Institutions, Comparative Advantage, and the Environment

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What Explains Cross-Country Pollution Differences?

- **Classic answers:**
  - Weak environmental regulation (Pollution Haven Hypothesis)
  - Non-homothetic preferences (Environmental Kuznets curve)
  - Cheap labor (factor endowments)

- **This paper:**
  - Institutions provide comparative advantage in clean industries
    - ★ Credit, judicial, labor market institutions
    - ★ "[H]umanly devised constraints that structure political, economic, and social interaction." – North (1991)

Results Preview

1. Cross-industry: Clean industries depend on institutions
2. Trade regressions: Countries with strong institutions specialize in clean industries
3. Explanations: sophisticated, skilled, specialized inputs
4. Quantitative trade model: Improving institutions decreases pollution 20%
5. Decomposition: Composition explains 60% of pollution; technique 40%

What is New Here

- **Environment: international differences in pollution** (Grossman and Krueger 1993; Copeland and Taylor 2003; Broner, Bustos, Carvalho 2012, Cherniwchan et al. 2017)
  - Institutions drive environmental quality
- **Environment: pollution decompositions** (Antweiler et al. 2001; Levinson 2009; Brunel 2016; Barrows & Ollivier 2018; Shapiro & Walker 2018; Copeland et al. 2022)
  - Composition, not just technique
- **Environment: institutions** (Coase 1960; Chichilnisky 1994; Greenstone & Jack 2015)
  - Comparative advantage important
- **Institutions: economic consequences** (Rajan & Zingales 1998; Acemoglu, Johnson, Robinson 2005; Nunn 2007; Chor 2010; Dell 2010; Cuñat & Melitz 2012; Manova 2013)
  - Important for environment

Overview

- **Data**
  - Country
  - Industry
  - Country$\times$industry
- **Methods and Results**
  - Country, industry correlations
  - Gravity trade regressions
  - Explanations
  - Quantitative trade model
  - Decomposition: scale/composition/technique
- **Conclusions**

Data: Country Variables

- **Sample**: 133 countries plus rest of world, 2012 cross section or 1996-2015 panel
- **Institutions**
  - Financial: Credit by banks & other institutions / GDP (Beck et al. 2019)
  - Judicial: Rule of Law index (World Bank 2007)
  - Labor market freedom index (Heritage Foundation 2021)
  - Index (principal components)
- **Factors**
  - Capital: capital stock per worker (Penn World Tables)
  - Skill: human capital index (Penn World Tables)
- **Environmental regulation**
  - Stringency; enforcement; treaties; gasoline lead; diesel sulfur; environmental taxes/GDP; standards for particulates, sulfur (Broner et al. 2011; WEF 2013; Joss et al. 2017; IMF 2022)
- **Instruments**
  - Legal origins (La Porta et al. 1999)
  - Year 1500 population density (Acemoglu & Johnson 2002)
  - Settler mortality (Acemoglu, Johnson, & Robinson 2001)

Data: Industry Variables

- **Variation**: Baseline: US, manufacturing, NAICS 6-digit. Also: Exiobase
- **Institution intensity**
  - Financial intensity: free cash flow v. capital investment
  - Judicial intensity: inputs priced on open markets, reference-priced
  - Labor intensity: sales volatility
- **Factor intensity**
  - Capital per worker
  - Skills: non-production workers as share of employment
- **Clean index**
  - Air pollution / sales, water pollution / sales
  - "Clean index" = principal component $\times$ (-1)
- **Explanations**
  - Energy share; upstreamness; inverse export supply elasticity; mean wage; college educated; shipping cost per ton$\times$km; mean firm size; etc.
- **Sources**: Rajan & Zingales (1998); Rauch (1999); BEA; Cunat & Melitz (2012); Census of Manufactures: Compustat

Data: Country×Industry Data

- **CEPII**
  - Bilateral trade
  - Distance, language, colonization, borders
- **Exiobase** (version 3.81)
  - Global Multi-Region Input-Output Table
  - 163 industries, 49 countries
  - Pollution emissions from each country×industry

Data: Proximate Explanations

Table: Proximate Explanations for Dependence of Clean Industries on Institutions

Energy share
Raw materials share
Upstreamness
Inverse export supply elasticity
Mean wage
Unemployment (%)
College educated
Union membership
Intra-industry share
Geographic dispersion
Labor share
Capital share
Log shipping cost per ton*km
Mean firm size
Std. dev. Firm size
Concentration ratio
Log output
Output trend 1977-2007

Overview

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- **Methods and Results**
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  - Gravity trade regressions
  - Explanations
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- Conclusions

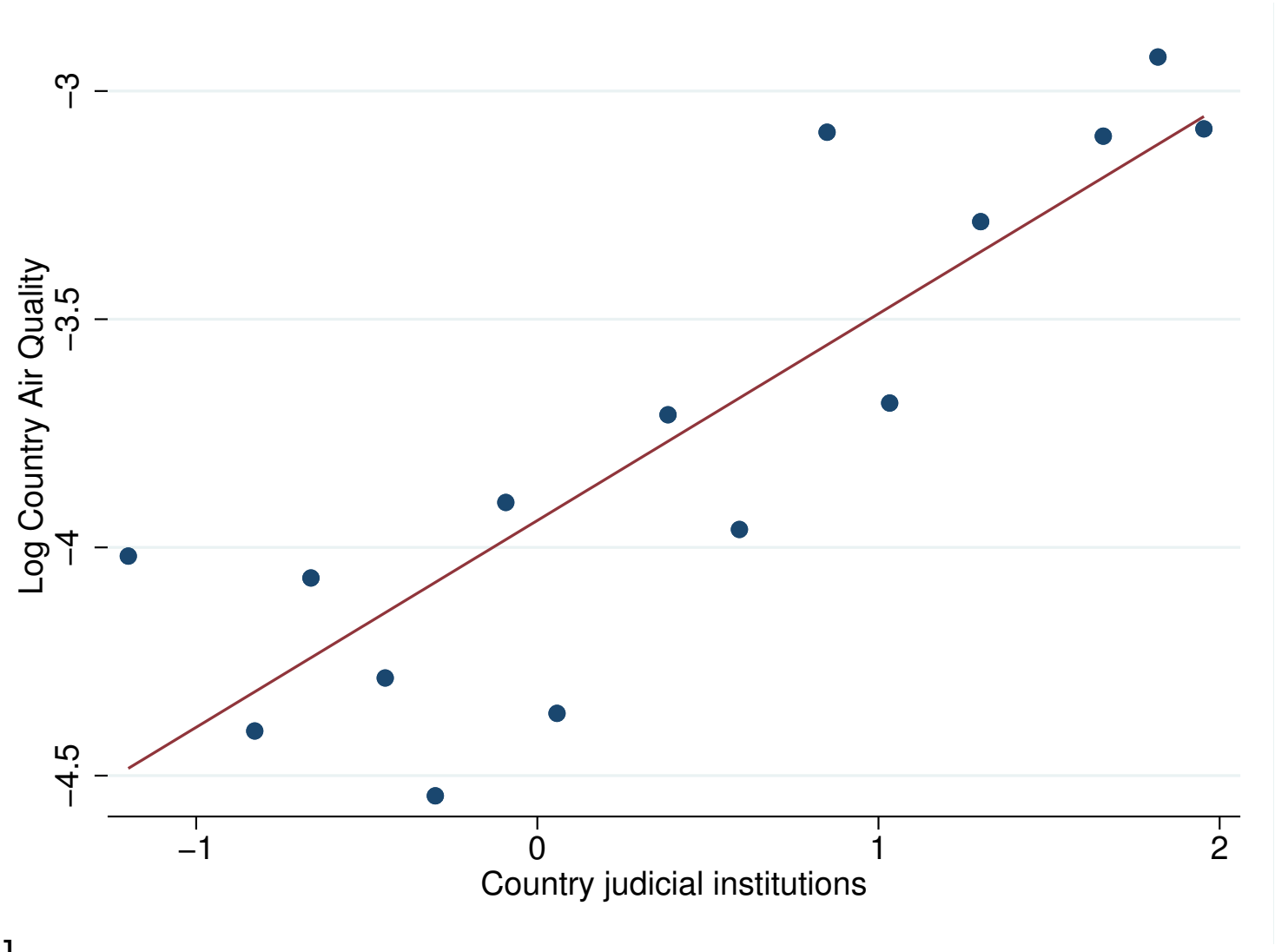
Country Correlations: Institutions v. Environmental Quality

$$Z_i = \rho_0^C + \rho_1^C I_i + \epsilon_i$$

- Z_i Country environmental quality (air, water) in country i
- I_i Country institutions

Country Correlations: Institutions v. Air Quality

$$Z_i = \rho_0^C + \rho_1^C I_i + \epsilon_i$$



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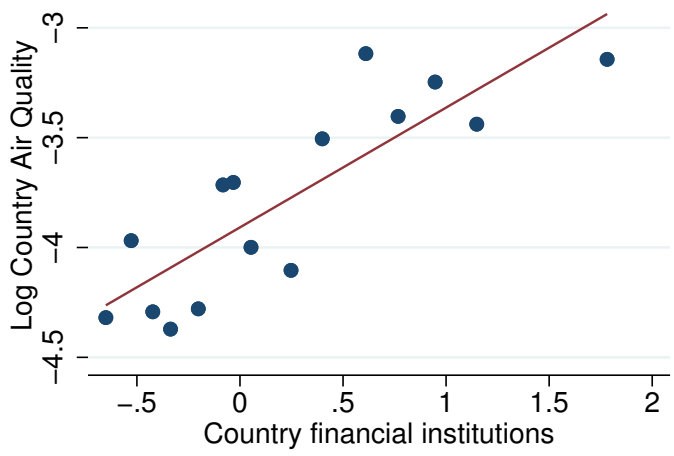
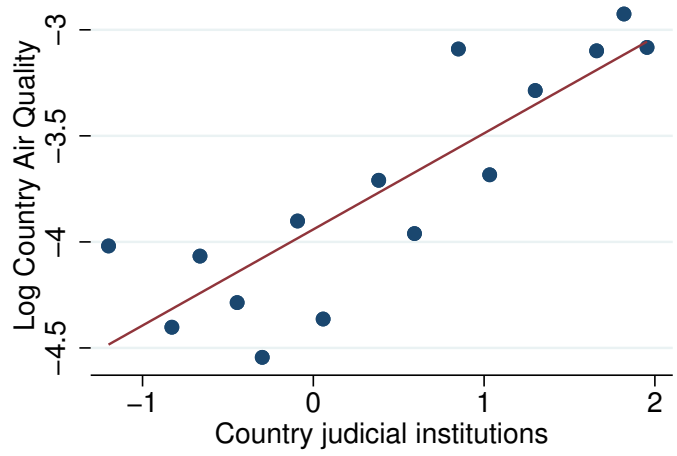
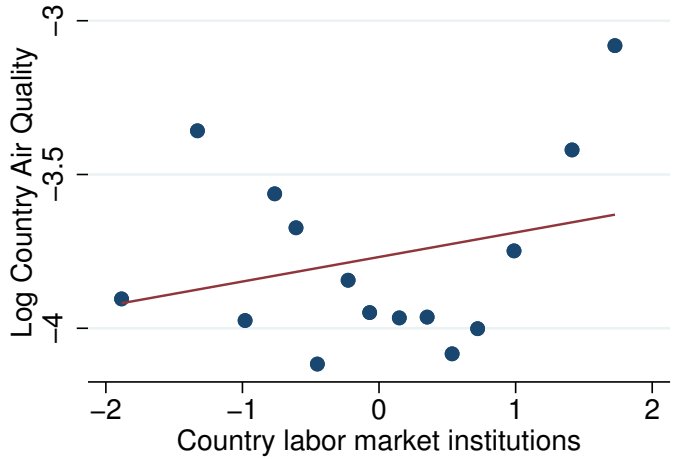
Country Correlations: Institutions v. Air Quality

$$Z_i = \rho_0^C + \rho_1^C I_i + \epsilon_i$$







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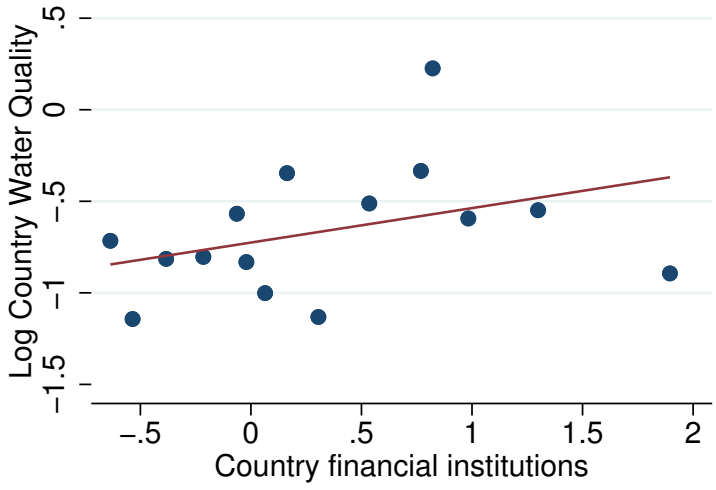
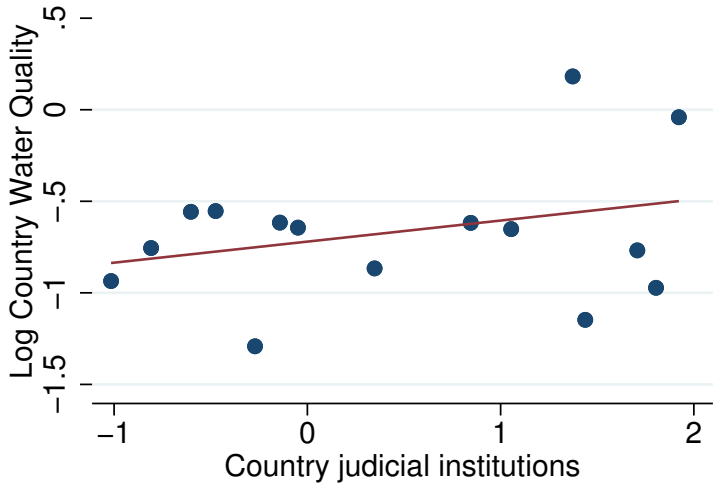
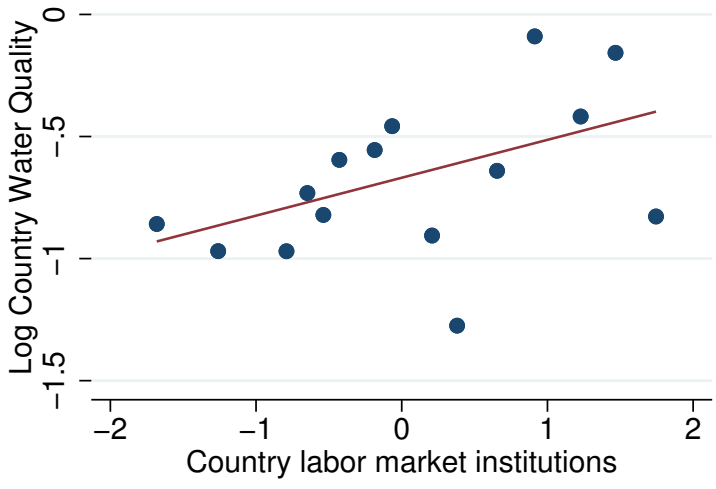
Country Correlations: Institutions v. Water Quality

$$Z_i = \rho_0^C + \rho_1^C I_i + \epsilon_i$$







Industry Correlations: Institution Intensity v. Clean Index

- Cross-industry: Industries intensive in institutions are clean

$$Z_s = \rho_0^I + \rho_1^I I_s + \epsilon_s$$

- Definitions:
  - Z_s: Industry s clean index
  - I_i: Industry s dependence on institutions

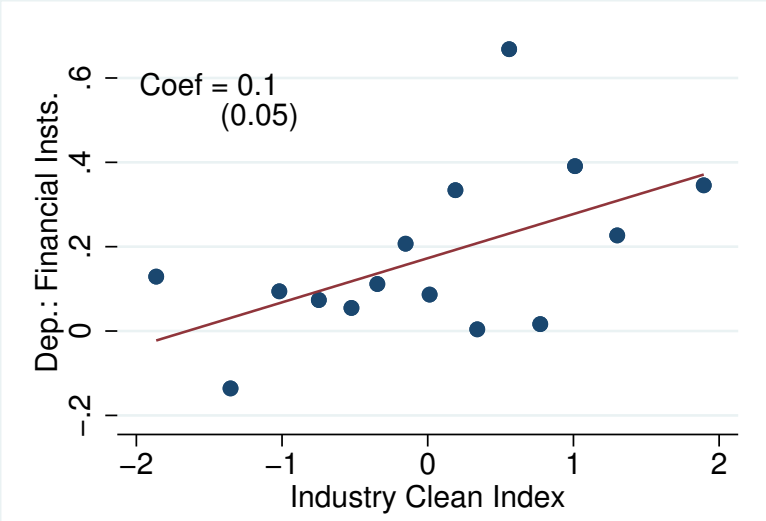
Industry Correlations: Examples

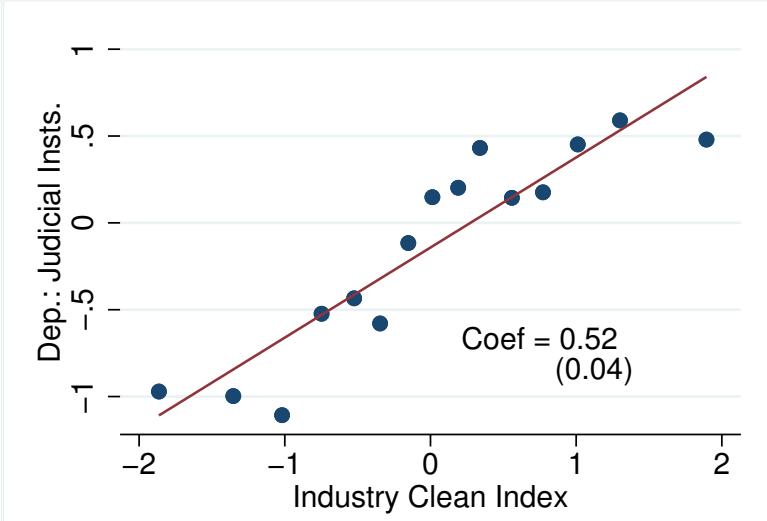
Table 2—Industry Clean Index and Industry Dependence on Institutions

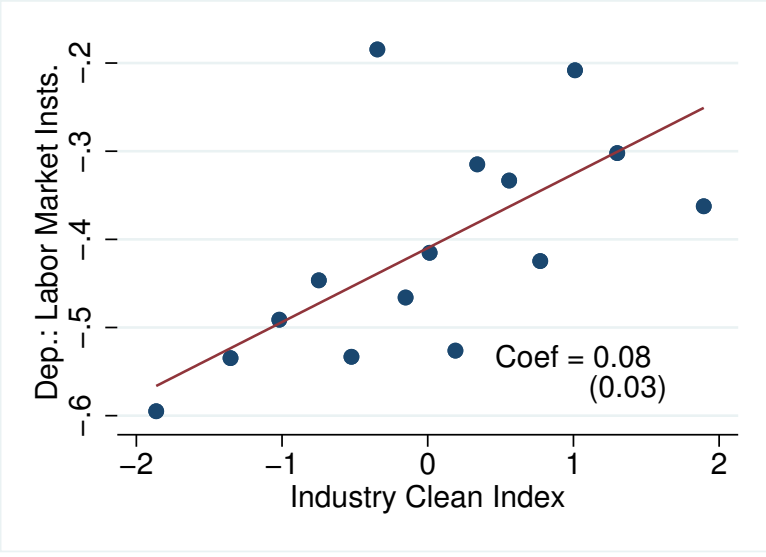
		Industry dependence on institutions			
	Clean index	Financial	Judicial	Labor markets	Index
	(1)	(2)	(3)	(4)	(5)
Panel A. Cleanest industries					
Office Supply Manufacturing	2.64	0.47	-0.06	0.12	0.13
Instruments for Industrial Processes	2.58	1.75	1.20	-0.54	1.25
Fluid Power Pumps and Motors	2.42	1.54	0.71	0.88	1.38
Curtain and Linen Mills	2.40	-0.23	0.52	1.35	0.88
Precision Turned Product Manufacturing	2.23	-0.61	0.20	0.08	0.00
Mean for cleanest industries	*2.46*	*0.58*	*0.51*	*0.38*	*0.73*
Panel B. Dirtiest industries					
Aluminum Refining and Production	-2.17	-0.49	-1.65	-0.53	-1.69
Gypsum Product Manufacturing	-2.18	-0.59	-1.27	-1.22	-1.70
Pulp Mills	-2.22	-0.49	-0.69	-0.18	-0.78
Newsprint Mills	-2.30	-0.53	-0.66	-0.81	-1.03
Other Petroleum, Coal Products	-2.43	-0.22	-1.45	0.64	-0.97
Mean for dirtiest industries	*-2.26*	*-0.46*	*-1.14*	*-0.42*	*-1.23*

Industry Correlations: Dependence on Institutions

$$I_s = \rho_0^I + \rho_1^I Z_s + \epsilon_s$$







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- **Methods and Results**
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  - Quantitative trade model
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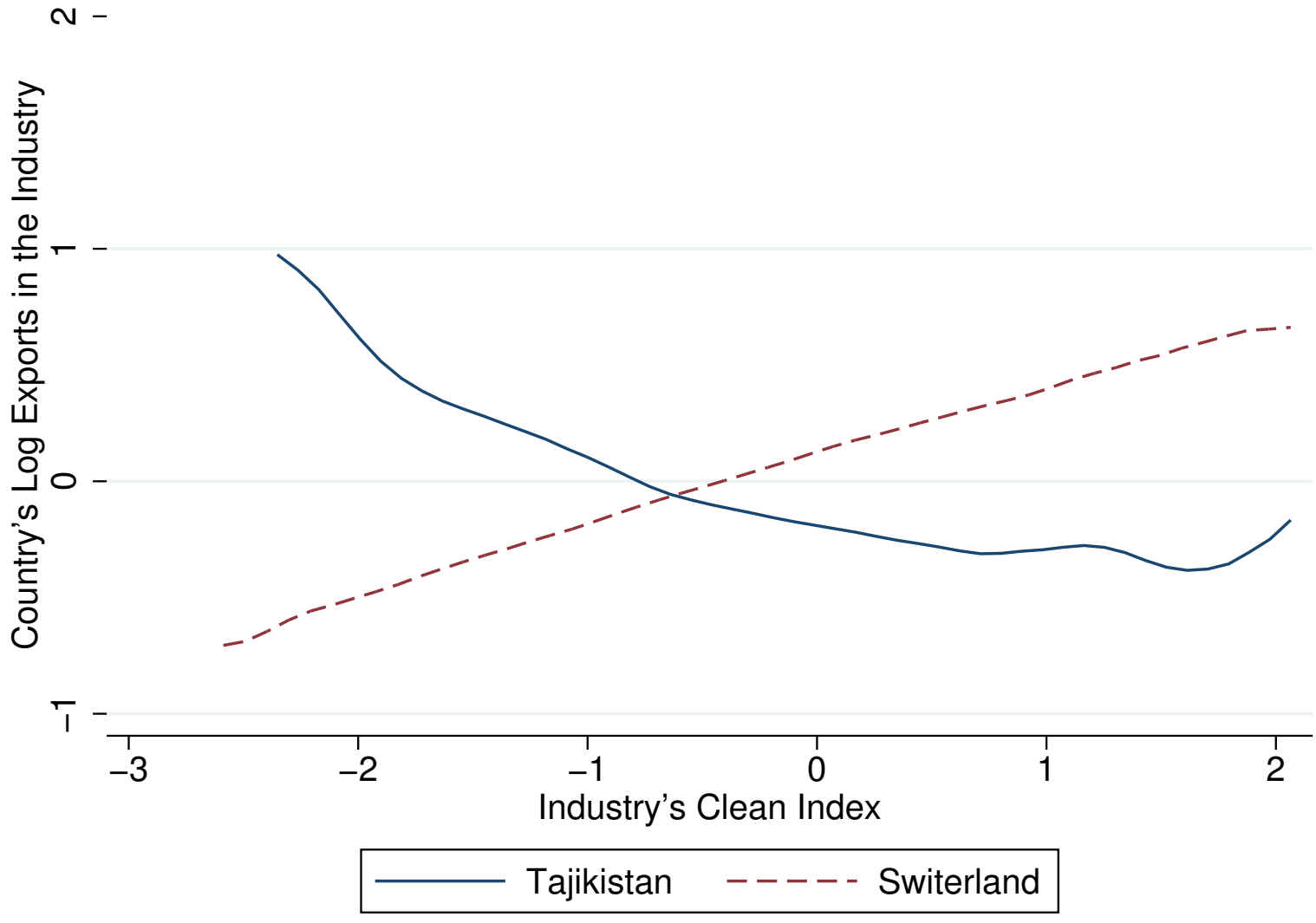
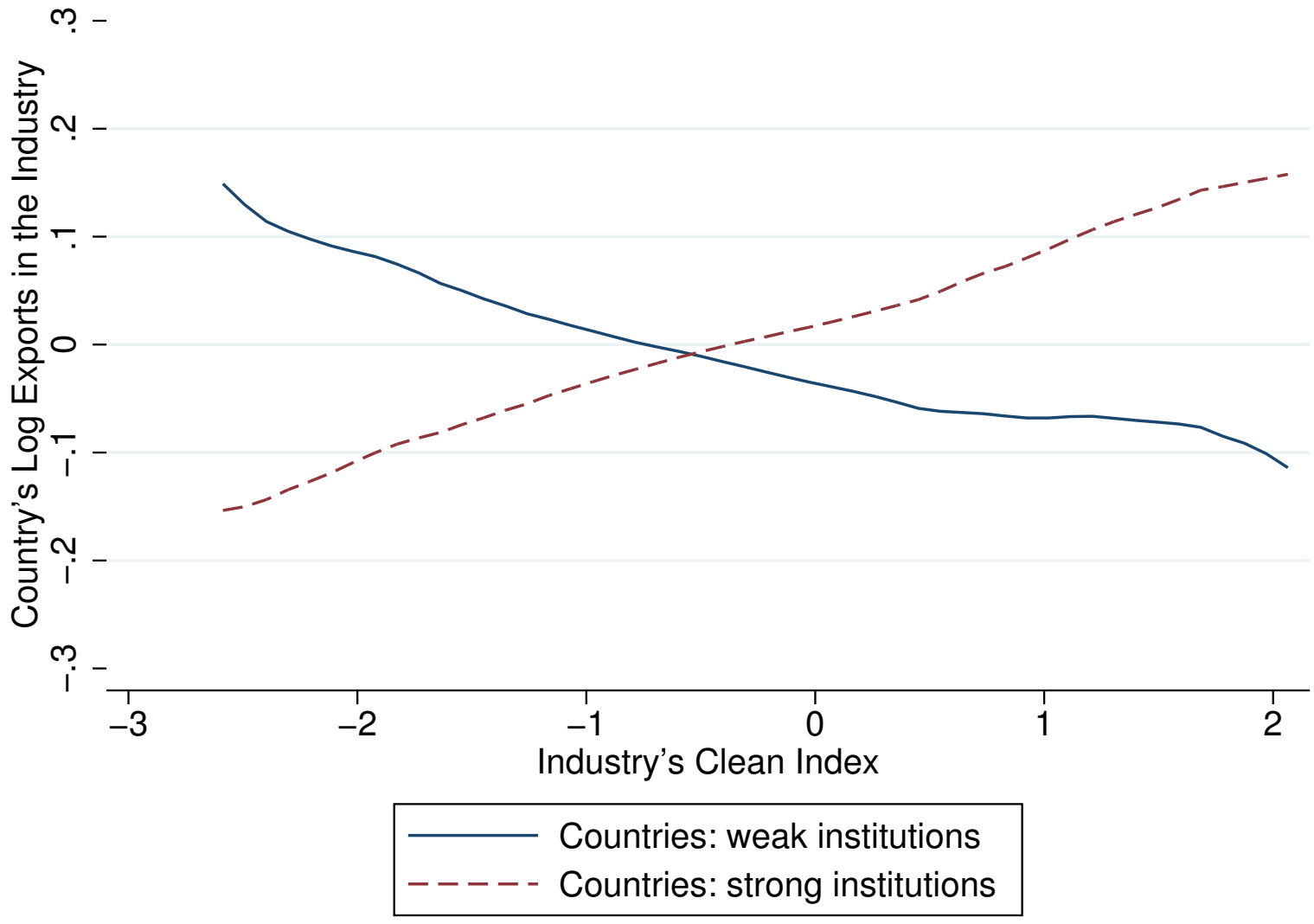
Comparative Advantage: Graphs



Comparative Advantage: Graphs



▸ Balassa (1965), CDK (2012)

Comparative Advantage: All Industries

$$lnX_{ij,s} = \underbrace{\alpha E_i I_s}_{\text{Institutions}} + \underbrace{\pi R_i Z_s}_{\text{Enviro. Policy}} + \underbrace{\Sigma_f \beta_f E_i^f I_s^f}_{\text{Factors}} + \underbrace{\gamma t_{ij,s}}_{\text{Tariffs}} + \zeta_{j,s} + \eta_{ij} + \epsilon_{ij,s}$$

Table 3—Sources of Comparative Advantage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. Comparative advantage in all industries										
Country endowment × industry intensity:										
Institutions: financ.	0.019***	—	—	—	—	—	—	—	0.011***	—
	(0.001)	—	—	—	—	—	—	—	(0.001)	—
Institutions: judicial	—	0.052***	—	—	—	—	—	—	0.036***	—
	—	(0.002)	—	—	—	—	—	—	(0.002)	—
Institutions: labor	—	—	0.003***	—	—	—	—	—	0.003***	—
	—	—	(0.001)	—	—	—	—	—	(0.001)	—
Institutions: index	—	—	—	0.053***	—	—	—	—	—	0.036***
	—	—	—	(0.002)	—	—	—	—	—	(0.002)
Environmental reg.	—	—	—	—	0.048***	—	—	—	0.025***	0.029***
	—	—	—	—	(0.002)	—	—	—	(0.002)	(0.002)
Factor capital/lab.	—	—	—	—	—	0.002	—	—	0.022***	0.020***
	—	—	—	—	—	(0.002)	—	—	(0.002)	(0.002)
Factor: skills	—	—	—	—	—	—	0.071***	—	0.056***	0.056***
	—	—	—	—	—	—	(0.002)	—	(0.002)	(0.002)
Tariffs	—	—	—	—	—	—	—	-0.049***	-0.049***	-0.049***
	—	—	—	—	—	—	—	(0.005)	(0.005)	(0.005)
N	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444

Comparative Advantage: Clean Industries

$$lnX_{ij,s} = \underbrace{\alpha^C E_i Z_s}_{\text{Institutions} \times \text{clean}} + \underbrace{\pi^C R_i Z_s}_{\text{Enviro. Policy}} + \underbrace{\Sigma_f \beta_f^C E_i^f I_s^f}_{\text{Factors}} + \underbrace{\gamma^C t_{ij,s}}_{\text{Tariffs}} + \zeta_{j,s}^C + \eta_{ij}^C + \epsilon_{ij,s}^C$$

Table 3—Sources of Comparative Advantage

	(1)	(2)	(3)	(4)	(5)	(6)
Panel B: Comparative advantage in clean industries						
Country endowment × clean industry index:						
Institutions: financ.	0.052***	—	—	—	0.035***	—
	(0.002)	—	—	—	(0.003)	—
Institutions: judicial	—	0.051***	—	—	0.010*	—
	—	(0.002)	—	—	(0.005)	—
Institutions: labor	—	—	0.019***	—	0.007***	—
	—	—	(0.002)	—	(0.002)	—
Institutions: index	—	—	—	0.054***	—	0.040***
	—	—	—	(0.002)	—	(0.003)
Environmental reg.	—	—	—	—	0.009*	0.010***
	—	—	—	—	(0.005)	(0.003)
Country endowment × industry intensity:						
Factors capital/lab.	—	—	—	—	0.016***	0.016***
	—	—	—	—	(0.002)	(0.002)
Factors: skills	—	—	—	—	0.060***	0.059***
	—	—	—	—	(0.002)	(0.002)
Tariffs	—	—	—	—	-0.049***	-0.049***
	—	—	—	—	(0.005)	(0.005)
N	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444
Fitted effect 10→90%	-21.2%	-37.0%	-15.4%	-35.4%	-23.4%	-26.7%
Importer×exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer×industry FE	Yes	Yes	Yes	Yes	Yes	Yes

Other Research Designs: IV-First Stage

$$E_i I_s = \underbrace{\Sigma_o \alpha_o^F L_{i,o} I_s}_{\text{Legal origins}} + \underbrace{\Sigma_f \beta_f^F E_i^f I_s^f}_{\text{Factors}} + \underbrace{\pi^F R_i Z_s}_{\text{Enviro. policy}} + \underbrace{\gamma^F t_{ij,s}}_{\text{Tariffs}} + \zeta_{j,s}^F + \eta_{ij}^F + \epsilon_{ij,s}^F$$

Appendix Table 4—Institutions and Legal Origin Interactions: First-Stage Estimates

	All industries				Clean industries			
Which institutions:	Financial	Judicial	Labor	Inst. Index	Financial	Judicial	Labor	Inst. Index
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Clean index × …								
Legal origins: British	-0.001	0.001	0.044***	0.091***	-0.013	0.010	0.617***	0.202***
	(0.003)	(0.006)	(0.003)	(0.012)	(0.029)	(0.012)	(0.043)	(0.025)
Legal origins: French	-0.016***	-0.125***	-0.028***	-0.137***	-0.199***	-0.225***	-0.215***	-0.259***
	(0.004)	(0.007)	(0.003)	(0.013)	(0.033)	(0.012)	(0.052)	(0.024)
Legal origins: German	-0.011***	-0.019***	0.001	-0.024***	-0.083***	-0.028***	0.049	-0.032*
	(0.002)	(0.002)	(0.002)	(0.008)	(0.019)	(0.004)	(0.030)	(0.017)
Legal origins: Socialist	-0.026***	-0.148***	-0.007***	-0.135***	-0.214***	-0.276***	-0.075*	-0.262***
	(0.003)	(0.004)	(0.003)	(0.010)	(0.025)	(0.008)	(0.038)	(0.019)
N	1,957,753	1,957,753	1,957,753	1,957,753	1,957,753	1,957,753	1,957,753	1,957,753
R-K F Statistic	35.0	410.5	367.9	315.3	37.5	341.0	356.7	255.4
Importer×exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer×industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Factor interactions, tariffs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Panel E uses state and industry FE. Each table entry shows beta coefficients. Standard errors are clustered by importer×exporter pair. Asterisks denote p-value * < 0.10, ** < 0.05, *** < 0.01.

Other Research Designs: IV

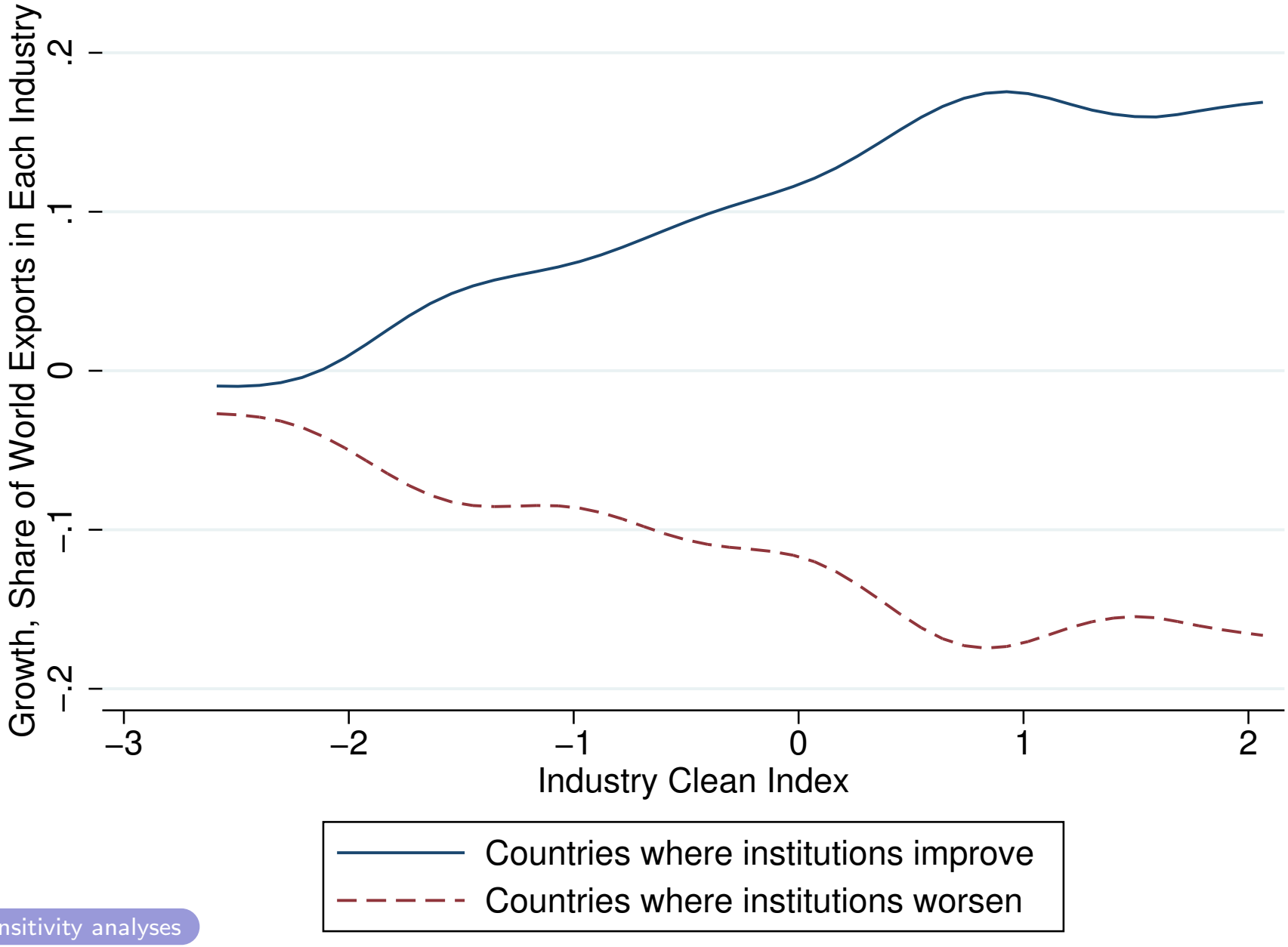
$$lnX_{ij,s} = \underbrace{\alpha^S E_i I_s}_{\text{Institutions}} + \underbrace{\Sigma_f \beta_f^S E_i^f I_s^f}_{\text{Factors}} + \underbrace{\pi^S R_i Z_s}_{\text{Enviro. policy}} + \underbrace{\gamma^S t_{ij,s}}_{\text{Tariffs}} + \zeta_{j,s}^S + \eta_{ij}^S + \epsilon_{ij,s}^S$$

Table 4—Institutions and Comparative Advantage, Alternative Research Designs

	All industries				Clean industries			
Institution:	Financial	Judicial	Labor	Inst. Index	Financial	Judicial	Labor	Inst. Index
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel B. Instrument with legal origins								
Institutions interaction	0.152	0.107***	-0.002	0.033***	0.189***	0.106***	0.020***	0.044***
	(0.127)	(0.027)	(0.002)	(0.006)	(0.062)	(0.014)	(0.002)	(0.005)
Environmental regulation	0.033***	-0.003	0.040***	0.030***	-0.074*	-0.052***	0.037***	0.007*
	(0.006)	(0.011)	(0.002)	(0.003)	(0.038)	(0.012)	(0.002)	(0.004)
N	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444
Importer×exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer×industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Factor interactions, tariffs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: "Institution interaction: is interaction of county institutions×industry clean index. Environmental regulation is interaction of country environmental regulation and industry clean index. Additional controls in Panel E are state FE, industry FE, and factor interactions. Table entries show standardized beta coefficients. Standard errors are clustered by importer×exporter pair. Asterisks denote p-value * < 0.10, ** < 0.05, *** < 0.01.

Other Research Designs: Panel Graph



▸ Sensitivity analyses

Other Research Designs: Panel

$$lnX_{ij,sy} = \alpha^P E_{i,y} Z_s + \sum_f \beta_f^P E_{i,y}^f I_s^f + \zeta_{j,sy}^P + \eta_{ij,y}^P + \epsilon_{ij,sy}^P$$

Table 4—Institutions and Comparative Advantage, Alternative Research Designs

	All industries				Clean industries			
Institution:	Financial	Judicial	Labor	Inst. Index	Financial	Judicial	Labor	Inst. Index
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel C. Full panel								
Institutions interaction	0.002***	0.018***	0.003***	0.010***	0.005***	0.021***	0.006***	0.013***
	(0.000)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
N	29,615,619	31,205,815	29,179,570	27,743,169	30,409,354	31,205,815	29,179,570	28,488,568
Panel D. Long difference								
Institutions interaction	0.002	0.070***	0.034***	0.043***	0.014***	0.073***	0.050***	0.061***
	(0.003)	(0.015)	(0.009)	(0.008)	(0.004)	(0.014)	(0.008)	(0.008)
N	2,977,570	3,129,772	3,125,693	2,973,978	3,057,707	3,129,772	3,125,693	3,054,038
Importer×exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer×industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Factor interactions, tariffs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: "Institution interaction: is interaction of county institutions×industry clean index. Environmental regulation is interaction of country environmental regulation and industry clean index. Additional controls in Panel E are state FE, industry FE, and factor interactions. Table entries show standardized beta coefficients. Standard errors are clustered by importer×exporter pair. Asterisks denote p-value * < 0.10, ** < 0.05, *** < 0.01.

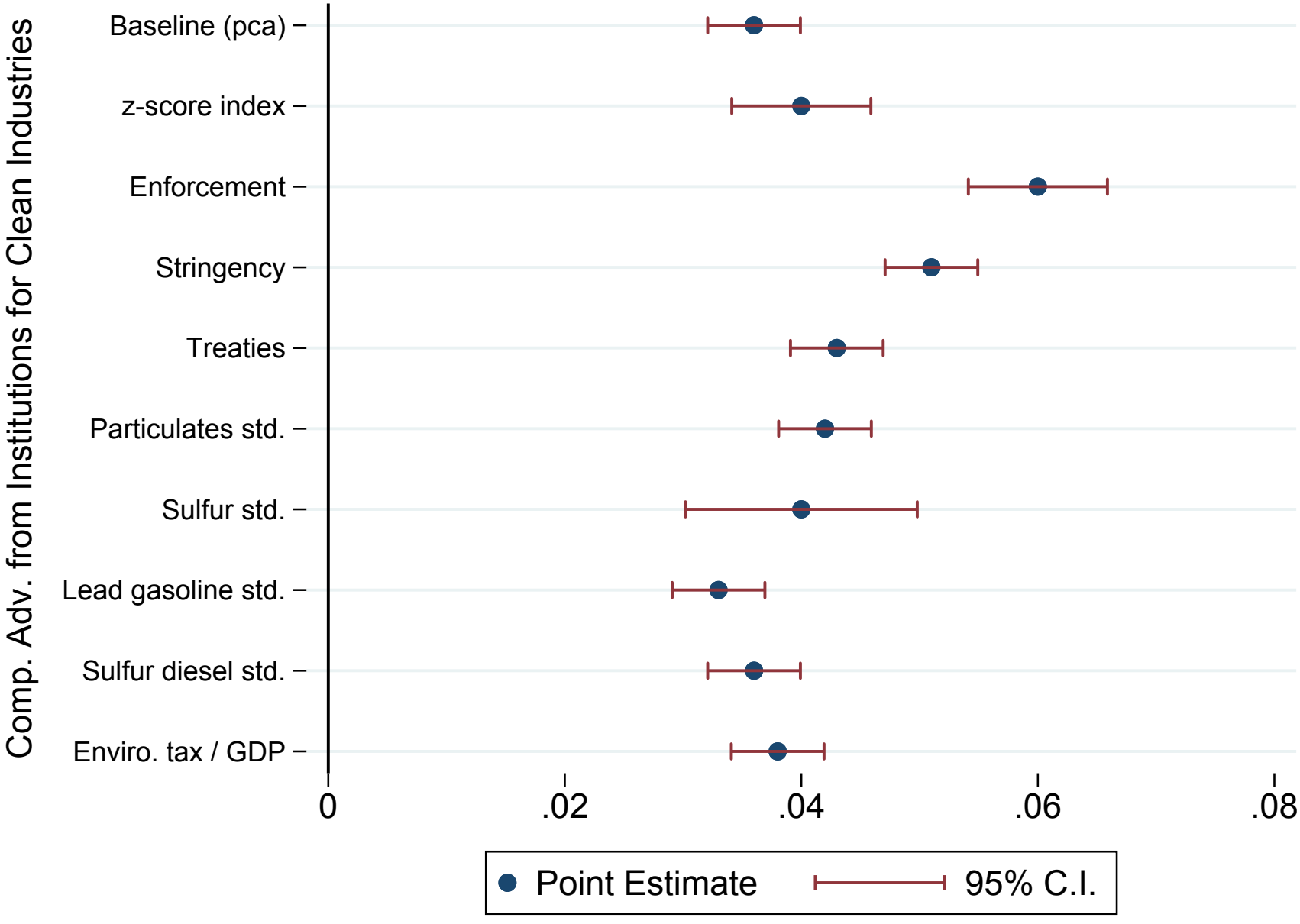
Other Research Designs: Intra-National India

$$lnX_{is} = \alpha^I E_i I_s + \sum_f \beta_f^I E_i^f I_s^f + \pi^I R_i Z_s + \eta_i^I + \zeta_s^I + \epsilon_{i,s}^I$$

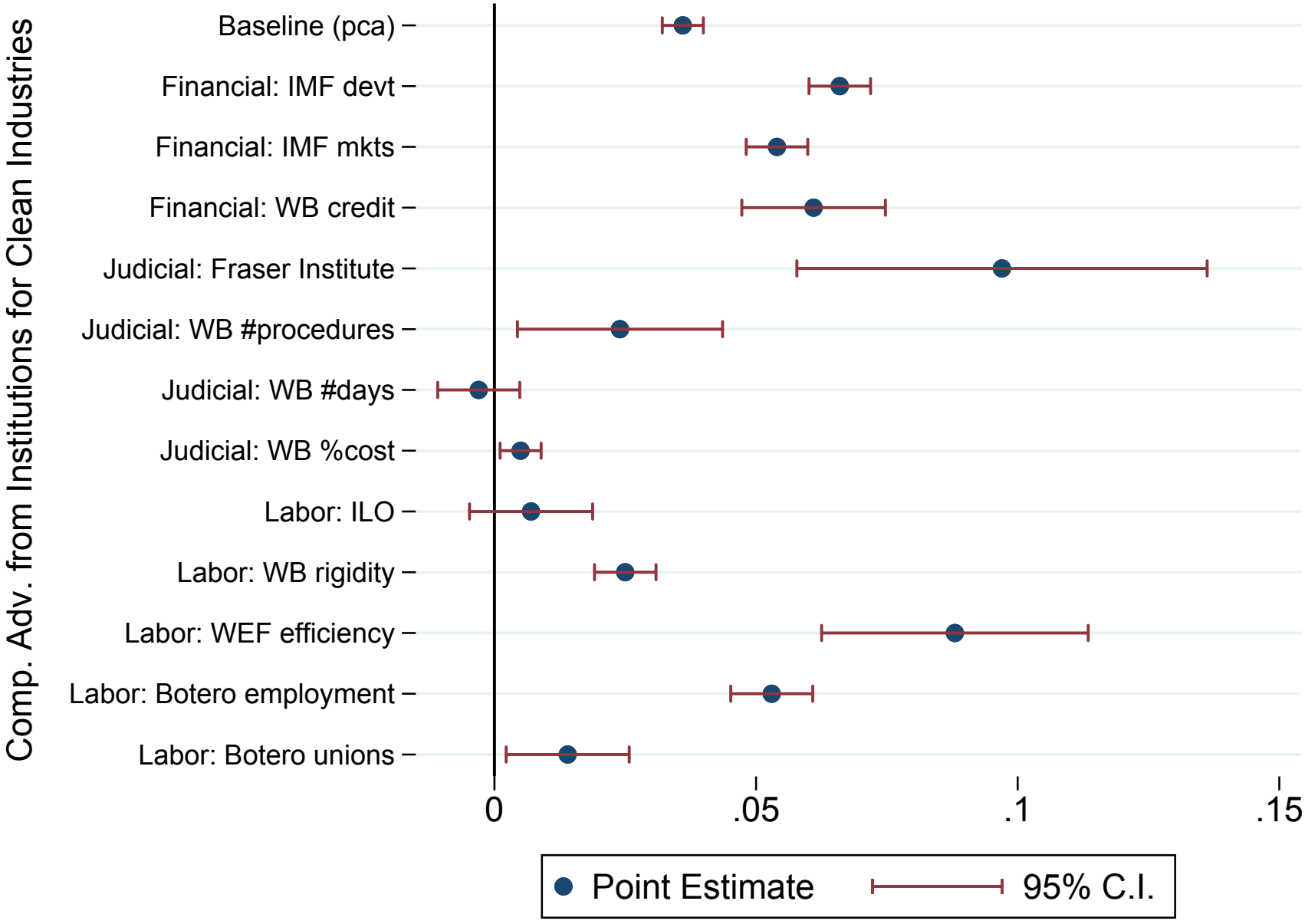
Table 4—Institutions and Comparative Advantage, Alternative Research Designs

	All industries				Clean industries			
Institution:	Financial	Judicial	Labor	Inst. Index	Financial	Judicial	Labor	Inst. Index
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel E. Intra-national: India								
Institutions interaction	0.492***	0.098***	0.008	0.116***	0.837***	0.066***	-0.006	0.077***
	(0.104)	(0.020)	(0.017)	(0.010)	(0.091)	(0.017)	(0.015)	(0.009)
N	6,189	7,840	6,686	6,189	6,328	7,840	6,686	6,328
Importer×exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer×industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Factor interactions, tariffs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

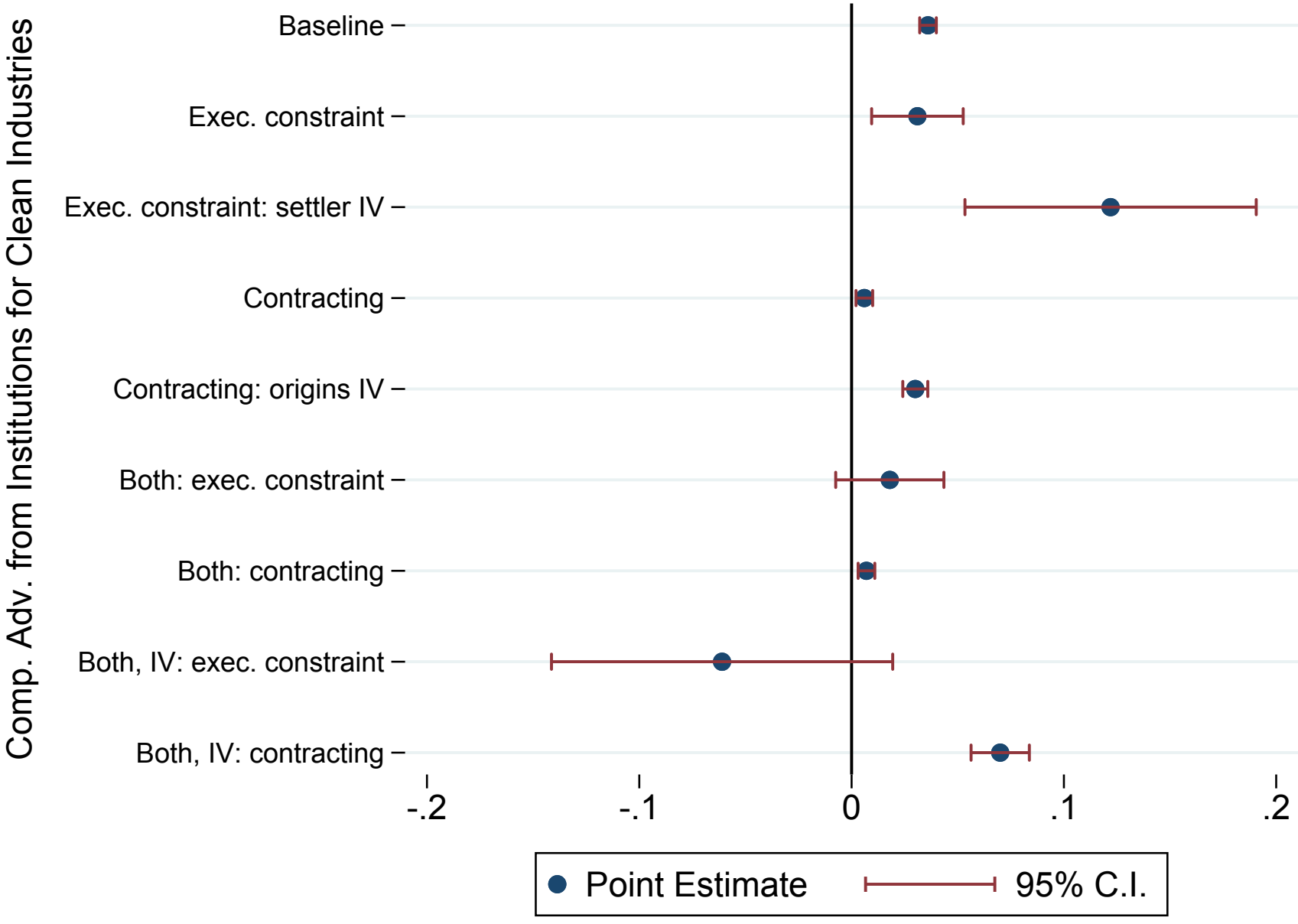
Sensitivity: Measures of Environmental Regulation



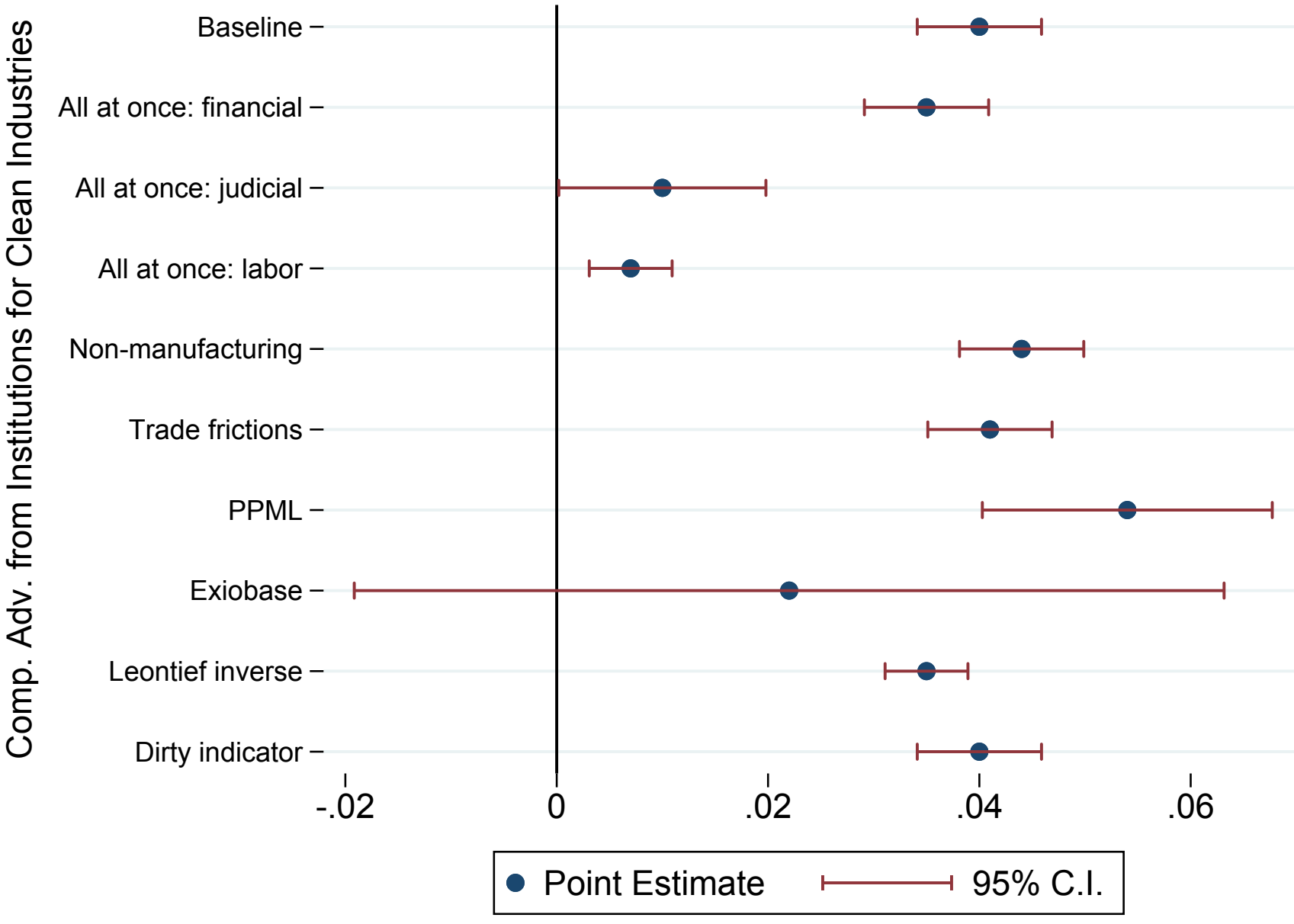
Sensitivity: Other Measures of Institutions



Sensitivity: Unbundling Institutions



Sensitivity: Other



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Regressions: Proximate Explanations

- Correlation with industry clean index:

$$Z_s = \rho_0^W + \rho_1^W W_s + \epsilon_s^W$$

- Attenuates correlation of clean index and institutional dependence?

$$I_s = \rho_0^{IW} + \rho_1^{IW} Z_s + \rho_2^{IW} W_s + \epsilon_s^{IW}$$

- Attenuates comparative advantage?

$$lnX_{ij,s} = \alpha^W E_i Z_s + \alpha^W E_i W_s + \sum_f \beta_f^W E_i^f I_s^f + \pi^W R_i Z_s + \gamma^W t_{ij,s} + \zeta_{j,s}^W + \eta_{ij}^W + \epsilon_{ij,s}^W$$

Regressions: Proximate Explanations

Table 5: Roles of Other Industry Characteristics

	Association with clean index	Dependence of clean industries on institutions:			Comparative advantage of clean industries
		Financial	Judicial	Labor	
	(1)	(2)	(3)	(4)	(5)
Baseline	—	0.10**	0.52***	0.14***	0.036***
	—	(0.05)	(0.04)	(0.05)	(0.002)
Energy share	-0.37***	0.11*	0.44***	0.13***	0.031***
	(0.12)	(0.06)	(0.04)	(0.05)	(0.002)
Raw materials share	-0.36***	0.07	0.36***	0.15***	0.024***
	(0.05)	(0.06)	(0.04)	(0.05)	(0.002)
Upstreamness	-0.35***	0.09	0.40***	0.12**	0.043***
	(0.05)	(0.06)	(0.04)	(0.05)	(0.002)
Inverse export supply elasticity	0.27***	0.08	0.54***	0.12*	0.040***
	(0.06)	(0.07)	(0.05)	(0.06)	(0.002)
Mean wage	0.14**	0.08	0.48***	0.09*	0.033***
	(0.06)	(0.06)	(0.05)	(0.05)	(0.002)
Unemployment (%)	0.09*	0.13**	0.50***	0.11**	0.039***
	(0.05)	(0.06)	(0.04)	(0.05)	(0.002)
College educated	0.20***	0.05	0.48***	0.08	0.028***
	(0.06)	(0.06)	(0.05)	(0.05)	(0.002)
Union membership	-0.25***	0.14**	0.51***	0.10*	0.036***
	(0.05)	(0.07)	(0.05)	(0.06)	(0.002)

Regressions: Proximate Explanations

Table 5: Roles of Other Industry Characteristics

	Association with clean index	Dependence of clean industries on institutions:			Comparative advantage of clean industries
		Financial	Judicial	Labor	
	(1)	(2)	(3)	(4)	(5)
(Continued from previous)					
Intra-industry share	0.12*	0.09	0.60***	0.12**	0.035***
	(0.06)	(0.07)	(0.05)	(0.06)	(0.002)
Geographic dispersion	-0.02	0.12**	0.51***	0.10**	0.039***
	(0.06)	(0.06)	(0.04)	(0.05)	(0.002)
Labor share	0.27***	0.17***	0.46***	0.09	0.040***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.002)
Capital share	-0.20***	0.10*	0.52***	0.10*	0.043***
	(0.07)	(0.06)	(0.05)	(0.05)	(0.002)
Log shipping cost per ton*km	-0.45***	0.00	0.45***	0.03	0.017***
	(0.06)	(0.09)	(0.06)	(0.07)	(0.002)
Mean firm size	-0.10***	0.13**	0.51***	0.10*	0.037***
	(0.04)	(0.06)	(0.04)	(0.05)	(0.002)
Std. dev. Firm size	-0.06	0.13**	0.51***	0.10*	0.038***
	(0.04)	(0.06)	(0.04)	(0.05)	(0.002)
Concentration ratio	-0.11*	0.13**	0.52***	0.10*	0.038***
	(0.06)	(0.06)	(0.04)	(0.05)	(0.002)
Log output	0.02	0.13**	0.50***	0.10*	0.040***
	(0.05)	(0.06)	(0.04)	(0.05)	(0.002)
Output trend 1977-2007	-0.11*	0.13**	0.52***	0.06	0.037***
	(0.06)	(0.06)	(0.05)	(0.05)	(0.002)
All at once	—	-0.06	0.15***	-0.02	0.007***
	—	(0.12)	(0.06)	(0.10)	(0.002)

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Methods: Quantitative Trade Model

- **Key model features:**
  - Ricardian (Eaton-Kortum, perfect competition)
  - Multiple industries, intermediates, input-output, trade imbalances, tariffs
  - Fixed emission rates per country$\times$industry
  - Exact hat algebra for counterfactuals

Methods: Quantitative Trade Model

- **Preferences**

$$U_j = \prod_s \left[\left(\int_\Omega q_{j,s}(\omega)^{\frac{\sigma_s - 1}{\sigma_s}} d\omega \right)^{\frac{\sigma_s}{\sigma_s - 1}} \right]^{\beta_{j,s}} f(Z_j) \tag{1}$$

- **Price index**

$$P_{j,s} = \xi_1 \left[\sum_i T_{i,s} (c_{i,s} \phi_{ij,s})^{-\theta_s} \right]^{-1/\theta_s} \tag{2}$$

- **Production costs**

$$c_{i,s} = \xi_2 w_i^{1-\alpha_{i,s}} \prod_k P_{i,k}^{\alpha_{i,ks}} \tag{3}$$

- **Pollution**

$$Z_i = \sum_s \frac{\gamma_{i,s} R_{i,s}}{c_{i,s}} \tag{4}$$

- **Equilibrium expenditure**

$$X_{j,s} = \beta_{j,s}(Y_j + D_j + G_j) + \sum_k \alpha_{j,sk} R_{j,k} \tag{5}$$

$$\lambda_{ij,s} = \frac{T_{i,s}(\phi_{ij,s} c_{i,s})^{-\epsilon_s}}{\sum_l T_{i,s}(\phi_{lj,s} c_{l,s})^{-\epsilon_s}} \tag{6}$$

Methods: Quantitative Trade Model

- Define $\hat{x} \equiv x'/x$ (Dekle, Eaton, & Kortum 2008)
- Exact hat algebra:

$$\hat{c}_{i,s} = \hat{Y}_i^{1-\alpha_{i,s}} \prod_k \hat{P}_{i,k}^{\alpha_{i,ks}} \tag{7}$$

$$\hat{P}_{j,s} = \left(\sum_i \lambda_{ij,s} (\hat{c}_{i,s})^{-\epsilon_s} \hat{T}_{i,s} \right)^{-\epsilon_s} \tag{8}$$

$$\hat{\lambda}_{ij,s} = \frac{(\hat{c}_{i,s})^{-\epsilon_s} \hat{T}_{i,s}}{\sum_m \lambda_{mj,s} (\hat{c}_{m,s})^{-\epsilon_s} \hat{T}_{m,s}} \tag{9}$$

$$\hat{E}_{j,s} E_{j,s} = \beta \left(\hat{w}_j Y_j + D_j + \sum_{i,l} \hat{\lambda}_{ij,l} \lambda_{ij,l} \sum_k \alpha_{j,lk} \hat{R}_{j,k} R_{j,k} \right) + \sum_k \alpha_{j,sk} \hat{R}_{j,k} R_{j,k} \tag{10}$$

$$\hat{R}_{i,s} R_{i,s} = \sum_j \frac{\hat{\lambda}_{ij,s} \lambda_{ij,s}}{1 + t'_{ij,s}} \hat{E}_{j,s} E_{j,s} \tag{11}$$

$$\hat{Y}_i Y_i = \sum_s (1 - \alpha_{i,s}) \hat{R}_{i,s} R_{i,s} \tag{12}$$

$$\sum_i \hat{Y}_i Y_i = 1 \tag{13}$$

Quantitative Trade Model: Counterfactual Productivity

Change in country×industry due to changing institutions:

$$\hat{T}_{i,s} = exp\left\{\alpha I_s(E_i^{'} - E_i)\right\}$$

- α: estimated from comparative advantage regressions
- I_s: data
- E_i: data
- E_i': shock (defines a counterfactual)

Trade Model: Implementation

- **Exiobase**
  - Aggregation: 10 countries, 21 industries
  - Air pollution, trade from Exiobase
- **Parameters**
  - Trade elasticities: aggregate across studies (Caliendo & Parro 2015; Shapiro 2016; Giri et al. 2020; Bagwell et al. 2021)
- **Counterfactuals**
  - Equalize institutions across countries
  - Improve institutions for bottom half of countries
  - Improve institutions for region with worst institutions

Model Results: Counterfactual # 1

Table 7—Effects of Counterfactual Institutions on Emissions: Model-Based Analysis

		Counterfactual change in…			Change: share output from…		
	Baseline institutions (z-score)	Institutional quality (z-score)	Emissions (%)	Emissions/ output (%)	Dirty industries	Moderate industries	Clean industries
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A. Counterfactual: remove institutional differences between countries							
Pacific Ocean	1.9	-1.1	5.1%	6.8%	1.3%	0.1%	-1.4%
Western Europe	1.2	-0.4	0.8%	1.5%	0.3%	0.0%	-0.3%
Eastern Europe	-0.3	1.2	-4.6%	-4.6%	-1.4%	-0.4%	1.8%
Latin America	-0.5	1.3	-9.5%	-10.0%	-1.1%	-0.6%	1.7%
North America	2.1	-1.2	1.9%	3.4%	0.5%	0.2%	-0.7%
China	0.7	0.2	-0.9%	-0.9%	-0.3%	-0.1%	0.4%
Southern Europe	0.7	0.1	-1.3%	-1.5%	-0.3%	-0.1%	0.4%
Northern Europe	2.6	-1.8	11.8%	13.8%	2.2%	0.8%	-3.0%
Indian Ocean	-0.1	1.0	-4.6%	-4.3%	-0.8%	0.0%	0.7%
Rest of World	0.1	0.7	-6.6%	-6.4%	-0.9%	-0.5%	1.4%
Global	—	—	*-2.4%*	*-1.7%*	—	—	—

Model Results: Counterfactual # 2

Table 7—Effects of Counterfactual Institutions on Emissions: Model-Based Analysis

		Counterfactual change in…			Change: share output from…		
	Baseline institutions (z-score)	Institutional quality (z-score)	Emissions (%)	Emissions/ output (%)	Dirty industries	Moderate industries	Clean industries
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel B. Counterfactual: improve institutions in countries with below-median baseline institutions							
Pacific Ocean	1.9	0.0	4.9%	4.9%	1.0%	0.1%	-1.1%
Western Europe	1.2	0.0	3.9%	3.9%	0.8%	0.1%	-0.9%
Eastern Europe	-0.3	2.0	-4.1%	-4.0%	-1.1%	-0.2%	1.3%
Latin America	-0.5	2.2	-8.0%	-8.4%	-0.8%	-0.4%	1.2%
North America	2.1	0.0	2.5%	2.4%	0.4%	0.1%	-0.5%
China	0.7	1.1	-5.5%	-4.7%	-1.2%	-0.1%	1.3%
Southern Europe	0.7	0.0	3.3%	3.2%	0.8%	0.1%	-0.9%
Northern Europe	2.6	0.0	4.5%	4.4%	0.7%	0.1%	-0.8%
Indian Ocean	-0.1	1.8	-4.8%	-4.1%	-0.5%	0.3%	0.2%
Rest of World	0.1	1.6	-8.5%	-7.9%	-1.0%	0.0%	1.1%
Global	—	—	*-4.1%*	*-3.9%*	—	—	—

Model Results: Counterfactual # 3

Table 7—Effects of Counterfactual Institutions on Emissions: Model-Based Analysis

		Counterfactual change in…			Change: share output from…		
	Baseline institutions (z-score)	Institutional quality (z-score)	Emissions (%)	Emissions/ output (%)	Dirty industries	Moderate industries	Clean industries
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel C. Counterfactual: improve institutions in Latin America							
Pacific Ocean	1.9	0.0	0.4%	0.4%	0.1%	0.0%	-0.1%
Western Europe	1.2	0.0	0.4%	0.3%	0.1%	0.0%	-0.1%
Eastern Europe	-0.3	0.0	0.2%	0.2%	0.1%	0.0%	-0.1%
Latin America	-0.5	3.1	-19.0%	-19.8%	-2.1%	-0.9%	3.0%
North America	2.1	0.0	1.1%	1.0%	0.1%	0.1%	-0.2%
China	0.7	0.0	0.3%	0.4%	0.1%	0.0%	-0.1%
Southern Europe	0.7	0.0	0.4%	0.3%	0.1%	0.0%	-0.1%
Northern Europe	2.6	0.0	0.5%	0.5%	0.1%	0.0%	-0.1%
Indian Ocean	-0.1	0.0	0.3%	0.3%	0.1%	0.0%	-0.1%
Rest of World	0.1	0.0	1.0%	0.9%	0.1%	0.0%	-0.2%
Global	—	—	*-0.7%*	*-0.7%*	—	—	—

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Methods: Scale, Composition, and Technique

- **Accounting identity**:

$$\mathcal{E} = \sum_s \mathcal{E}_s = \sum_s X_s e_s = X \sum_s \kappa_s e_s$$

- **Total derivative**:

$$\frac{d\mathcal{E}}{\mathcal{E}} = \frac{dX}{X} + \frac{d\kappa}{\kappa} + \frac{de}{e}$$

- **Implementation**:

$$Scale = \frac{\sum_s x_{i,s}}{\sum_s x_{r,s}}$$

$$Composition = \frac{\sum_s \kappa_{i,s} e_{r,s}}{\sum_s \kappa_{r,s} e_{r,s}} = \frac{\sum_s \kappa_{i,s} e_{r,s}}{\mathcal{E}_r / X_r}$$

$$Technique = \frac{\sum_s \kappa_{i,s} e_{i,s}}{\sum_s \kappa_{i,s} e_{r,s}} = \frac{\mathcal{E}_i / X_i}{\sum_s \kappa_{i,s} e_{r,s}}$$

Results: Scale, Composition, and Technique Decomp.

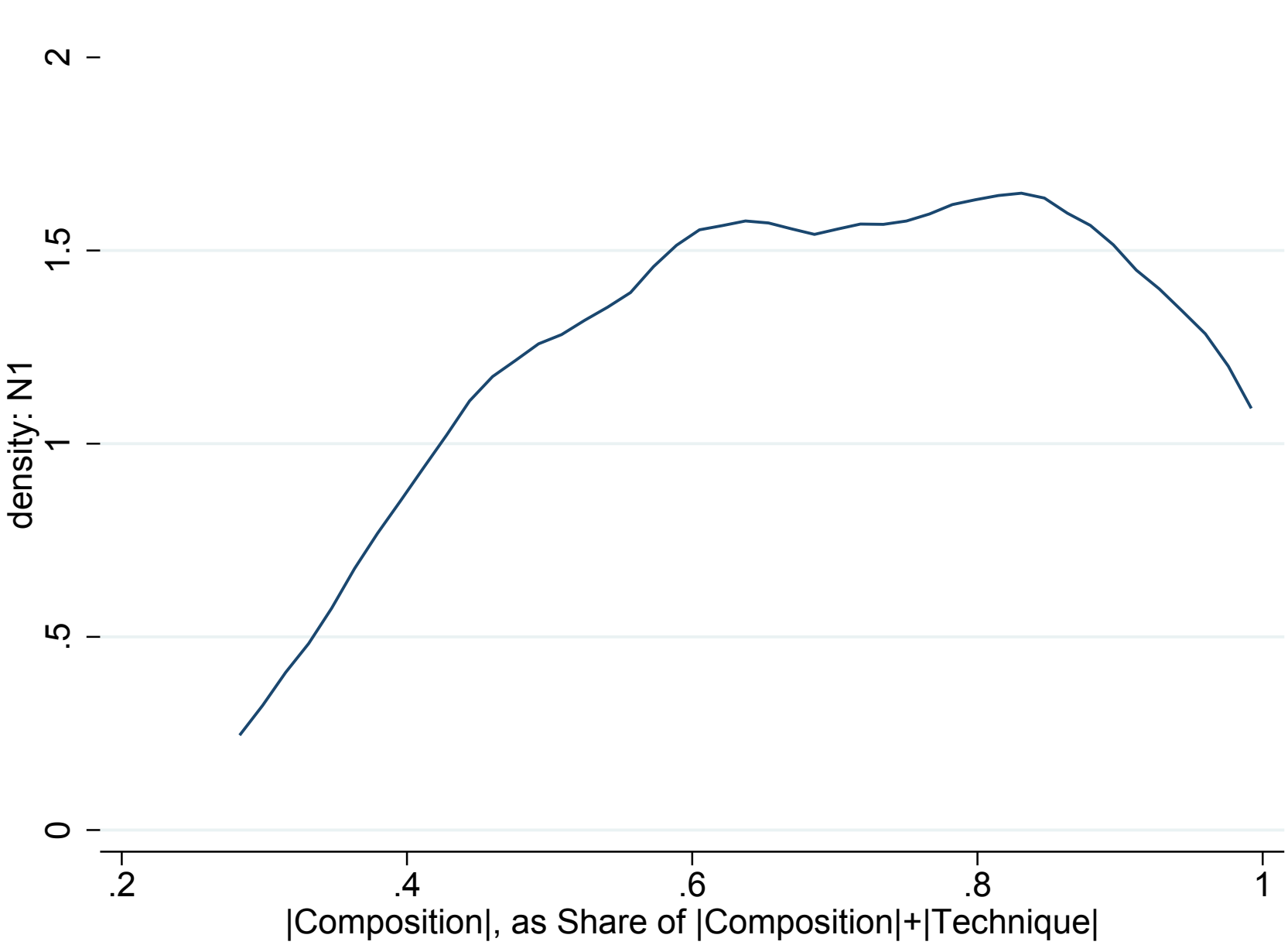
$S_{i,r} = \sum_s x_{is} / \sum_s x_{rs}$; $C_{i,r} = \sum_s \kappa_{is} e_{rs} / (Z_r / X_r)$; $T_{i,r} = (Z_i / X_i) / \sum_s \kappa_{is} e_{rs}$

Table 6—Decomposition: Scale, Composition, and Technique, US as Reference

	All Local	CO	NO_x	$PM_{2.5}$	SO_x	CO_2
	(1)	(2)	(3)	(4)	(5)	(6)
1. Scale, composition, and technique	-0.68	-0.75	-0.83	-0.46	-0.70	-0.85
	(0.83)	(0.66)	(0.35)	(1.50)	(0.83)	(0.35)
2. Scale	-0.89	—	—	—	—	—
	(0.19)	—	—	—	—	—
3. Composition	1.82	1.18	1.90	2.52	1.67	1.20
	(1.22)	(1.21)	(1.29)	(1.69)	(1.41)	(1.36)
4. Technique	-0.03	-0.02	-0.36	0.25	-0.01	-0.36
	(0.61)	(0.56)	(0.44)	(1.05)	(0.84)	(0.33)
5. |Composition|	1.84	1.22	1.92	2.54	1.69	1.25
	(1.19)	(1.17)	(1.26)	(1.66)	(1.39)	(1.31)
6. |Technique|	0.48	0.43	0.49	0.73	0.66	0.42
	(0.37)	(0.35)	(0.28)	(0.78)	(0.51)	(0.26)

Results: Scale, Composition, and Technique Decomp.

$S_{i,r} = \sum_s x_{is} / \sum_s x_{rs}$; $C_{i,r} = \sum_s \kappa_{is} e_{rs} / (Z_r / X_r)$; $T_{i,r} = (Z_i / X_i) / \sum_s \kappa_{is} e_{rs}$



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Conclusions

- **Environment**
  - What explains cross-country pollution differences?
  - Usual answers: environmental policy, factor endowments, income per capita
  - Additional answer: weak institutions

- **Institutions**
  - Usual view: Important for the economy
  - Additional view: important for the environment
  - But, comparative advantage means reshuffling pollution globally

Data: Two Example Industries

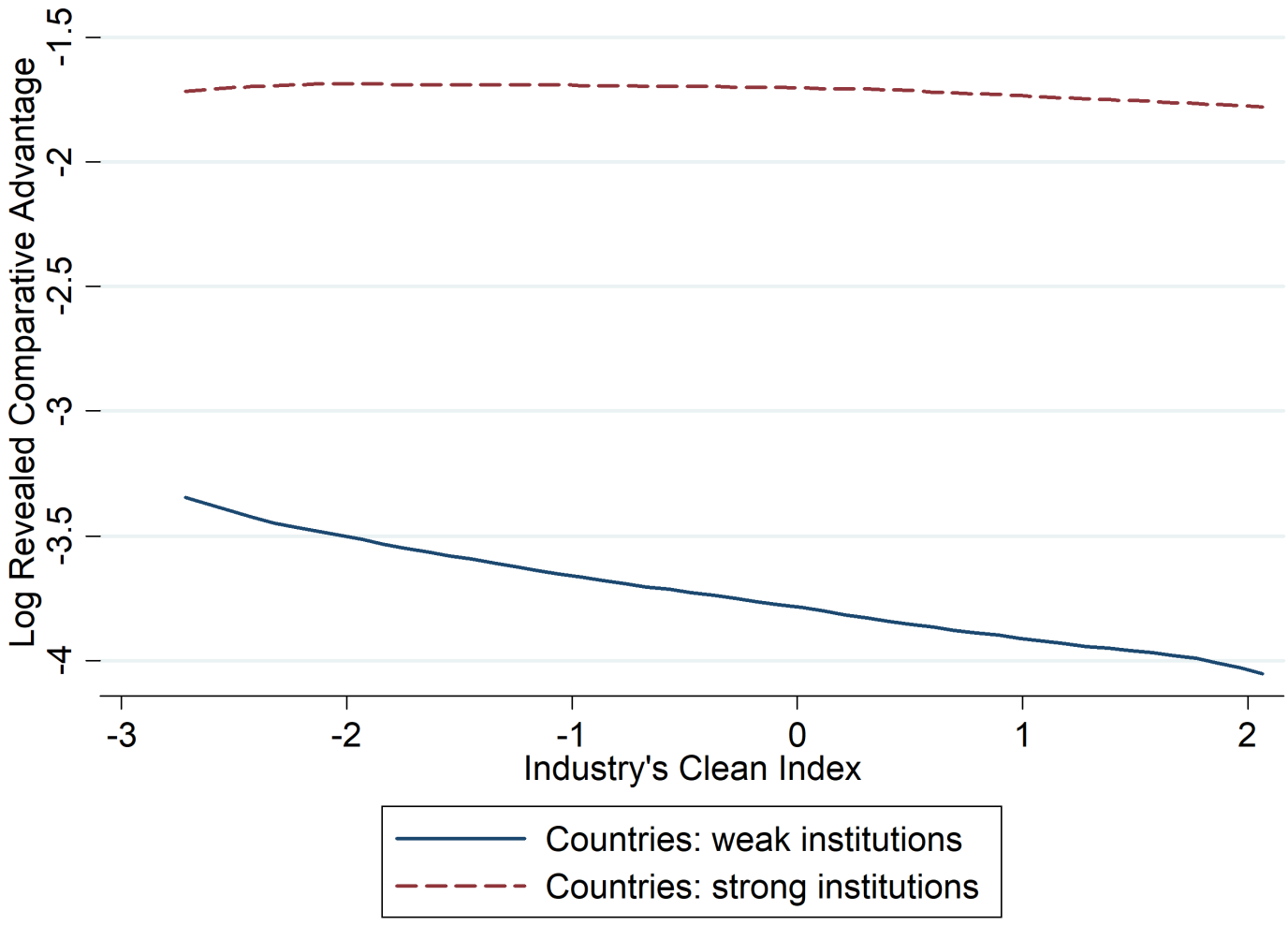
Fluid pumps (clean)

Financial: low cash flow
Labor: volatile sales
Judicial: input contracts

Gypsum products (dirty)

Financial: more cash v. investment
Labor: steadier sales
Judicial: inputs from exchanges

Result 3: Revealed Comparative Advantage, Balassa (1965)



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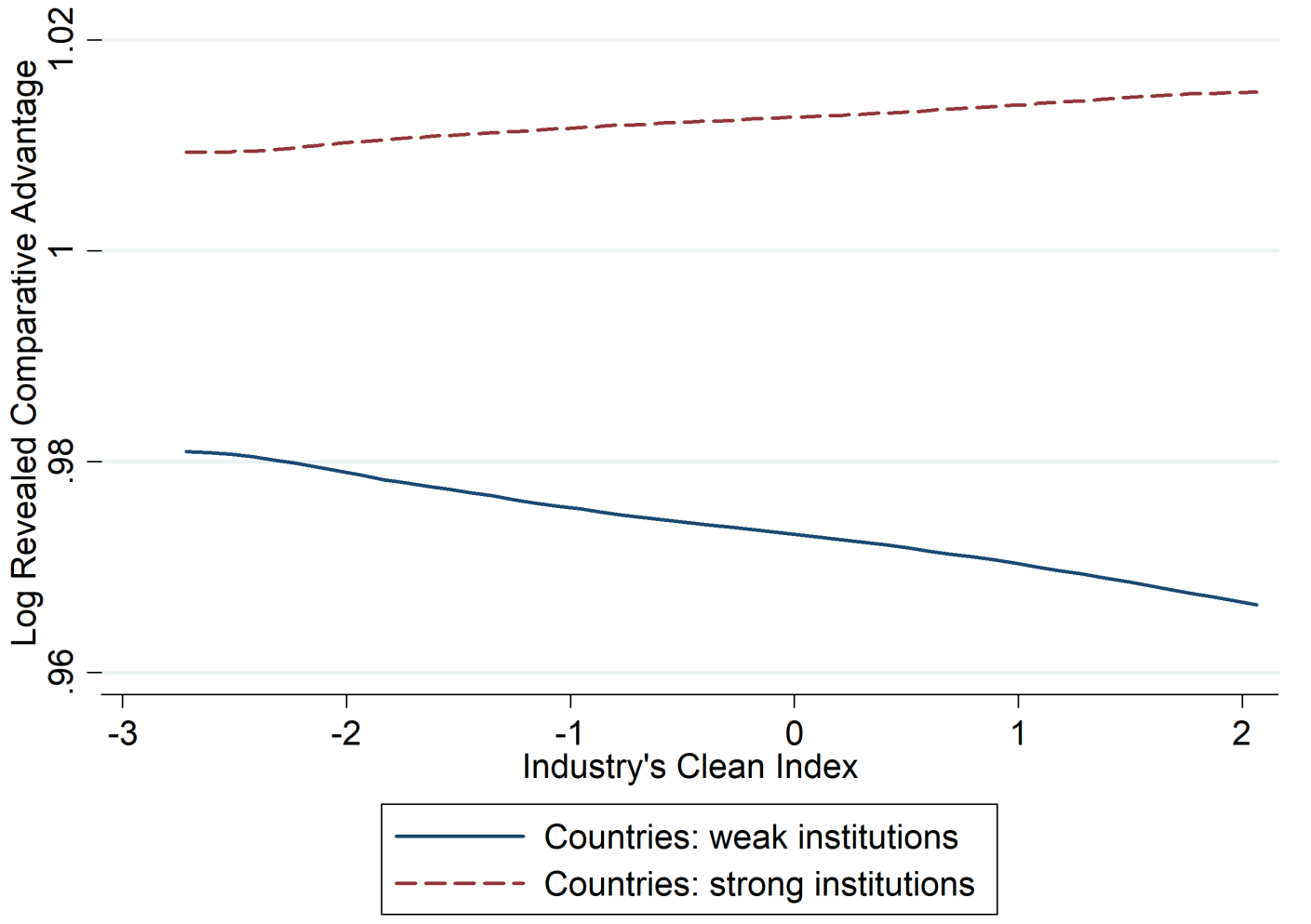
Result 3: Revealed Comparative Advantage, Costinot, Donaldson, & Komunjer 2012



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Result 1: Country Institutions Versus Pollution, Exports

$Z_i = \gamma_0 + \gamma_1 I_i + \epsilon_i$

Appendix Table 2—Clean Index of a Country's Exports and Country Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(9)
Country institutions: financial	0.35***	—	—	—	—	—	—
	(0.07)	—	—	—	—	—	—
Country institutions: judicial	—	0.32***	—	—	—	—	—
	—	(0.07)	—	—	—	—	—
Country institutions: labor markets	—	—	0.19**	—	—	—	—
	—	—	(0.09)	—	—	—	—
Country institutions: index	—	—	—	0.35***	—	—	—
	—	—	—	(0.07)	—	—	—
Factor endowment: capital	—	—	—	—	0.21***	—	—
	—	—	—	—	(0.08)	—	—
Factor endowment: skills	—	—	—	—	—	0.29***	—
	—	—	—	—	—	(0.08)	—
Environmental regulation	—	—	—	—	—	—	0.36***
	—	—	—	—	—	—	(0.09)
N	132	132	132	132	132	132	132

Regressions: Do Institutions Evolve?

- **Institutions**: long history, path dependence. Relevant to policy, future?
- **Approach**: Measure abs. value of 1996-2015 change for mean country in standard deviations: $|E_{i,2015} - E_{i,1995}|$
  - Financial institutions: 0.4
  - Judicial institutions: 0.4
  - Labor market institutions: 0.5
  - Capital endowments: 0.6
  - Skill endowments: 0.4

Comparative Advantage: Regression Origin

- **Gravity**:

$$X_{ij,s} = \xi \frac{T_{i,s}(c_{i,s}\phi_{ij,s})^{-\theta_s}}{(P_{j,s})^{-\theta_s}} X_{j,s}$$

- **Assumptions**:

$$\begin{aligned} lnX_{j,s} + \theta_s lnP_{j,s} &= \zeta_{j,s} \\ lnT_{i,s} &= \alpha E_i I_s + \sum\nolimits_f \beta_f E_i^f I_s^f + \pi R_i Z_s + \omega_{i,s} \\ ln\xi - \theta_s lnc_{i,s} - \theta_s ln\phi_{ij,s} &= \gamma t_{ij,s} + \eta_{ij} + \omega_{ij,s} \\ \epsilon_{ij,s} &= \omega_{i,s} + \omega_{ij,s} \end{aligned}$$

- **Result**:

$$lnX_{ij,s} = \alpha E_i I_s + \sum_f \beta_f E_i^f I_s^f + \pi R_i Z_s + \gamma t_{ij,s} + \zeta_{j,s} + \eta_{ij} + \epsilon_{ij,s}$$

- **Clean**:

$$lnX_{ij,s} = \alpha^C E_i Z_s + \sum_f \beta_f^C E_i^f I_s^f + \pi^C R_i Z_s + \gamma^C t_{ij,s} + \zeta_{j,s}^C + \eta_{ij}^C + \epsilon_{ij,s}^C$$

Comparative Advantage: Clean Industries

$$lnX_{ij,s} = \alpha^C E_i Z_s + \sum_f \beta_f^C E_i^f I_s^f + \pi^C R_i Z_s + \gamma^C t_{ij,s} + \zeta_{j,s}^C + \eta_{ij}^C + \epsilon_{ij,s}^C$$

$$Z' = \sum_{j,s} [X_{ijs} Z_s + e^{\hat{\alpha}^C Z_i [E_{0.9}^e - E_{0.1}^e]} Z_s]$$

Table 3—Sources of Comparative Advantage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel B: Comparative advantage in clean industries										
Country endowment × clean industry index:										
Institutions: financ.	0.052***	—	—	—	0.035***	—	—	—	—	—
	(0.002)	—	—	—	(0.003)	—	—	—	—	—
Institutions: judicial	—	0.051***	—	—	0.010*	—	—	—	—	—
	—	(0.002)	—	—	(0.005)	—	—	—	—	—
Institutions: labor	—	—	0.019***	—	0.007***	—	—	—	—	—
	—	—	(0.002)	—	(0.002)	—	—	—	—	—
Institutions: index	—	—	—	0.054***	—	0.040***	—	—	—	—
	—	—	—	(0.002)	—	(0.003)	—	—	—	—
Environmental reg.	—	—	—	—	0.009*	0.010***	—	—	—	—
	—	—	—	—	(0.005)	(0.003)	—	—	—	—
Country endowment × industry intensity:										
Factors capital/lab.	—	—	—	—	0.016***	0.016***	—	—	—	—
	—	—	—	—	(0.002)	(0.002)	—	—	—	—
Factors: skills	—	—	—	—	0.060***	0.059***	—	—	—	—
	—	—	—	—	(0.002)	(0.002)	—	—	—	—
Tariffs	—	—	—	—	-0.049***	-0.049***	—	—	—	—
	—	—	—	—	(0.005)	(0.005)	—	—	—	—
N	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	1,826,444	—	—	—	—
Fitted effect 10→90%	-21.2%	-37.0%	-15.4%	-35.4%	-23.4%	-26.7%	—	—		
Importer×exporter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer×industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Comparative Advantage: Other Research Designs

- **IV-FS**:

$$E_i I_s = \sum_o \alpha_o^F L_{i,o} I_s + \sum_f \beta_f^F E_i^f I_s^f + \pi^F R_i Z_s + \gamma^F t_{ij,s} + \zeta_{j,s}^F + \eta_{ij}^F + \epsilon_{ij,s}^F$$

- **Panel / long difference**:

$$lnX_{ij,sy} = \alpha^P E_{i,y} Z_s + \sum_f \beta_f^P E_{i,y}^f I_s^f + \zeta_{j,sy}^P + \eta_{ij,y}^P + \epsilon_{ij,sy}^P$$

- **India**:

$$lnX_{i,s} = \alpha E_i I_s + \sum_f \beta_f E_i^f I_s^f + \pi R_i Z_s + \gamma t_i + \zeta_s + \epsilon_{i,s}$$

Data: Correlations Between Country Variables

Appendix Table 1—Correlation Between Country and Industry Characteristics

	Institutions				Factor		Enviro. reg.,
	Financial	Judicial	Labor	Index	Capital	Skills	clean index
	(1)	(2)	(3)	(4)	(5)	(6)	(9)
Panel A. Country characteristics							
Institutions: financial	1.00	—	—	—	—	—	—
Institutions: judicial	0.84	1.00	—	—	—	—	—
Institutions: labor markets	0.29	0.34	1.00	—	—	—	—
Institutions: index	0.92	0.94	0.54	1.00	—	—	—
Factor intensity: capital	0.78	0.73	0.24	0.76	1.00	—	—
Factor intensity: skills	0.76	0.70	0.26	0.74	0.79	1.00	—
Enviro. regulation	0.74	0.77	0.14	0.74	0.62	0.66	1.00

Data: Correlations Between Industry Variables

Appendix Table 1—Correlation Between Country and Industry Characteristics

	Institutions				Factor		Enviro. reg.,
	Financial	Judicial	Labor	Index	Capital	Skills	clean index
	(1)	(2)	(3)	(4)	(5)	(6)	(9)
Panel B. Industry characteristics							
Institutions: financial	1.00	—	—	—	—	—	—
Institutions: judicial	0.15	1.00	—	—	—	—	—
Institutions: labor markets	0.22	-0.03	1.00	—	—	—	—
Institutions: index	0.51	0.83	0.45	1.00	—	—	—
Factor intensity: capital	-0.02	-0.45	-0.14	-0.42	1.00	—	—
Factor intensity: skills	0.25	0.28	0.07	0.33	0.02	1.00	—
Clean index	0.10	0.52	0.14	0.51	-0.48	0.32	1.00