International Environmental Agreements and Imperfect Enforcement: Evidence from CITES

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Introduction

- Biodiversity crisis $\Rightarrow$ Wildlife is in decline.
- Trade in endangered species has been identified as a major driver of this loss (Scheffers et al., 2019).
- CITES is an international environmental agreement (IEA) addressing the biodiversity crisis through (multilateral) wildlife trade policy.
- Large, mostly theoretical literature on whether, and under which conditions, IEAs are effective.

CITES: a trade agreement to protect endangered species

- The **C***onvention on* **I***nternational* **T***rade in* **E***ndangered* **S***pecies of Wild Fauna and Flora* entered into force in 1975.
- Large membership, currently 183 parties (=countries).
- Species can be protected by CITES via inclusion into:
  - **Appendix I**: prohibits commercial international trade of listed species.
  - **Appendix II**: regulates commercial international trade of listed species (export and import permits etc.) to incentivize sustainable use.

Challenges to enforce CITES

- It targets numerous species (roughly 5,950 species of animals and 32,800 species of plants).
- Its regulations have to be implemented and enforced by national authorities across all member countries.
- Imposes costs on wildlife trade or render it illegal.
- With imperfect enforcement, wildlife trade might be driven ...
  - from regulated to unregulated countries.
  - from legal to illegal sources.

Our contribution

- First across-species, global evaluation of the effectiveness of CITES.
- Problem: species are not randomly included into CITES $\Rightarrow$ selection bias.
- We correct the selection bias: We combine a panel of time- and geo-referenced data on 11,054 populations of 3457 species in 185 countries with data on species-level threat status and the history of CITES protection of (sub-)species.

Preview of results

- Wildlife populations increase after their corresponding species is listed in CITES.
- The effect of CITES increases over time.
- Both wildlife trade bans and restrictions prevent wildlife declines.
- Enforcement is crucial for effective international environmental agreements.

Data

- **Living Planet Index raw data**
  - contains population size data for vertebrates: amphibians, birds, fishes, mammals, and reptiles. ▸ raw LPI wildlife data
- **CITES Checklist data**
  - contains history of additions of species into CITES appendices.
    ▸ LPI data combined with CITES species information
- **IUCN Red List data**
  - contains information about status of endangerment of a species.
  - data from the IUCN-CMP Unified Classification of Direct Threats.
- ...

Baseline specification

- We want to identify the average treatment effect of protection offered to a species by inclusion into CITES (Appendix I or II):

$$\underbrace{\ln N_{slt}}_{\text{population size}} = \mu_{sl} + \eta_t + \beta(\text{in CITES})_{st} + \varepsilon_{slt} \quad (1)$$

- We may observe the same species across several locations and years: unit of observation is a **population (=species s at location l)** in year t.
- Our data allow us to identify the year when a species was included into the appendices for the first time.
- Including population-specific fixed effects remedies the documented time-invariant selection bias.

▸ time-invariant selection bias
▸ time-variant selection bias
▸ checking parallel trends

Event study specification

$$\ln N_{slt} = \sum_{\substack{\tau \in \{-10,-5,5,0 \\ 10,15,20,>20\}}} \beta_\tau \mathbf{1}(t = t_s^{CITES} + \tau)_{st} + \mu_{sl} + \eta_t + \varepsilon_{slt} \quad (2)$$

- $\tau = -10$: years 6 to 10 years *before* a species' CITES listing,
- $\tau = -5$: years 1 to 5 *before* a species' CITES listing,
- $\tau = 0$: year of a species' CITES listing,
- $\tau = 5$: years 1 to 5 *after* a species' listing into CITES,
- $\tau = 10$: years 6 to 10 *after* CITES' listing,
- $\tau = 15$: years 11 to 15 *after* CITES' listing,
- $\tau = 20$: years 16 to 20 *after* CITES' listing, and
- $\tau > 20$: more than 20 years *after* a species' CITES listing.

Baseline results: CITES is effective...

$$\ln N_{slt} = \mu_{sl} + \eta_t + \beta(\text{in CITES})_{st} + \varepsilon_{slt}$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
in CITES	0.184				0.242	−1.281	−0.146	0.008	0.082	0.061	−0.139
	(0.071)				(0.132)	(0.325)	(0.105)	(0.091)	(0.104)	(0.106)	(0.172)
in CITES in 1975		0.207		0.217							
		(0.122)		(0.122)							
in CITES after 1975			0.164	0.170							
			(0.081)	(0.082)							
in CITES × *NONSANCTIONED*					−0.058						−0.051
					(0.114)						(0.117)
in CITES ×(1 − *P*(*BRIBE*=1))						1.700					
						(0.393)					
in CITES ×(1−*CORRUPT*)							0.420				0.183
							(0.131)				(0.138)
in CITES × *HIGH-INCOME*								0.263			0.148
								(0.084)			(0.090)
in CITES × *MEMBER*									0.122	−0.199	−0.068
									(0.093)	(0.133)	(0.139)
in CITES × *MEMBER* × *CATEGORY 1*										0.399	0.229
										(0.168)	(0.161)
N	119538	119538	119538	119538	119538	107566	113818	119538	119538	119538	113818

Event study: . . . but it takes time

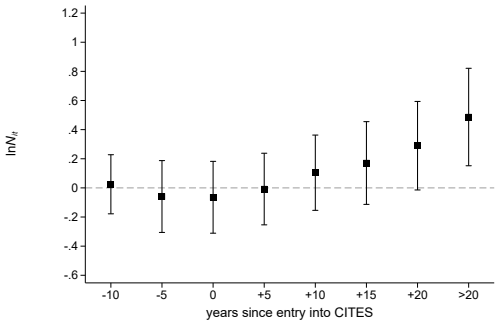
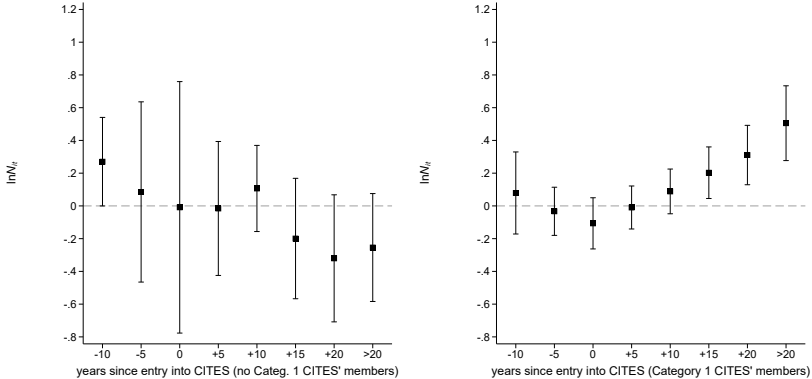


Figure: Effect of CITES on population size (species listed in CITES)

95% confidence intervals. Standard errors are clustered at the species level. Number of observations: 111,292.

Enforcement matters: CITES is only effective in countries with strict enforcement (Cat. 1 countries) or low corruption



Panel regression of log of population size on a set of treatment dummies, population and year fixed effects. Left panel shows the coefficient estimates of dummy variables indicating the years since a species' entry into CITES interacted with a variable indicating whether the country is a CITES member in year t for non-"Category 1" countries. Right panel shows the coefficient estimates of dummy variables indicating the years since entry into CITES interacted with a variable indicating whether the country is a CITES member in year t for "Category 1" countries. 95% CIs. Species-clustered SEs. N=119538.

▸ low- vs. high-corruption member countries

Robustness

- More endangered species may be more likely to get listed: reverse causality! We use an approach inspired by Ferraro and Miranda (2017) that estimates TWFE on a matched sample of species with similar probability of CITES' listing. ▸ Results for matched sample
- Dropping species with contentious listing decisions (Blundell and Rodan, 2001): elephants, sharks, turtles, whales ▸ Results excluding contentious species
- Results are not driven by domestic regulation ⇒ Use of **Appendix III** listings (species-country-year level). ▸ Results controlling for domestic regulation
- Estimating cohort-specific treatment effects to avoid wrong comparisons due to the staggered treatment (CITES listings), see, e.g., Sun and Abraham (2021). ▸ Results for individual cohorts (CoPs)
- Controlling for country-specific time-varying confounding factors:
  - country-specific trends (with different functional forms).
  - country-year fixed effects.

Mechanisms: Is CITES effective because it bans wildlife trade or because it enables sustainable wildlife trade?

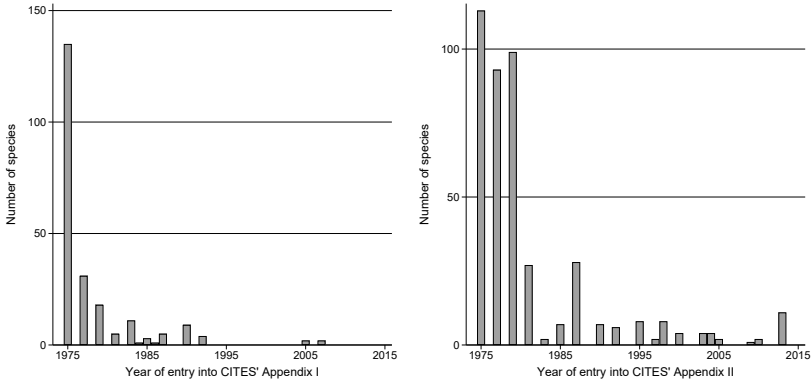


Figure depicts the distribution of the year a species entered into Appendix I (left panel) and Appendix II (right panel) in our data.

Effects of CITES' listings in Appendix I and II

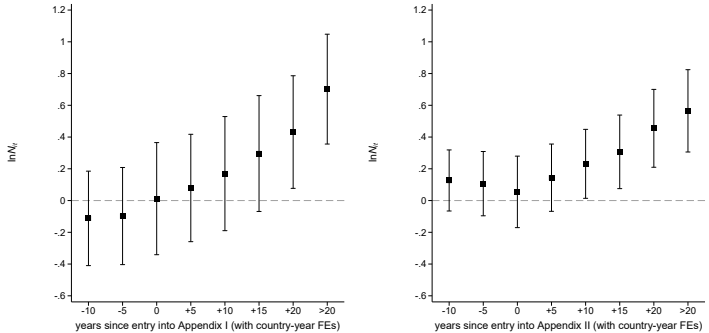


Figure: Effect of CITES on population size (App. I vs. App.II), including country-year FEs

95% percent confidence intervals. Standard errors are clustered at the species level. Number of observations: 118,106.

Conclusion

- Using detailed population-level panel data on population sizes, we find a positive effect of CITES listing on species' population sizes.
- Both sustainable wildlife trade and wildlife trade bans are effective.
- Effect channelled by countries with strong enforcement.
- Studies of IEAs should not only take into account their *de jure* membership but also their *de facto* level of enforcement.

Thank you

Thank you for your attention!
We are looking forward to your questions and comments.

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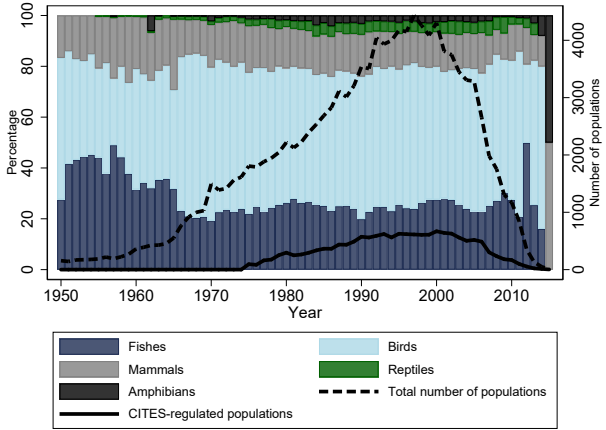
International Environmental Agreements and Imperfect Enforcement: Evidence from CITES

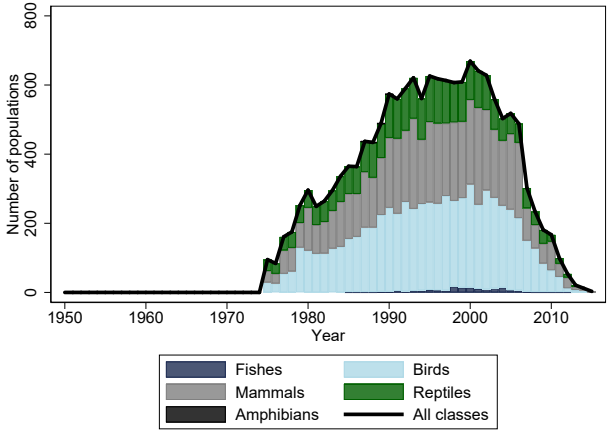
CESifo Working Paper No. 8757 (first version);
https://benediktheid.weebly.com/research.html (most recent version).

Raw LPI wildlife data



back Class distribution and number of records in the raw wildlife data

LPI data combined with CITES species information



back Number of records protected by CITES Appendices I and II in the raw wildlife data

Species are not randomly listed into CITES ⇒ Selection bias (time-invariant)

Table: Determinants of CITES listings (cross-section)

	(1)	(2)	(3)	(4)	(5)
mammal	0.416	0.353	0.346	0.308	0.053
	(0.025)	(0.024)	(0.023)	(0.024)	(0.023)
bird	0.123	0.116	0.167	0.136	
	(0.011)	(0.012)	(0.013)	(0.014)	
reptile	0.246	0.228	0.276	0.244	
	(0.034)	(0.038)	(0.037)	(0.038)	
amphibian	−0.014	−0.039	0.019	−0.012	
	(0.009)	(0.014)	(0.015)	(0.016)	
vulnerable		0.280	0.231	0.227	0.195
		(0.023)	(0.023)	(0.023)	(0.033)
intentional use			0.162	0.184	0.131
			(0.016)	(0.019)	(0.034)
fishing				−0.097	
				(0.020)	
log of body mass					0.038
					(0.004)
R^2	0.16	0.22	0.25	0.25	0.27
N	3622	2838	2838	2838	1647

Notes: Coefficients from an OLS regression of a dummy variable that equals one when the species has ever been listed in CITES (and zero when the species has never been listed in CITES) on a number of variables affecting the probability of being listed. Standard errors in parentheses (clustered at the species level). Data are for a cross-section of the subsample of species from the LPI data for which the IUCN Red List reports information on threats.

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Selection bias (time-variant)

The probability of a species getting listed may change over time because new scientific evidence on the status of a species becomes known:

$$CITES_{st} = \alpha_s + \beta ACCUMULATEDSTUDIES_{st} + \delta t + \varepsilon_{st} \quad (3)$$

Table: Determinants of CITES listings (panel)

	(1)	(2)	(3)	(4)
trend	0.003	0.003	0.003	0.003
	(0.000)	(0.000)	(0.000)	(0.000)
accumulated number of studies available		0.005		−0.000
		(0.003)		(0.001)
R^2	0.05	0.05	0.58	0.58
N	228162	228162	228162	228162

Notes: Table 2 reports estimated coefficients from a panel linear probability model of variants of Equation (3). The dependent variable is a dummy variable that equals one when the species is listed in CITES in year t and zero otherwise. As regressors we use a variable that measures the accumulated number of published studies in our dataset in t on a specific species and a time trend. Column (1) estimates Equation (3) but drops $ACCUMULATEDSTUDIES_{st}$ using pooled OLS, i.e., without a species fixed effect α_s. Column (2) re-estimates Column (1) but adds $ACCUMULATEDSTUDIES_{st}$. Columns (3) and (4) re-estimate Columns (1) and (2) but add a species fixed effect. Column (4) estimates Equation (3) as presented in the main text. Standard errors are in parentheses and are clustered at the species level.

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Checking for parallel pre-trends

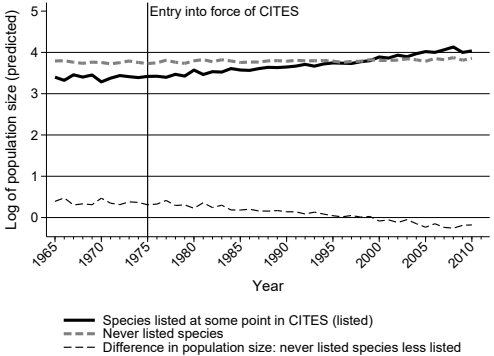

Figure: Average population size: Listed and never listed species by year

Figure depicts predicted population size per year for species that have ever been listed in CITES versus species that have never been listed in CITES.

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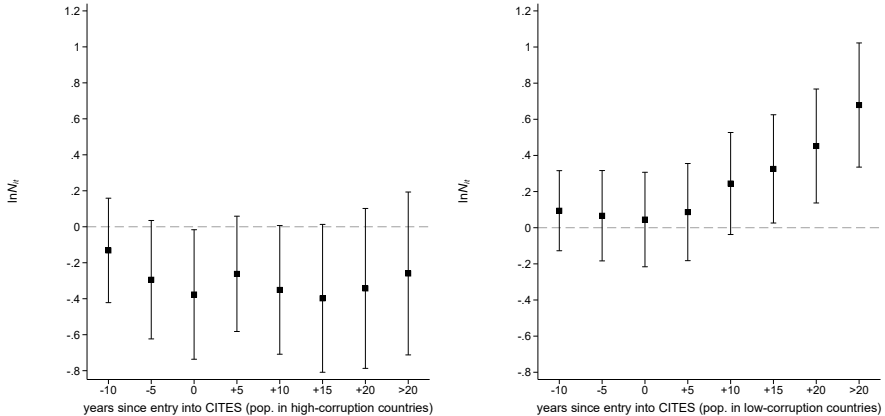
Low- vs. high-corruption countries



This figure shows results from a panel regression of log of population size on a set of treatment dummies, population, and year fixed effects. The left panel shows the coefficient estimates of dummy variables indicating the years since a species' entry into CITES interacted with a variable indicating whether the population is located in high-corruption countries. The right panel shows the coefficient estimates of dummy variables indicating the years since entry into CITES interacted with a variable indicating whether the population is located in a low-corruption country. 95% CIs. Species-clustered SEs. N=113818.

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Results combining TWFE estimated on a matched sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
in CITES	0.048				0.192	−1.130	−0.196	−0.080	0.032	0.034	−0.047
	(0.113)				(0.168)	(0.383)	(0.134)	(0.114)	(0.125)	(0.120)	(0.176)
in CITES in 1975		0.228		0.222							
		(0.144)		(0.147)							
in CITES after 1975			−0.090	−0.010							
			(0.119)	(0.125)							
in CITES × *NONSANCTIONED*					−0.144						−0.137
					(0.123)						(0.123)
in CITES ×(1 − *P*(*BRIBE*=1))						1.532					
						(0.476)					
in CITES ×(1−*CORRUPT*)							0.446				0.171
							(0.181)				(0.169)
in CITES × *HIGH-INCOME*								0.290			0.196
								(0.106)			(0.104)
in CITES × *MEMBER*									0.024	−0.304	−0.139
									(0.103)	(0.129)	(0.143)
in CITES × *MEMBER* × *CATEGORY 1*										0.440	0.270
										(0.184)	(0.158)
N	13645	13645	13645	13645	13645	11579	13076	13645	13645	13645	13076

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Results dropping species with contentious listing decisions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
in CITES	0.225				0.218	−1.645	−0.199	−0.005	0.113	0.074	−0.182
	(0.078)				(0.145)	(0.325)	(0.121)	(0.107)	(0.116)	(0.116)	(0.198)
in CITES in 1975		0.299		0.309							
		(0.151)		(0.151)							
in CITES after 1975			0.188	0.194							
			(0.086)	(0.087)							
in CITES × *NONSANCTIONED*					0.007						0.000
					(0.128)						(0.129)
in CITES ×(1 − *P*(*BRIBE*=1))						2.203					
						(0.374)					
in CITES ×(1−*CORRUPT*)							0.543				0.265
							(0.135)				(0.152)
in CITES × *HIGH-INCOME*								0.318			0.107
								(0.095)			(0.088)
in CITES × *MEMBER*									0.133	−0.388	−0.247
									(0.106)	(0.148)	(0.147)
in CITES × *MEMBER* × *CATEGORY 1*										0.635	0.423
										(0.150)	(0.160)
N	113930	113930	113930	113930	113930	102867	108513	113930	113930	113930	108513

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Results controlling for domestic regulation

$$\begin{aligned} \ln N_{slt} &= \mu_{sl} + \eta_{ct} + \beta(\text{in CITES})_{st} \\ &\quad + \delta(\text{domestic regulation})_{sct} + \varepsilon_{slt} \end{aligned} \tag{4}$$

Table: Effect of CITES on population size controlling for domestic regulation

	(1)	(2)	(3)
domestic regulation	−0.112		−0.215
	(0.226)		(0.218)
in CITES		0.211	0.212
		(0.061)	(0.061)
N	118106	118106	118106

Notes: Table reports estimated regression coefficients from a panel regression of log of population size on a set of regressors along with a set of population and country-year fixed effects. Standard errors are in parentheses and are clustered at the species level.

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Cohort-specific treatment effects: Cohort of species listed in 1975

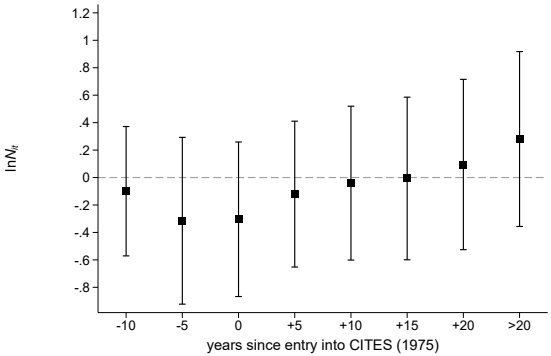
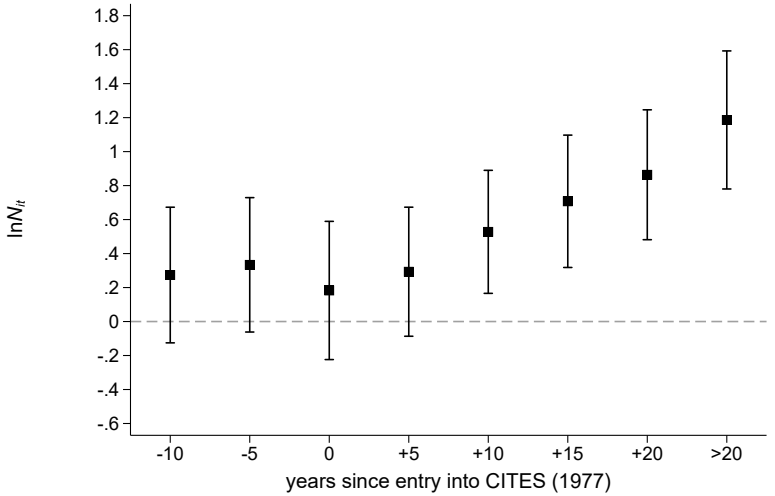
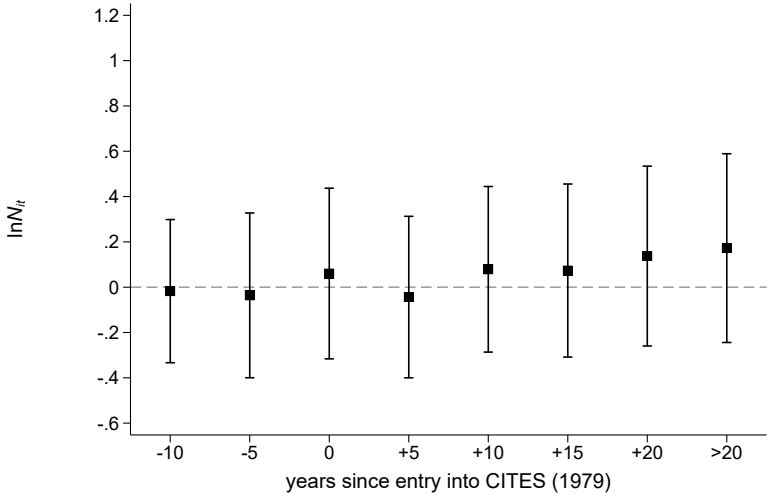


Figure: Effect of CITES on population size (species listed in CITES in 1975). Excluding species listed in CITES in other years

Cohort-specific treatment effects: Cohort of species listed in 1977



Cohort-specific treatment effects: Cohort of species listed in 1979



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