constant rate with the moderator. Second, estimates of the conditional effects of the independent variable can be misleading if there is a lack of common support of the moderator. To test whether these assumptions are met, the authors recommend a series of diagnostic tools (beyond the subsequent discussion, see their article for more technical details). In the following, I apply two of these tools.

As a diagnostic plot, Hainmueller, Mummolo, and Xu (2019) suggest to visualize interactions using a three-dimensional surface plot generated by a generalized additive model. This tool explicitly allows to include other variables as well as fixed effects. Figure A5 plots two generalized additive models with my two measures of top income inequality as response variables. Both of these models include the long series of controls and use fixed effects. The graphs show that the LIE assumption is not violated by the data. Holding institutional integration constant, top income inequality is decreasing in union strength and holding union strength constant, top income inequality is increasing in institutional integration. Second, the slope of top income inequality on union strength is smaller with higher institutional integration than with lower institutional integration. Third, the surface of top income inequality over union strength and institutional integration is fairly smooth, with a gentle curvature in the middle but devoid of drastic humps, wrinkles, or holes.

Figure A5: Diagnostic plots of two generalized additive models with controls and FEs.

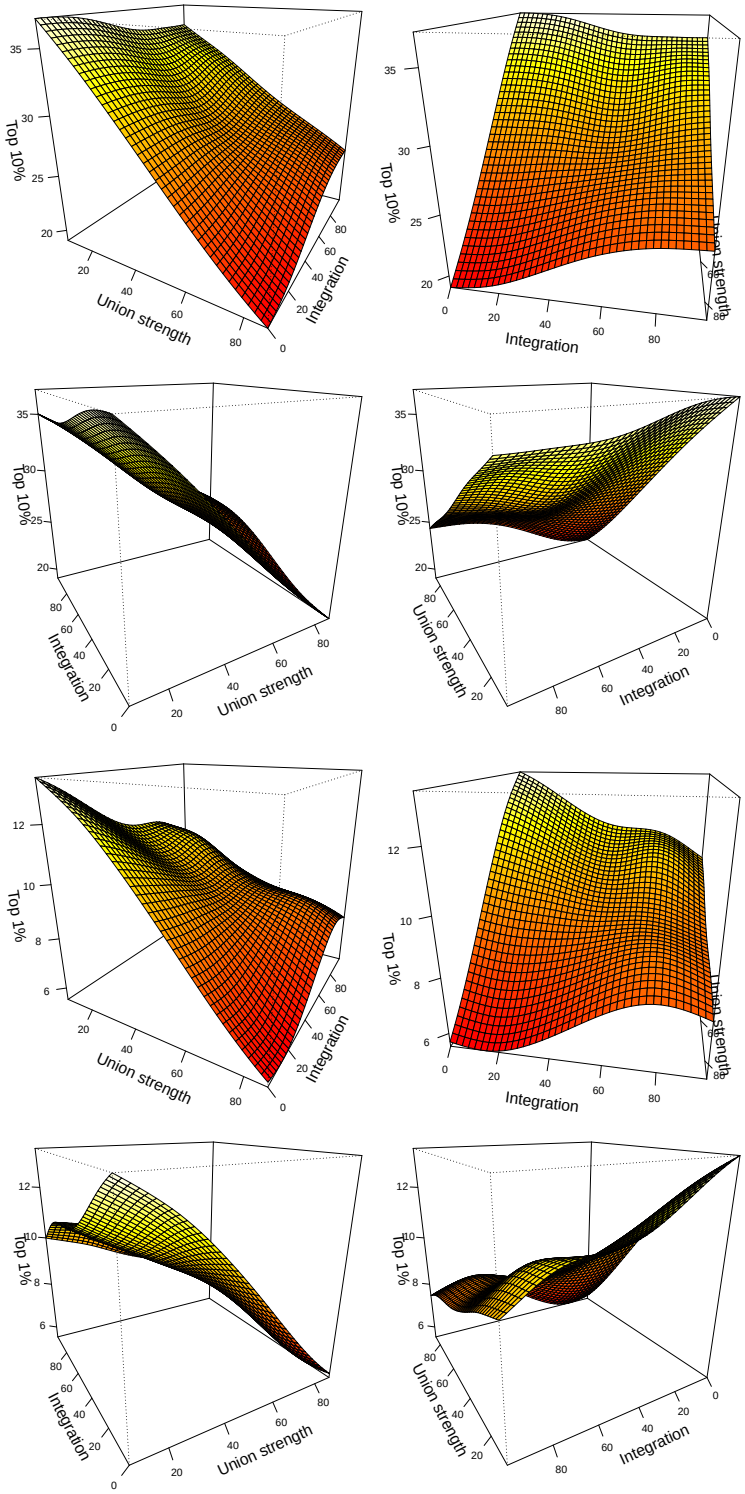
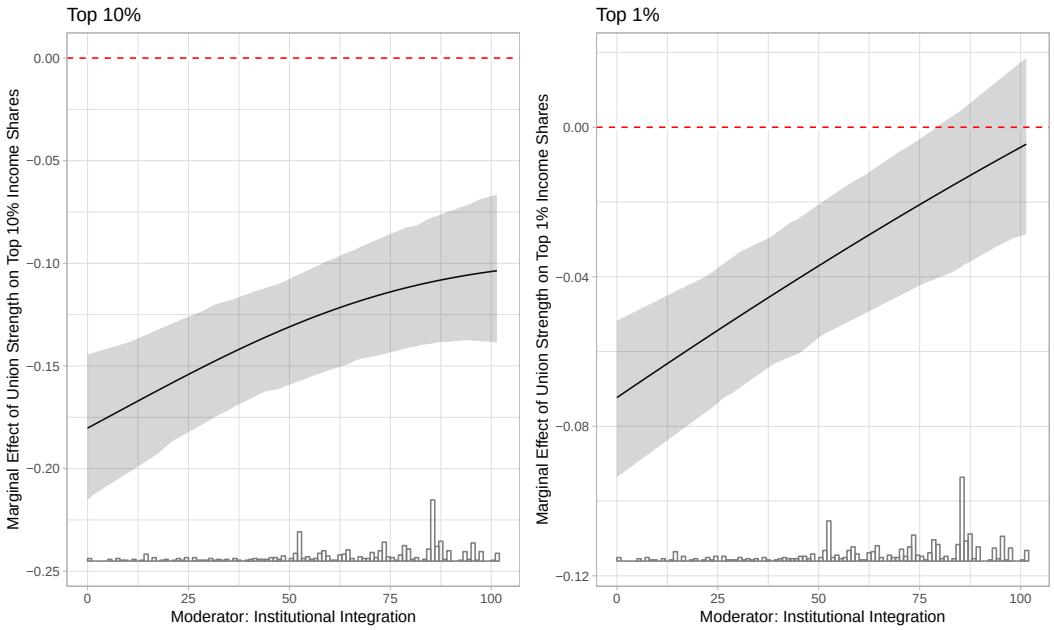


Figure A6: Kernel smoothing estimator with controls and FEs.



A further diagnostic tool is a kernel smoothing estimator of the marginal effect, which estimates a series of local effects with a kernel reweighing scheme (the number of evaluation points was set to 200). This estimation strategy allows to flexibly estimate the functional form of the marginal effect of union strength on top income inequality across the range of institutional integration. Thus, by utilizing a more flexible estimator, the marginal effect can be closely approximated regardless of potential violations of the LIE assumption. Figure A6 presents results from the kernel smoothing estimator. The negative marginal effect of union strength on top 10% income shares substantially declines as institutional integration increases. The slope of the line flattens slightly at higher levels of European institutional integration but always increases (when I use the short series of controls, the increase is fully linear). In case of 1% income shares, the linear effect is even more apparent. In the line with Table 2 in the main text, the kernel smoothing estimator finds that the marginal effect of trade union strength on top 1% income shares becomes statistically insignificant at higher levels of European institutional integration.

Giesselmann and Schmidt-Catran (2018) show that an interaction term in a fixed-effects model captures three product terms: the product of the between variation in the first constitutive term and the within variation in the second constitutive term, the product of the within variation in the first constitutive term and the between variation in the second constitutive term, and the product of the within variations of both constitutive terms. This can be seen by expanding a simplified version of my statistical model:

$$ine_{ct} = \beta_1 u_{ct} + \beta_2 i_{ct} + \beta_3 u_{ct} i_{ct} + \alpha_c + \epsilon_{ct},$$

where ine_{ct} is the level of inequality in country c ($c = 1, \ldots, n_t$) at time point (year) t ($t = 1, \ldots, T$), u_{ct} is the level of trade union density, i_{ct} is the level of European institutional integration, and $u_{ct} i_{ct}$ is the interaction term between trade union density and European institutional integration. The country fixed effects demean the variables, which yields

$$ine_{ct} - \overline{ine_c} = \beta_1 (u_{ct} - \overline{u_c}) + \beta_2 (i_{ct} - \overline{i_c}) + \beta_3 (u_{ct} i_{ct} - \overline{(ui)_c}).$$

I only expand the interaction term $u_{ct} i_{ct} - \overline{(ui)_c}$, which is crucial to this discussion:

$$\begin{aligned}
&u_{ct} i_{ct} - \overline{(ui)_c} = u_{ct} i_{ct} - \frac{\sum_{t=1}^{T_c} u_{ct} i_{ct}}{T_c} = \\
&[\overline{u_c} + (u_{ct} - \overline{u_c})][\overline{i_c} + (i_{ct} - \overline{i_t})] - \frac{\sum_{t=1}^{T_c} [\overline{u_c} + (u_{ct} - \overline{u_c})][\overline{i_c} + (i_{ct} - \overline{i_c})]}{T_c} = \\
&\overline{u_c i_c} + \overline{u_c}(i_{ct} - \overline{i_c}) + \overline{i_c}(u_{ct} - \overline{u_c}) + (u_{ct} - \overline{u_c})(i_{ct} - \overline{i_c}) \\
&- \frac{\sum_{t=1}^{T_c} \overline{u_c i_c} + \overline{u_c}(i_{ct} - \overline{i_c}) + \overline{i_c}(u_{ct} - \overline{u_c}) + (u_{ct} - \overline{u_c})(i_{ct} - \overline{i_c})}{T_c} = \\
&\overline{u_c i_c} + \overline{u_c}(i_{ct} - \overline{i_c}) + \overline{i_c}(u_{ct} - \overline{u_c}) + (u_{ct} - \overline{u_c})(i_{ct} - \overline{i_c}) - \overline{u_c i_c} - \overline{u_c} \frac{\sum_{t=1}^{T_c} (i_{ct} - \overline{i_c})}{T_c} \\
&- \overline{i_c} \frac{\sum_{t=1}^{T_c} (u_{ct} - \overline{u_c})}{T_c} - \frac{\sum_{t=1}^{T_c} (u_{ct} - \overline{u_c})(i_{ct} - \overline{i_c})}{T_c} = \\
&\underbrace{\overline{u_c}(i_{ct} - \overline{i_c})}_{\text{term 1}} + \underbrace{\overline{i_c}(u_{ct} - \overline{u_c})}_{\text{term 2}} + \underbrace{(u_{ct} - \overline{u_c})(i_{ct} - \overline{i_c})}_{\text{term 3}} - \frac{\sum_{t=1}^{T_c} (u_{ct} - \overline{u_c})(i_{ct} - \overline{i_c})}{T_c}.
\end{aligned}$$

Thus, the interaction is based on three terms: the product of the between variation in the union density rate and the within variation in integration, the product of the between variation in integration and the within variation in the union density rate, and the product of the within variation of both variables (the final term subtracts the country-specific mean of the third term). Put more simply, the interaction is based on between variation (terms 1 and 2) and within variation (term 3). My theoretical argument is about the moderating influence of within-country differences in European institutional integration on within-country variation

Table A5: Double-demeaned estimator (see Giesselmann and Schmidt-Catran, 2018).

	Model 1 Top 10%	Model 2 Top 10%	Model 3 Top 1%	Model 4 Top 1%
Union strength	−.302*	−.233*	−.121*	−.086
	(.037)	(.055)	(.021)	(.043)
Institutional Integration	.011	−.021*	.002	−.019*
	(.013)	(.007)	(.008)	(.007)
$(u_{ct} - \overline{u_c})(i_{ct} - \overline{i_c})$	.004*	.003*	.002*	.002*
	(.000)	(.001)	(.000)	(.001)
Long series	✓	✓	✓	✓
Time trends	✓		✓	
Year indicators		✓		✓
Countries	15	15	15	15
Observations	516	516	516	516
Within R^2	.576	.716	.477	.614

* Zero outside the confidence interval. Driscoll-Kraay standard errors (in parentheses) robust to a generalized form of spatial and serial autocorrelation. Intercept term and coefficients of control variables not reported to save space.

in trade union strength, i.e., term 3.

Giesselmann and Schmidt-Catran (2018) argue that the terms that capture between variation (terms 1 and 2) might yield biased results in a fixed effects regression, as these terms do not control for unobserved heterogeneity. Thus, the authors propose to specify the interaction term only as defined by term 3 (they call this a 'double-demeaned' estimator). Giesselmann and Schmidt-Catran claim that this proposed estimator is less efficient than the standard estimator but produces unbiased results. Table A5 applies the proposed estimator to my data. The results show that the theoretically relevant within-term, $(u_{ct} - \overline{u_c})(i_{ct} - \overline{i_c})$, is always statistically significant and has the expected positive sign across different specifications. In terms of statistical variation, the within-country dimension of European institutional integration (SD = 34.5) is also much more important than its cross-country dimension (SD = 7.3), which illustrates that the moderating influence of within-country differences in European institutional integration drives the result of the overall interaction term.

References

Giesselmann, Marco, and Alexander Schmidt-Catran. 2018. Interactions in Fixed Effects Regression Models. SSRN Scholarly Paper ID 3227779 Social Science Research Network. Rochester, NY. https://papers.ssrn.com/abstract=3227779

Hainmueller, Jens, Jonathan Mummolo, and Yiqing Xu. 2019. "How Much Should We Trust Estimates from Multiplicative Interaction Models? Simple Tools to Improve Empirical Practice." *Political Analysis* 27(2): 163–192.