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A Shifting Course

ENVIRONMENTAL AND SOCIAL GOVERNANCE DURING AND AFTER THE "CHINA BOOM" IN THE AMAZON BASIN

REBECCA RAY, PAULO ESTEVES, KEVIN P. GALLAGHER, YAXIONG MA AND MARIA ELENA RODRIGUEZ[1]

ABSTRACT

In the first decade of the 21st century, China's rapid urbanization and investment-led growth model brought skyrocketing demand for raw commodities and an ensuing investment wave in Amazon basin countries. In the wake of this "China boom," national governments in Amazon basin countries enacted a series of social and environmental protections, many of which were later relaxed as commodity prices eventually cooled. This working paper presents a systematic exploration—the first to the authors' knowledge—of changes in environmental and social protection across the Amazon basin during and after the "China boom," and ensuing changes in Chinese investment in the region. Our findings reinforce the "resource nationalism" literature's suggestion that Amazon basin countries' levels of environmental and social protections rose and fell in direct relation to commodity export prices—strengthening to take advantage of a boom and then relaxing to expedite new investment as prices fell. Our results also reinforce governance literature on the Belt and Road Initiative (BRI), in showing that Chinese investment did not change significantly in

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response to these policy changes. Thus, our findings suggest that host countries to Chinese investment have policy space to set and enforce protections that meet their national needs, rather than the anticipated preferences of Chinese investors.

Keywords: China; Latin America; Chinese overseas investment; environmental and social governance; China boom;

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INTRODUCTION

In the last 15 years, China's outbound economic activity has grown at such a rapid pace as to dramatically alter economic prospects across the developing world. In South America in particular, China has become the top export destination, top source of bilateral official finance and a top source of investment—particularly raw commodity production investment—in many countries, particularly the Amazon basin countries of Bolivia, Brazil, Ecuador and Peru (Ray et al 2017). Since 2006, China's two policy banks have extended over $130 billion in loans to South American countries, including $30 billion to Brazil alone (Gallagher and Myers 2022).

This wave of Chinese investment, finance and trade formed the backbone of the 2002-2011 South American commodity boom, as China's rapid urbanization created skyrocketing demand for agricultural and mineral goods to supply its growing cities. During this commodity "supercycle," Amazon basin countries developed a host of environmental and social protections to ensure that the boom benefited—or at least did not harm—ecosystems and the communities that depend on them. As the supercycle ended, however, national governments began to face pressure to relax these protections, in the hopes of expediting new investments and prolonging the boom. In the decade that has elapsed since the commodity price peak, Amazon basin countries have enacted significant regulatory changes, including major legislative packages whose names reflect a perceived connection between regulatory burdens and investment flows, such as Peru's 2014 Law 30230 ("Ley que establece medidas tributarias, simplificación de procedimientos y permisos para la promoción y dinamización de la inversión en el país", Congreso de la República 2014) continuing through Ecuador's 2021 Executive Decree 151 (establishing the "Plan de Acción para el Sector Minero", Lasso Mendoza 2021). These processes have been traced by scholars anecdotally, but rarely in a systematic, regional and quantitative approach (see for example Ballón et al 2017; Ray et al 2017). Nor have the results of these changes been traced through ensuing changes in patterns of inbound investments.

With a decade of evidence available since the peak of commodity prices, this working paper explores the following research questions: First, to what extent did Amazon basin countries' social and environmental regulations trace the rise and fall of commodity prices? Second, to the extent that regulations were relaxed in the wake of the boom, did Chinese Amazon basin investment increase thereafter, either in terms of the number of projects or the speed with which they progressed from announcement to final purchase or groundbreaking? Finally, did the environmental and social risk and impact profile of Chinese investment projects change in conjunction with the changing policy framework? The working paper then draws on the results of these research questions to develop policy recommendations for social, environmental and sectoral ministries in the region.

CONTEXT: ENVIRONMENTAL GOVERNANCE AMID SOUTH AMERICAN RESOURCE NATIONALISM AND THE BRI

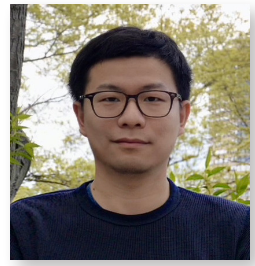
Since the early years of the current century, the "China boom" has defined the economic paradigm for much of South America (see for example Dosch and Goodman 2012; Jenkins 2011; Ray et al 2017).

South America's economic relationship with China has entailed the region exporting generally raw and low-technology commodities to China and importing manufactured goods in return (Dosch and Goodman 2012; Gallagher and Porzecanski 2010). Moreover, the commodity sectors driven by this relationship—such as mining, hydrocarbons extraction and large-scale commercial agriculture—are among the most environmentally and social sensitive, particularly with regards to the destruction of carbon sinks such as the Amazon rainforest, the use and contamination of water and impacts on communities that are dependent on both forests and water for traditional livelihoods (Ray 2017; Ray et al 2017). Thus, the environmental governance framework that applies to these sensitive sectors is paramount for minimizing risks to ecosystems, communities and investments themselves (Gallagher and Yuan 2017). Four countries in particular have received the bulk of Chinese investment in the Amazon basin and have also seen significant reforms in environmental and social governance that apply to those projects: Bolivia, Brazil, Ecuador and Peru. Thus, this working paper focuses on the changing regulatory framework in these four countries and the landscape of Chinese investment in their portions of the Amazon basin during and after a period of significant governance reform.

Political science literature has described the 2002-2011 commodity boom supercycle and its economic and environmental governance in these countries through a lens of "resource nationalism," in which leaders sought to ensure that natural resource exploitation furthered national development goals. This approach brought two trends in tandem: the expansion of commodity production sectors and the strengthening of social and environmental protections for communities impacted by those sectors (Ballón et al 2017; Bebbington and Bury 2013; Bebbington and Humphreys Bebbington 2011). Scholars have classified national strategies as either "open" resource nationalism (seeking inbound international investment, as in the Brazilian and Peruvian cases) or "closed" resource nationalism (building domestic state-owned enterprises for natural resource extraction, such as the cases of Bolivia and Ecuador) (Fontaine, Medrano Caviedes and Narváez 2019; Fontaine, Narváez and Velasco 2015). However, even among the countries with more "closed" strategies, such as Ecuador and Bolivia, China has been a core driver of the investment in the Amazon basin, through both direct investment in commodity production and public-sector infrastructure projects financed by China's two policy banks, the China Development Bank and the Export-Import Bank of China (see for example Gallagher and Myers 2022; Ray et al 2017). For this reason, this research examines both foreign direct investment (FDI) (which plays a significant role in "open" resource nationalism) and infrastructure projects supported by Chinese sovereign loans (which plays a significant role in "closed" resource nationalism). Thus, the term "investment" is here used to broadly include both direct investment (FDI) and portfolio investment in the form of direct, project-based overseas development finance (ODF).

China's own governance of the environmental and social performance of its outbound investment and finance projects follows a "country systems" approach. Based in the "Five Principles of Harmonious Coexistence," this framework cedes oversight to host countries' central governments (Chin and Gallagher 2019; Wen 2004). China is not unique in this approach to international socio-ecological governance in Latin America and the Caribbean (LAC); the New Development Bank and Brazil's Banco Nacional de Desenvolvimento Econômico e Social (BNDES) follow a similar approach in their international lending (de Souza Borges and da Cunha Cruz 2018; Esteves, Zoccal Gomes and Torres 2016; Gallagher and Yuan 2017). However, case study analysis has shown that relying on country systems can create incentives for national oversight bodies to relax or circumvent their own environmental and social protections to expedite projects or lower short-term costs, bringing potentially serious risks to ecosystems, communities and investors themselves (de Souza Borges and da Cunha Cruz 2018; Gallagher and Yuan 2017; Ray et al 2020).

In fact, the commodity boom of the early 2000s was followed by rapid declines in export prices (and government revenue from taxes and royalties on commodity investments), bringing significant



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pressure to relax social and environmental protections across the countries studied here in order to expedite further investments. While environmental and social protections could be enacted during the commodity boom, that boom ended suddenly as Chinese economic policy pivoted from rapid urbanization to a "new normal" of slower growth, reducing its demand for commodities and putting downward pressure on global minerals prices (Garnaut, Fangand Song, Eds 2013; Farooki 2011; Jenkins 2011; Jepson 2020). Scholars have traced anecdotally, though rarely systematically, the mounting pressure faced by governments to expedite new investments during the ensuing commodity price slump by relaxing these social and environmental protections (see for example Ballón et al 2017; Ray et al 2017). Such patterns have emerged in particular in countries hoping to attract Chinese investment and finance, given its emphasis on environmentally sensitive sectors and its reliance on country systems of governance described above (see for example Ray et al 2017; Gerlak et al 2020).

However, the extent to which relaxing environmental and social standards may or may not attract greater investment relies on the incentive structures of the investors themselves. According to Dunning's (1980) eclectic framework for international production, investment may be resource-seeking (motivated by proximity to inputs), efficiency-seeking (motivated to reduce costs of production), or market-seeking (motivated by proximity to buyers). In the last 15 years, scholars have noted two parallel motivations of Chinese investors in Latin America: resource-seeking investment in commodity production sectors and market-seeking investment in industrial sectors (see for example Castello Esquerdo 2021; Jenkins, Dussel Peters and Moreira 2008; Paus 2020; Ray et al 2017). Noteworthy for its absence is efficiency-seeking investment. While Chinese investment in Latin American manufacturing is not unusual, the products of this investment are typically sold within the Latin American market rather than exported back to China (see for example Albright, Ray and Liu 2022). Given the lack of efficiency-seeking behavior, it may be expected that Chinese investor behavior in Latin America exhibits less sensitivity to the short-term cost impacts of environmental and social regulations.

Another reason to expect that Chinese investment in Latin America may not exhibit high levels of sensitivity to regulatory changes is the important role played by Chinese state-owned enterprises (SOEs). Major Chinese SOEs have played a central role in the economic relationship for most of the past 15 years, with more recent private-sector participation supplementing but not supplanting it (see for example Dosch and Goodman 2012; Niu 2015; Roy 2022). Finance and firm scholars have noted that state ownership is associated with longer-term investment horizons, making SOEs likely to place less value on short-term cost considerations and more value on long-term considerations of securing resources, markets or relationships (see for example Oikonomou, Yin and Zhao 2020; Wang, Kiao and An 2022). Thus, based both on predominant Chinese investor ownership and motivation, these investors may not be highly sensitive to the short-term cost impacts of regulatory changes in Latin America.

As of 2022, a decade has passed since the commodity price peak, creating sufficient evidence to empirically examine these changing policy frameworks and investment landscapes. This study explores the extent to which the countries of Bolivia, Brazil, Ecuador and Peru relaxed their standards in the wake of the "China boom." It also traces trends in Chinese investment and finance in the Amazon basin portion of these countries from 2006-2019. It measures trends in the social and environmental risk and impact of these projects in three ways: their proximity to Indigenous territories, their geographic overlap with the ranges of threatened species and the post-hoc change in the rate of tree cover loss in the surrounding buffer zone, compared to the existing rates of tree cover loss prior to groundbreaking or purchase.

METHODS

Timeline of environmental and social governance

The research team built on the work of the "Observatório Dos Sistemas Nacionais De Proteção Socioambiental Da Região Amazônica," a library of social and environmental protection policies maintained by the BRICS Policy Center of Pontifical Catholic University, Rio de Janeiro (BPC 2022, hereinafter "the Observatório"). The Observatório includes legal occurrences (the enactment of laws, decrees or agreements impacting socio-environmental protection within these dimensions) in five Amazon countries: Bolivia, Brazil, Colombia, Ecuador and Peru. This analysis relies on regulatory changes in Bolivia, Brazil, Ecuador and Peru, as no Chinese FDI or ODF in the Colombian Amazon basin were identified during the time period studied here.

The Observatório database classifies regulatory changes among three general directions of change: establishing baseline regulations, strengthening existing regulations, or relaxing those regulations (often referred to as "flexibilizing" in domestic policy discourse). It includes nine dimensions of socio-ecological regulation, ranging from procedural regulations such as environmental licensing to broader themes such as cultural heritage. To focus on the types of regulations most relevant to construction in the Amazon basin, this analysis relies on three policy dimensions within the "Observatório:" (i) Environmental licensing, (ii) Forests and protected areas and (iii) Indigenous Peoples and Traditional Communities. These dimensions were established taking the World Bank's environmental and social framework as a reference, particularly the following standards: Standard 1 - Assessment and management of environmental and social risks and impacts; Standard 6 - biodiversity Conservation and sustainable management of living natural resources; Standard 7 - indigenous peoples/sub-Saharan African historically Underserved traditional local Communities; Standard 10 - Stakeholder engagement and Information Disclosure (World Bank 2017). The dimension of forests and protected is a combination of two Observatório dimensions, for forests and for protected areas, respectively, but are combined here in order to give equal weight to the three resulting dimensions used in the present analysis: land (forests and protected areas), people (Indigenous peoples and traditional communities) and process (environmental licensing).

From the Observatório database, the research team summed the number of regulatory changes across each country, year and dimension and calculated net changes, as the number of strengthening changes less the number of relaxing changes. The results were then compared to regional export price indices, to explore the changes across the commodity super-cycle described above in existing research on resource nationalism.

In practice, regulatory changes are not uniform in their breadth and impact. Although this dataset is limited to counting changes in each direction, rather than thoroughly considering the extent of each policy's impact on planned investments, it is possible to apply weights that reflect reforms' breadth: the number of policy dimensions affected by each reform. For example, Bolivia's and Ecuador's current constitutions, enacted during the study period, establish baseline regulations across all three policy dimensions considered here. Thus, in applying weights to quantitative analysis, each of these Observatório entries may be given a frequency weight of three. The analysis below is conducted with and without these weights for the sake of robustness.

It should be noted that in two cases, a given regulatory change may appear under more than one direction of change. Ecuador's Acuerdo 61 (2015) and Executive Decree 752 (2019) are each shown as strengthening some aspects of environmental licensing regulations and relaxing others. This characterization is preserved to accurately reflect the net direction of change (which in the case of these two reforms is null on net). A more detailed description of the dataset is available in Supplementary Information 1.

Regression analysis was performed to explore the relationship between regulatory reforms and the export commodity boom, through probit and OLS regression analysis. Four models were developed. Models 1 and 2 are probit models, estimating the likelihood of a given reform representing change in a strengthening (Model 1) or relaxing (Model 2) direction. These are considered separately because reforms may be strengthening, relaxing, both (applying to policies with different directions of change under multiple dimensions), or neither. These two models take the form

$$D_{ijk} = F(\beta_1 EPD_{jk} + \beta_2 \text{Country}_j + \text{Year}_k)$$

where:

D_{ijk} is a binary variable indicating the direction of change of reform i in country j and year k. It takes a value of 1 for strengthening in Model 1 and for relaxation in Model 2,

EPD_{jk} indicates the annual change in country j's export price deflator in the year k.

Country_j incorporates fixed national effects, with Brazil serving as the baseline case, as it is the country with the least number of policy reforms included in the sample.

Year_k reflects the year of the policy reform.

Models 3 and 4 combine the strengthening and relaxation effects in OLS regression according to the formula

$$D_{ijk} = \alpha + \beta_1 EPD_{jk} + \beta_2 \text{Country}_j + \text{Year}_k + \varepsilon$$

where D_{ijk} indicates the net direction of regulation i in country j and year k, with a value of +1 for strengthening changes, –1 for relaxing changes and 0 for neither or for the two cases (listed above) that each have one strengthening and one relaxing aspect. The other regressors maintain their definitions from Models 1 and 2. Model 4 repeats this analysis using frequency weights reflecting the number of policy dimensions affected by a given reform, to weigh broader reforms more heavily.

Chinese investments in the Amazon basin

Forty-two Chinese FDI and ODF projects in the Amazon basin were identified between 2005-2019 using existing datasets of Chinese finance and investment, amounting to approximately $30 billion in investment (Custer et al 2021; DeaLogic 2022; *Financial Times* 2022; Gallagher and Myers 2022; Red Académica de América Latina y el Caribe sobre China 2022). The projects are categorized into three types: Greenfield FDI (GFDI), mergers and acquisitions FDI (M&As) and overseas development finance (ODF).

Forty-two projects were geolocated with sufficient precision to enable spatial analysis: 40 projects located with the exact position and two project located within 25 kilometers (km) to known locations. Table 1 shows the distribution and size by country and sector. A stepwise geolocation process that combines Google Maps/OpenStreetMap, published maps and satellite or aerial imagery is used to identify the projects' footprint. As many of these projects comprise multiple geographic sites, 118 individual location sites were identified associated with these projects.

The geolocated projects are classified into points, lines and polygons according to their spatial footprint. Point type includes single structures such as offices and manufacturing facilities, line type includes linear-shaped structures such as roads, power transmission lines and pipelines, polygon type includes projects with large defined boundaries such as mines or reservoirs.

Table 1: Chinese Investment Projects in the Amazon Basin by Sector, 2005-2019

	Projects				Sites				Size (USD billions)			
	GFDI	M&A	ODF	TOTAL	GFDI	M&A	ODF	TOTAL	GFDI	M&A	ODF	TOTAL
Extraction												
Hydrocarbons	2	3		5	2	5		7	0.76	4.12		4.88
Mining	7	5		12	33	6		39	9.03	7.20		16.22
Power												
Generation, hydro	3	1	4	8	4	1	12	17	0.49	1.40	3.93	5.82
Generation, oil		1		1		1		1		>0.01		>0.01
Generation, wind	1			1	6			6				
Transmission			1	1			12	12			0.51	0.51
Other												
Agriculture		2		2		11		11		0.09		0.09
Manufacturing	1	4		5	1	4		5	0.03	0.60		0.63
Offices	2	2		4	2	15		17	0.03	0.12		0.15
Roads			3	3			3	3			1.28	1.28
TOTAL	16	18	8	42	48	43	27	118	10.32	13.54	5.72	29.58

Source: Author compilation using Custer et al 2021; DeaLogic 2022; Financial Times 2022; Ray et al 2020; Red Académica de América Latina y el Caribe sobre China 2022.

Buffer zones are generated for point and line type projects to analyze the direct and indirect risk and impact of Chinses development finance projects in the Amazon basin. Buffers are not applied to polygon-type projects since their boundaries are already established. The buffer radius is set according to sector categories (see Supplementary Information 1.3). For projects with multiple sites, the same buffer radius is used for all sites.

Table 2. Buffer Radius by Chinese Project Industry Type

Sector	Buffer Radius	Num. of Projects with Buffers Applied	References
Hydroelectric	10 km	7	Ouyang et al., 2013; Zhao et al., 2013
Mining	40 km	1	Sonter et al., 2017
Road	15 km	3	Hyde et al., 2018
Manufacturing	3 km	7	
Office	3 km	4	
Power Transmission	5 km	1	Hyde et al., 2018
Wind Farm	4 km	1	Peri & Tal, 2020; van Haaren & Fthenakis, 2011

Note: Buffers are only added to point and line type projects, as polygon type projects have explicit bounds already defined. For manufacturing and office projects, for which no common buffer zones have been established in existing scholarship, a conservative buffer of 3 km was chosen.

Indigenous Lands

We used the Risk to Indigenous Lands index, developed by Yang et al. (2021), to evaluate the impact of projects to Indigenous people's lands. The index captures the impact through distance to Indigenous people's land. To consider varying levels of existing economic activity, these distances are weighted by the Human Footprint Index (Venter et al 2016). The resulting risk value ranges from 0 to 1. The risk is greatest within the Indigenous lands and diminishes as the distance increases.

$$Risks\ to\ Indigenous\ \ Lands_i = \begin{cases} IDI_i \times HFI_i, IDI_i < 1 \\ 1, IDI_i = 1 \end{cases}$$

Biodiversity

We estimated the risks to threatened species in four taxa: amphibians, birds, freshwater fish and mammals. Using the geographic ranges from The IUCN Red List of Threatened Species, threatened species (critically endangered, endangered and vulnerable) could be impacted by projects are collected. A site-wise biodiversity metric called species weighted range size rarity (WRSR) is calculated for each project site's impact area. Each project's score for each taxon is calculated as a weighted average of the share of each species' range covered by a project's buffer zone, with the weights defined as the rarity of each species within a taxon (Williams et al., 1996, Veach et al 2017).

$$wrsr_i = \sum w_j q_{ij}$$

where w_j = the weight assigned to species j, defined as its relative rarity and q_{ij} is the percent of species j's range that falls within the buffer zone of project j. This measure lowers the contribution of wide-ranging species to overall species richness and highlights areas with a relatively high proportion of narrow-range species. Our choice of weights assigned to species is guided by the severity level in the IUCN categories. We assign the following weights: critically endangered = 8; endangered = 6; vulnerable = 4; near Threatened = 2; least concern = 1; data deficient = 2 (following Montesino Pouzols et al. 2014).

Deforestation

To study the extent of deforestation that occurred before and after the project's groundbreaking/transaction date in the Amazon Basin, we used the Global Forest Cover (GFC) which is a satellite-derived, 30-meter resolution dataset that describes the global forest extent and change from 2000 to 2021. Relative change in tree cover (RCTC), a difference-in-difference approach (drawing from Anderson et al., 2018; Prem et al., 2020), is used to investigate if the trends change since the project's establishment.

$$RCTC_i = \frac{loss_{(T+3)\sim(T-1)} \big/ tree\ cover_{(T-1)}}{loss_{(T-1)\sim(T-5)} \big/ tree\ cover_{(T-5)}}$$

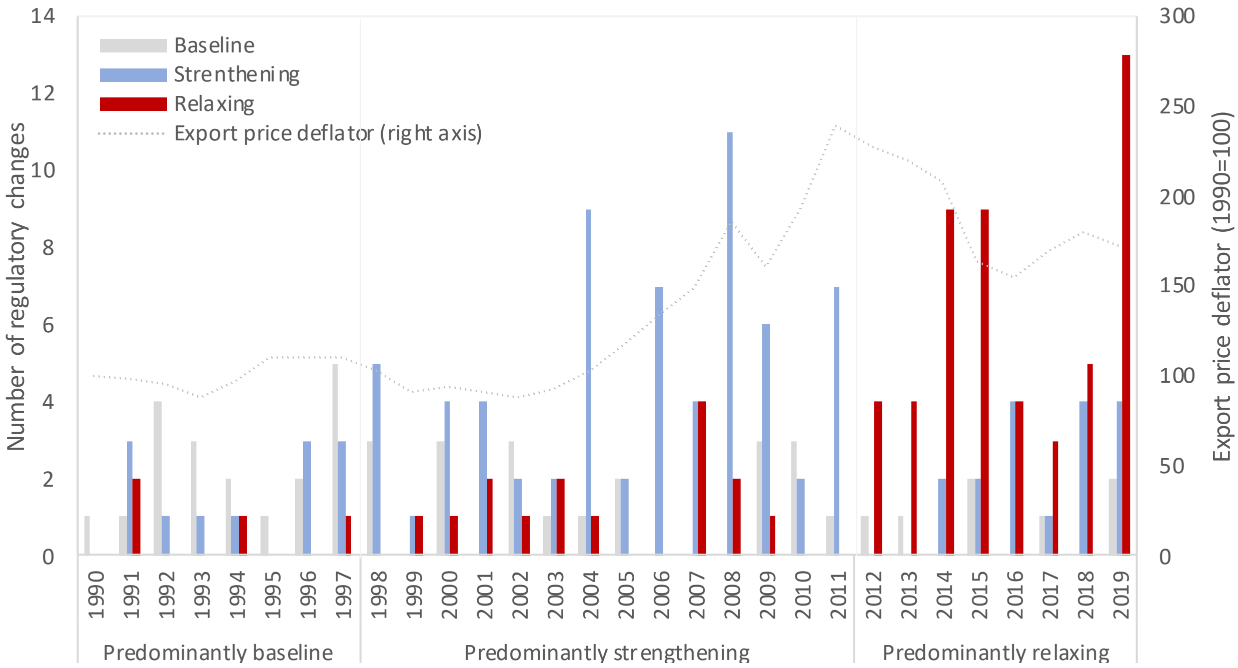
Where T= the groundbreaking year (for new projects) or purchase date (for mergers or acquisitions). This approach measures the change in the rate of tree cover in the years following groundbreaking or purchasing, relative to the existing tree cover loss rate and allows for variation among existing tree cover loss patterns. Instead of the year of actual groundbreaking or purchase, one year before (T-1) is used, to allow for a variety of dates used for each year's tree cover measure in GFC.

RESULTS

Socio-ecological regulatory changes from 1990-2019

Figure 1 and Table 3 aggregate the regulatory changes reported in the Observatório from 1990-2019, grouped by direction of change (establishing baselines, strengthening existing regulations and relaxing existing regulations) over the past thirty years. Weights are applied according to the number of affected policy dimensions for each reform, as discussed above. Figure 1 compares these changes to the combined export price deflator of the four countries here (weighted by each country's GDP). It is clear that regulatory frameworks followed the export commodity boom, as the "resource nationalism" literature suggests. Tracking the history of baseline, strength and flexibility regulatory changes shows that baseline changes predominated from 1990-1997, strengthening predominated until export prices peaked in 2011 and relaxing predominated thereafter. Strengthening changes were most prevalent during the years of greatest growth in commodity prices, from 2003-2011.

Figure 1: 30 Years of Socio-ecological Regulatory Changes in Bolivia, Brazil, Ecuador and Peru, by Direction of Change



Notes: See Supplementary Information 1 for a detailed timeline. Export price deflator is calculated as an average of the four countries, weighted by GDP. Each policy change is weighted by the number of dimensions affected: environmental licensing, forests and protected areas and Indigenous peoples and traditional communities.

Table 3 shows more detail by country and thematic coverage. It measures the net change of regulatory frameworks as the number of strengthening changes net of the number of relaxing changes. As Figure 1 shows, the period from 1998- 2011 shows an emphasis on strengthening regulatory frameworks, with a net change of 43, while the more recent period shows a net change of 35 in the other direction. Particularly notable is the volatility in the case of Brazil, which added 23 strengthening changes in Period 2 followed by 14 relaxing changes in Period 3. Thematically, significant swings are visible across all three areas of study: environmental licensing, forests and protected areas and Indigenous peoples and traditional communities.

Table 3: Net Change of Framework (Strengthening – Relaxing) by Country and Theme

	1990-1997	1998-2011	2012-2019
Total	**9**	**43**	**-35**
By country			
Bolivia	4	2	-10
Brazil	2	23	-14
Ecuador	1	4	0
Peru	0	19	-7
By dimension			
Environmental licensing	1	14	-11
Forests and protected areas	2	21	-6
Indigenous peoples and traditional communities	4	13	-14

Note: See Supplementary Information 1 for a detailed timeline.

Table 4 shows the results of the regression analysis described above, across the four models: probit regressions for the likelihood of a given reform moving policy in the strengthening (Model 1) or relaxing (Model 2) direction and OLS regressions for a policy's net change, without weights (Model 3) and with weights (Model 4) for the number of dimensions affected. Additional detail and alternative configurations are available in Supplementary Information 1.

Table 4: Regression Results: Regulatory Changes and Export Price Movement

	Likelihood of direction (probit)		Net direction (OLS)	
	1: Strengthening	2. Relaxing	3. Unweighted	4. Weighted
EPD (annual change) A	1.66*	-1.69*	1.14*	0.93*
	(0.76)	(0.84)	(0.48)	(0.43)
Bolivia	-1.02***	0.16	-0.41*	-0.40*
	(0.30)	(0.31)	(0.18)	(0.16)
Ecuador	-0.29	-0.16	0.12	-0.08
	(0.29)	(0.31)	(0.19)	(0.16)
Peru	-0.33	-0.07	0.10	-0.13
	(0.29)	(0.32)	(0.18)	(0.16)
Year	-0.02	0.06***	-0.02**	-0.03***
	(0.02)	0.01	(0.01)	(0.01)
Constant	30.54	-122.32***	49.05**	58.85***
	24.00	(27.11)	(15.31)	(14.05)
N B	172	172	172	211
(Pseudo) R2 C	0.0822**	0.1475***	0.1225***	0.1282***

Notes: A. EPD: Export Price Deflator, annual percent change. B. Model 4's higher N reflects the use of weights. C. Pseudo-R2 values apply to probit models; R2 values apply to OLS models.

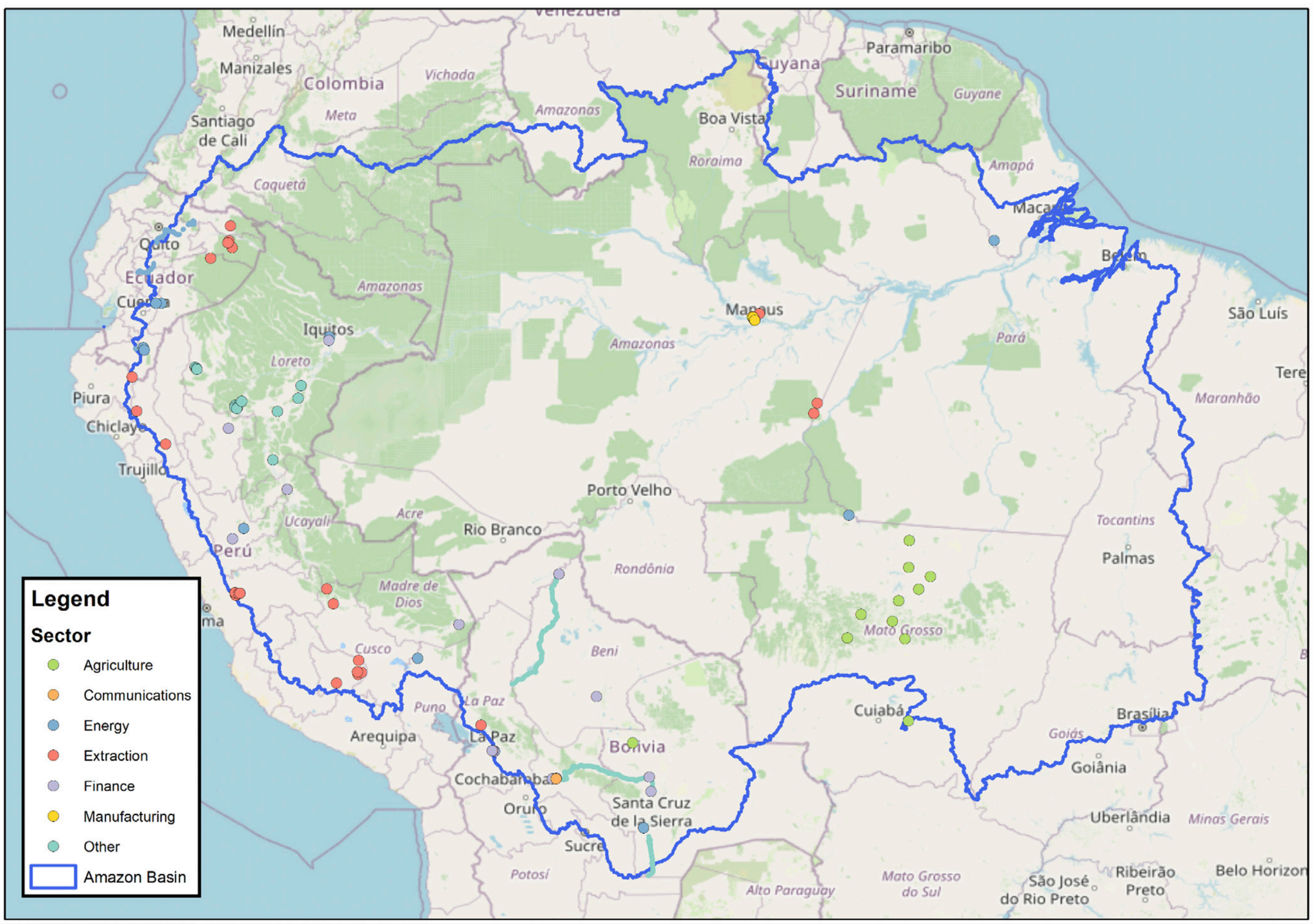
As Table 4 shows, each model finds a significant relationship between movement in a country's export price deflator and their social and environmental regulatory changes. During the time period studied here, these four countries were significantly more likely to strengthen their regulations when export prices were increasing, though Bolivia was significantly less prone to enact strengthening reforms during export boom years. Similarly, Model 2's negative coefficient for the export price deflator shows that these countries were less likely to relax existing regulations when export prices were rising.

These results reinforce the resource nationalism scholarship cited above. As the region's export price index more than doubled during the 2002-2011 commodity boom, governing regimes overwhelmingly chose to strengthen existing social and environmental protections. Once export prices reversed course, so too did the direction of policy change, abruptly favoring streamlining new investment over protecting affected communities and ecosystems.

Chinese investment in the Amazon basin

Relying on a wide variety of published datasets and reports, as described above, we have identified 42 Chinese investment and official finance projects in the Amazon basin or ecoregion during and after the 2002-2011 commodity boom, amounting to $26 billion and comprising 118 project sites. These investments occurred in Bolivia, Brazil, Ecuador and Peru from 2005 through 2019. These are shown in Figure 2.

Figure 2: Chinese Investment and Finance Projects in Amazon Basin Countries, 2006-2019



Note: Projects are displayed as lines for linear infrastructure and as representative points for poligonal projects such as oil and gas fields or grain warehouses, to maximize visibility. See Supplmentary Informaiton 2 for a complete list.

Table 5 tracks these investments over time. It shows the number of projects announced, the average time between announcement and final purchase or groundbreaking (in months) and the average size of projects in millions of US dollars (USD).

Table 5 shows that investment announcements grew until 2014, but that the following year saw no projects break ground or reach final purchase. Two significant projects comprise almost the entirety of the groundbreaking or final purchase activity in 2014. First, PetroChina announced its acquisition of Petrobras' assets in Peru (oil blocks X, 57 and 58) for $2.6 billion and its intention to invest an additional $635 million in greenfield FDI expansion of these assets (in oil blocks 6/7, 1-AB/8, 111 and 113). Second, China Minmetals announced its acquisition of the Las Bambas mine in Peru for $7 billion and an additional $3 billion greenfield investment in expansion of the project. (The M&A and GFDI portions are listed separately to allow for different completion years, as for example the Petro-China expansion of operations occurred the year following the acquisition.) If the relaxation in social and environmental regulations can be said to have facilitated any additional large-scale projects in

Table 5: Finance and Investment Projects by Year of Announcement and Groundbreaking/Purchase

	Project Announcements	Project Groundbreaking/ Purchases	Based on year of groundbreaking / purchase	
			Average time before purchase/ groundbreaking (months)	Average size (USD millions)
2005	1	0	n/a	n/a
2006	0	1	5.5	1,420.0
2007	1	0	n/a	n/a
2008	3	3	7.6	829.7
2009	2	2	4.9	12.6
2010	3	2	2.4	843.4
2011	5	6	1.1	272.1
2012	3	2	0.0	50.6
2013	2	1	8.0	556.7
2014	5	6	5.6	2,535.3
2015	2	0	n/a	n/a
2016	4	3	10.3	389.7
2017	2	1	6.3	438.0
2018	4	6	10.6	342.5
2019	5	5	6.1	309.2
Total	42	38	6.0	704.9

Note: See Supplementary Information 2 for a complete list. Projects that have been announced but that had not yet had a closing date or groundbreaking by 2020 include the Rositas hydroelectric project in Bolivia (announced in 2016) and four projects in Peru: the Hidrovía Amazónica (2017) and the Galeno (2008), Colca (2019) and Jalaoca (2019) mines. The Colca and Jalaoca mines are part of the same M&A project.

the Amazon, then, it is most likely to have been for these two major projects. Of course, projects need not be large to be environmentally or socially sensitive, so the section below examines the risk and impact profiles of each project regardless of size.

In parallel, the average length of time elapsed between announcement and purchase, or ground-breaking time also rose, peaking in 2016 and 2018 at an average of over ten months each. In part these greater delays reflect approvals of controversial projects. The longest delay was for the El Sillar highway in Bolivia, which took 20 months between approval and groundbreaking due to a series of labor disputes and engineering challenges posed by terrain and weather complications in the area (see for example "La Muestra" 2016; "Sinhidro atenderá" 2018; Manzaneda 2016). It is noteworthy that the projects with larger size and longer time delays are not the same projects; rather the larger projects are the oil and mining projects in Peru discussed above, while the projects with longer delays are highway projects in Bolivia, including El Sillar as well as Rurrenabaque-Riberalta (which took 16 months before groundbreaking) and El Espino - Charagua - Boyuibe (which took 17 months). However, while Bolivia enacted several reforms relaxing environmental and social protections in 2014 and 2015, these are unlikely to have had a significant impact on the approval process for these highways, as the reforms targeted hydrocarbons and agricultural industries rather than infrastructure or investments in general. Instead, this result is likely to be related to the documented tendency of Bolivian highway development to involve significant delays due to long-standing national factors (Ray et al 2020).

Overall, then, the period of regulatory relaxation does not appear to have either brought additional Chinese investment beyond 2014 or expedited projects' trajectories from announcement to groundbreaking or final purchase. However, the possibility remains that projects that advanced during this time may have had higher environmental or social risks or impacts related to the weaker protections. The following section explores those results in more detail.

Socio-ecological risk and impact profile of Chinese projects

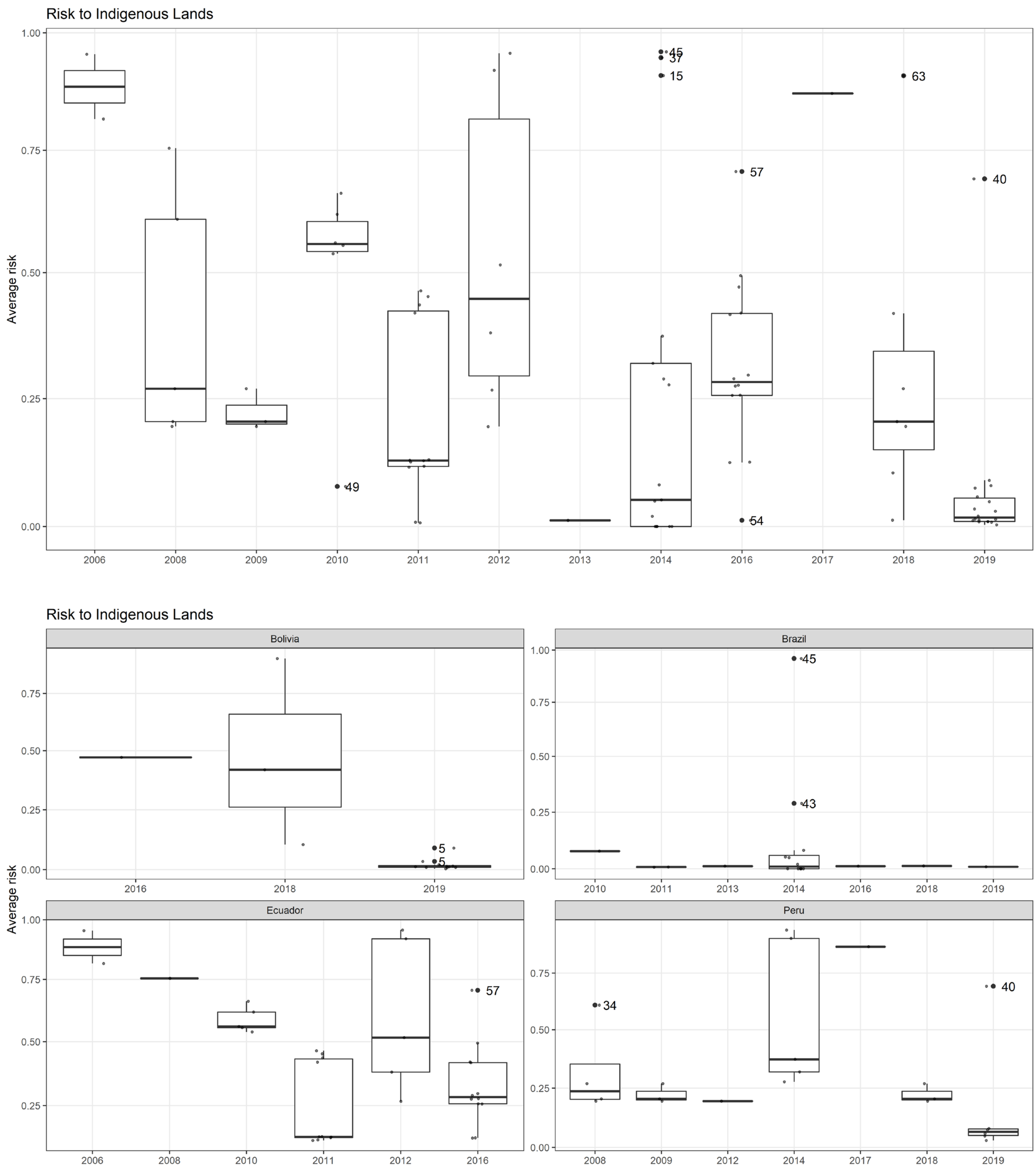
This section examines the risk factors for Indigenous territory and for biodiversity as well as ensuing changes in the rates of tree cover loss in proximity to each project. As the four countries have varying degrees of coverage of each factor (Indigenous territory, ranges of threatened species and tree cover), each factor is shown in aggregate and by country. Further detail is available in Supplementary Information 2.

Indigenous peoples' lands

Figure 3 shows the risk of Chinese investment and finance projects to Indigenous territory by groundbreaking or purchase date, from 2006 through 2019. As coverage of Indigenous territory varies by country, it shows both overall and national trends. Notably, the vertical axis varies by country in order to highlight trends in each national case, even in cases where those trends may not be visible on the regional chart due to a lower national range for Indigenous territory overlap.

The trajectory of annual median levels generally declines throughout the study period, although several high outliers occur in 2014-2019. These outliers include not only the PetroChina investments in Peru and one of the three Bolivian highways described above, but also the Huallaga hydroelectric dam (in Peru), as well as Cofco agricultural processing facilities and two hydroelectric dams in Brazil, the power transmission lines for Ecuador's Coca-Codo Sinclair hydroelectric damand Alianza Seguro's insurance offices throughout Bolivia, including the Amazon basin.

Figure 3: Chinese Projects' Risks to Indigenous Territories in the Bolivian, Brazilian, Ecuadorian and Peruvian Amazon Basin



Note: Outliers include 5: Alianza Seguros (Bolivia); 15: PetroChina oil blocks 6/7, 1-AB/8, 111 and 113 (Peru); 37: PetroChina oil blocks X, 57 and 58 (Peru); 40: Huallaga hydroelectric dam (Peru); 43: Cofco agricultural processing facilities (Brazil); 45: São Manoel dam (Brazil); 57: Coca-Codo-Sinclair power transmission lines (Ecuador); 63: El Espino - Charagua - Boyuibe highway (Bolivia).

Socio-ecological risk profile of Chinese projects: Risks to threatened species

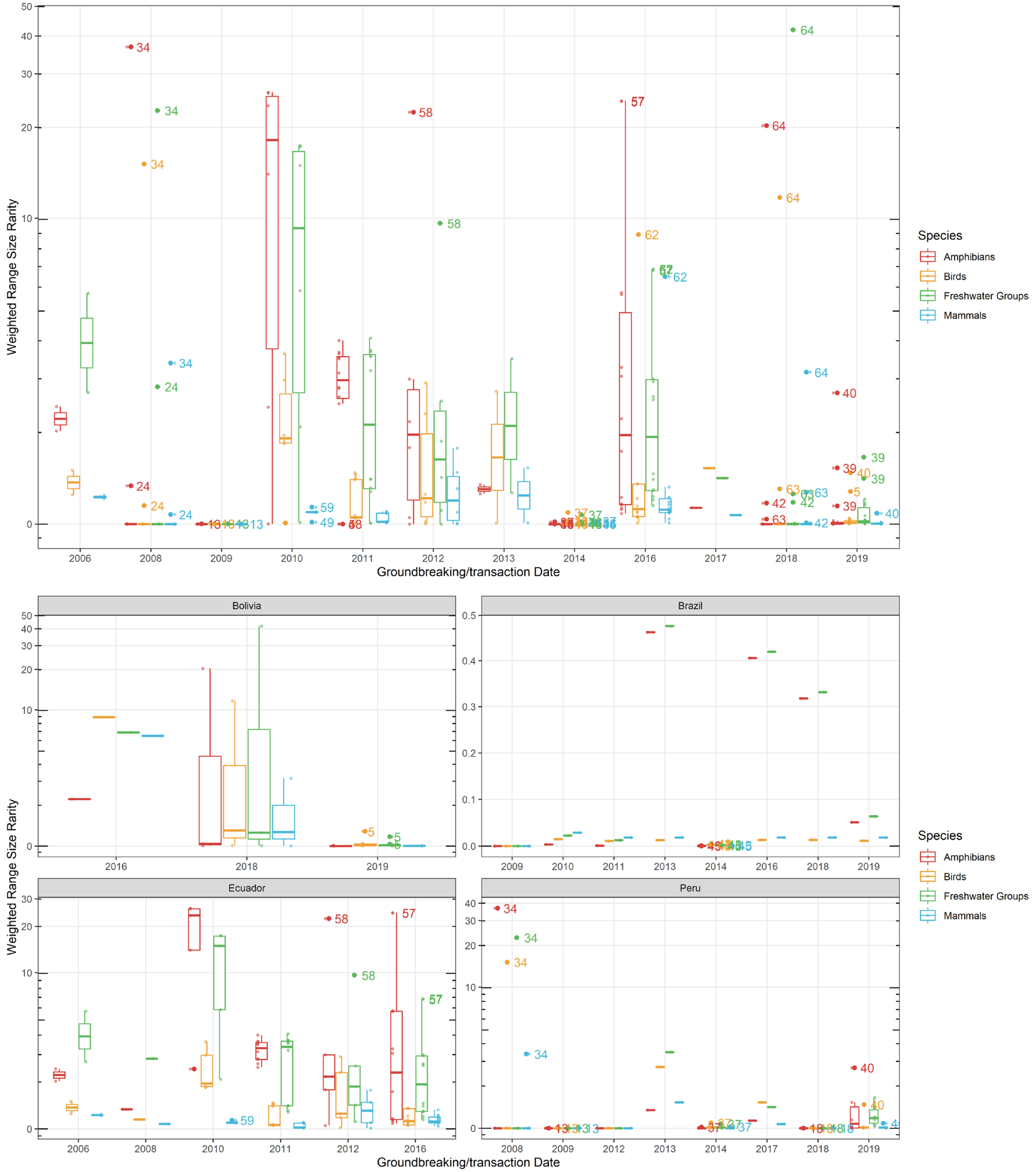
Figure 4 shows the weighted range size rarity (WRSR) values by year of groundbreaking or purchase. As above, while the median values decline over time, significant outliers appear in the latter years. In 2018, these high-risk projects have a strong enough impact to visibly affect the entire distribution for that year. As the national charts show, these higher-risk 2018 projects reflect a peak in Bolivia and Ecuador.

Socio-ecological impact profile: relative change in tree cover

Figure 5 shows the relative change in tree cover around each project, by year of groundbreaking or purchase and by country, as above. The reference line along the vertical axis indicates a value of 1, where tree cover change continued at the same rate after groundbreaking or purchase as it had before that year.

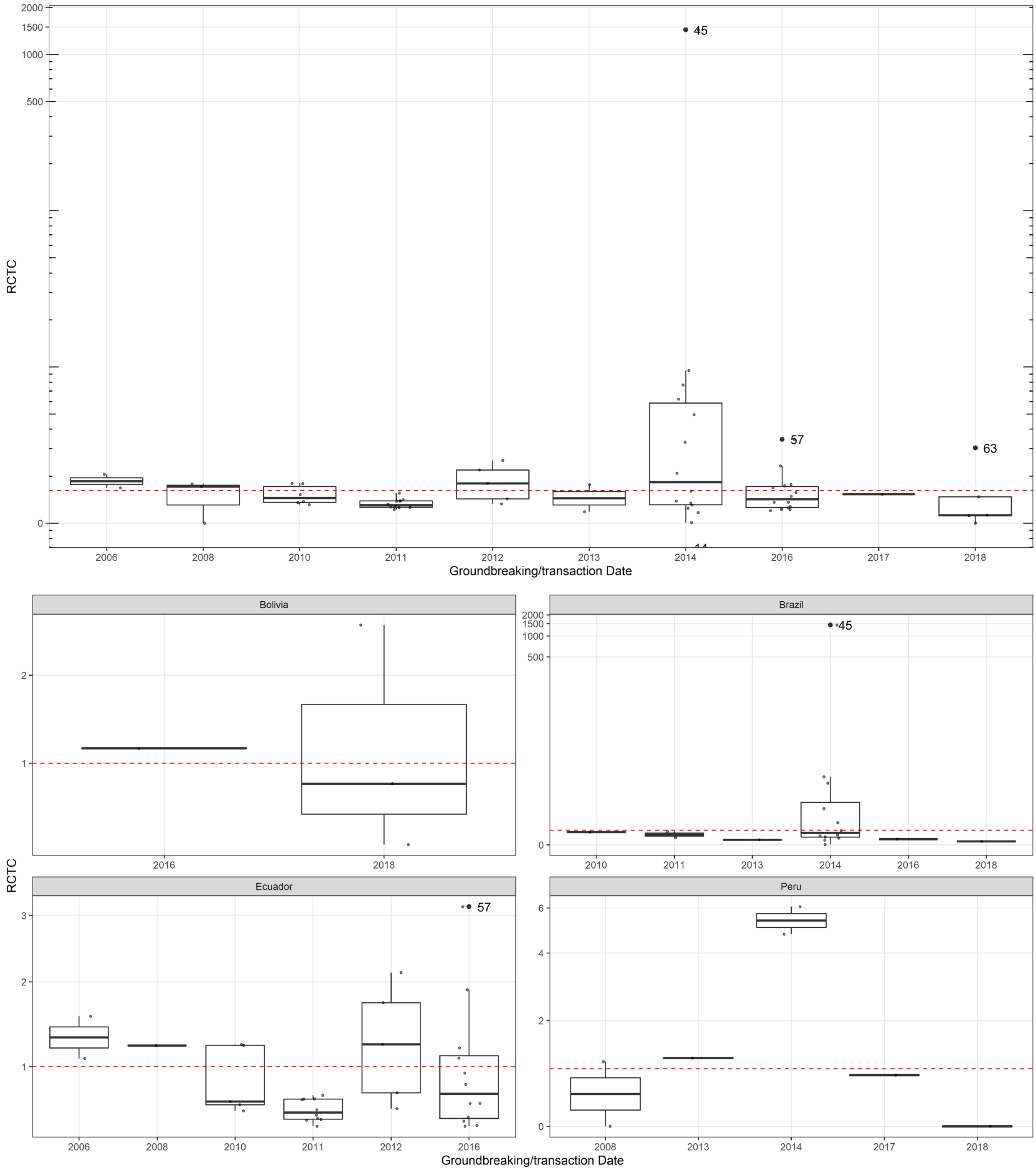
The role of outliers is even more visible in these results than in other variables. All three of these outliers occur as outliers in Figure 3 as well, indicating that these projects were associated with significant acceleration in tree cover loss in close proximity to Indigenous territory. The Coca-Codo Sinclair power transmission lines project in particular is the only project in the dataset to appear as an outlier across all three variables, indicating its status as a project associated with a rare combination of social and environmental risks and impacts. However, it should be noted that the relative tree cover change surrounding the São Manoel dam was many times more dramatic. São Manoel is located on the Pará - Mato Grosso border, where the infrastructure and agricultural frontier have expanded in tandem and so this result is reflective of a broader trend of local deforestation including the dam as well as agricultural activity.

Figure 4: Weighted Range Size Rarity for Threatened Species within the Buffer Zones of Chinese Projects in the Bolivian, Brazilian, Ecuadorian and Peruvian Amazon Basin



Note: Outliers include 24: Andes Petroleum Tarapoa oil block (Ecuador); 34: Rio Blanco mine (Ecuador); 40: Huallaga dam (Peru); 57: Coca-Codo Sinclair power transmission lines (Ecuador), 58: Paute Mazar dam (Ecuador); 62: Rurrenabaque - Riberalta highway (Bolivia), 64: El Sillar highway (Bolivia).

Figure 5: Relative Change in Tree Cover within Buffer Zones of Chinese Projects in the Bolivian, Brazilian, Ecuadorian and Peruvian Amazon Basin



Note: Outliers include 45: São Manoel dam (Brazil); 57: Coca-Codo-Sinclair power transmission lines (Ecuador); 63: El Espino - Charagua - Boyuibe highway.

DISCUSSION AND POLICY RECOMMENDATIONS

From the results in Section 4.1, it is clear that these four countries' social and environmental regulations for inbound investments followed their export price index, as predicted by the "resource nationalism" literature. However, the results in Section 4.2 also show that Chinese investments did not regain their prior strength after socio-ecological protections were relaxed. Chinese projects did not proceed more quickly from announcement to final purchase or groundbreaking date after 2012 than before. Thus, these findings reinforce the tendency of Amazon basin government regimes with "resource nationalism" approaches to vary eco-social protections according to export revenues during the "China boom" in natural resources in South America, but it does not find that these efforts succeeded in attracting greater investment or in expediting these projects.

These results also show that relaxing protections did not significantly expedite Chinese investment into the Amazon basin by lowering the costs of regulatory compliance. Instead, the average time between project announcement and commencement grew after 2011, even as the average size of investment shrank. One notable exception to trend—the 2014 Las Bambas mine purchase by China MinMetals—reached commencement quickly after regulatory requirements were relaxed but has been plagued ever since with operational difficulties. Thanks in part to regulatory changes, the new owners were able to revise their plans for transporting ore from relying on pipelines to using trucks, which has been the subject of ongoing cycles of protests and partial operational shutdowns (see for example De Echave Cáceres 2020). These findings reinforce other scholarship showing that international investments—Chinese or otherwise—with higher environmental and social risk levels are more prone to facing delays and possibly cancellations due to controversies that were not adequately prevented or resolved early in the project cycle (see for example Lu, Zhou and Simmons 2022; Coppens, Van Dooren and Thijssen 2018; Temper et al 2020; Watkins et al 2017).

Of course, it is impossible to disprove a counterfactual hypothesis, that Chinese investment might have been even stronger during the "China boom" without the wave of environmental and social protections, or that Chinese investment might have fallen off even more dramatically if not for the wave of relaxations of the same protections. Existing literature on the motivations of Chinese investment (see for example China and Gallagher 2019; Dosch and Goodman 2012; Wang, Liao and Weidong 2022) can help address this possibility. Their results show that Chinese investors' incentives reinforce the findings in the present paper, that Chinese investors' incentives are less dependent on short-term cost considerations than Western multinational corporate investors. Other recent research into post-boom Chinese investment trends has found that it is declining overall, regardless of the levels or directions of change in host country social and environmental governance. Instead, it appears to be responding to a combination of domestic factors (including reduced domestic Chinese demand for commodities and a reduced supply of foreign currency reserves) as well as international factors such as a rising awareness of project delays and cancellations that have occurred during these recent years (see for example Custer et al 2021; Oliveira and Myers 2020; Scissors 2019). However, to more fully explore the potential counterfactual—that a more dramatic investment boom and then slump may have happened without regulatory changes—would require future qualitative research into the Chinese firms that did (and did not) invest in Amazon basin countries during and after the commodity boom.

The results in Section 4.3 demonstrate that median project environmental and social risk profiles did not rise significantly as environmental and social protections relaxed, although several significantly higher-risk outliers went ahead after that point. For example, the PetroChina purchase and expansion of Petrobras' assets in Peru are among the largest projects in this dataset, announced and finalized after protections began to be relaxed and were also an outlier for risks to Indigenous territory. In addition, the partial purchase and development of the São Manoel dam by China Three Gorges Brazil

(CTG Brasil) appears as a far outlier in the acceleration of tree cover loss due to flooding for the new reservoir, as well as risk to Indigenous territory. Nonetheless, on the aggregate, the rollback was not followed by an across-the-board surge in high-risk projects.

It remains for future research to investigate whether similar conclusions can be drawn for Western multinational investment. Of course, Amazon basin countries depend on a variety of investment sources, even though the recent commodity boom was fueled by Chinese investment and finance, in particular. Western multinational investors in the Amazon may be resource-seeking and market-seeking like Chinese investors and therefore less prone to being incentivized by the short-term costs associated with social and environmental protections, but they are less likely to be active through the "coordinated credit spaces" of state-owned enterprises and policy banks that characterizes Chinese investment abroad (Chin and Gallagher 2019).

Nonetheless, regarding Chinese investment in particular, these results reinforce the hypothesis that China's resource-seeking and market-seeking investment is not likely to be incentivized or disincentivized through the short-term business costs related to regulatory frameworks. Based on these results, countries with strong environmental and social protections need not worry that these regulations are disincentivizing Chinese investment in resource-seeking or market-seeking sectors. Instead, they would be wise to base their regulations on their own sustainable development goals, to ensure that when Chinese investment does come, it benefits—or at least does not harm—local ecosystems and the communities that rely on them, while protecting investors from the risk of conflict for investors that may arise from unmitigated environmental and social risks.

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SUPPLEMENTARY INFORMATION 1

Usage of "Observatório Dos Sistemas Nacionais De Proteção Socioambiental Da Região Amazônica"

This working paper draws on the history of Amazon basin countries' environmental and social policy, as recorded in the "Observatório Dos Sistemas Nacionais De Proteção Socioambiental Da Região Amazônica" (hereinafter "the Observatório"). The Observatório is maintained by the BRICS Policy Center of Pontifical Catholic University, Rio de Janeiro (BPC 2022). This supplement contains three sections, providing a brief overview of the data source, a summary of trends found therein and greater detail regarding the regression analysis performed using the data in the main text, respectively.

DATA DESCRIPTION

The "Observatório Dos Sistemas Nacionais De Proteção Socioambiental Da Região Amazônica" was compiled in conjunction with an international expert panel, composed of legal, environmental and social policy researchers from every represented country, through a series of high-level workshops complemented with a peer-review process for validation. During this process, the Observatório research team adopted a content analysis approach and took these legal occurrences as data collection and analysis units. The coding scheme combined *a priori* and grounded coding techniques, incorporating internationally agreed standards and categories emerging from the legal archive. Table SI1.1 presents the dimensions and categories adopted in the study.

Table S1.1: Socio-environmental Protection Dimensions and Categories in the *Observatório Dos Sistemas Nacionais De Proteção Socioambiental Da Região Amazônica*

Dimension	Categories
1. Environmental licensing	Scope of Protection (SP)
	Licensing Procedures (LP)
	Authority Responsible for Licensing (ARL)
	Participation and Public Control (PCP)
2. Forests and protected areas	Scope of Protection (SP)
	Means of Implementation (MI)
	Authority responsible for the Public Policy (APP)
	Participation and Public Control (PCP)
3. Indigenous Peoples and Traditional Communities	Scope of Protection (SP)
	Means of Implementation (MI)
	Authority responsible for the Public Policy (APP)
	Participation and Public Control (PCP)

The expert panel conducted the coding process to assess whether a given occurrence established a baseline requirement or strengthened or relaxed an existing national baseline (Table SI1.2) presents codes and sub-codes adopted). Hence, the expert panel identified national baselines contrasting international agreements, national constitutions and national legislation. The research team reviewed the entire coding process.

Table S1.2: Codebook Summary, *Observatório Dos Sistemas Nacionais De Proteção Socioambiental Da Região Amazônica*

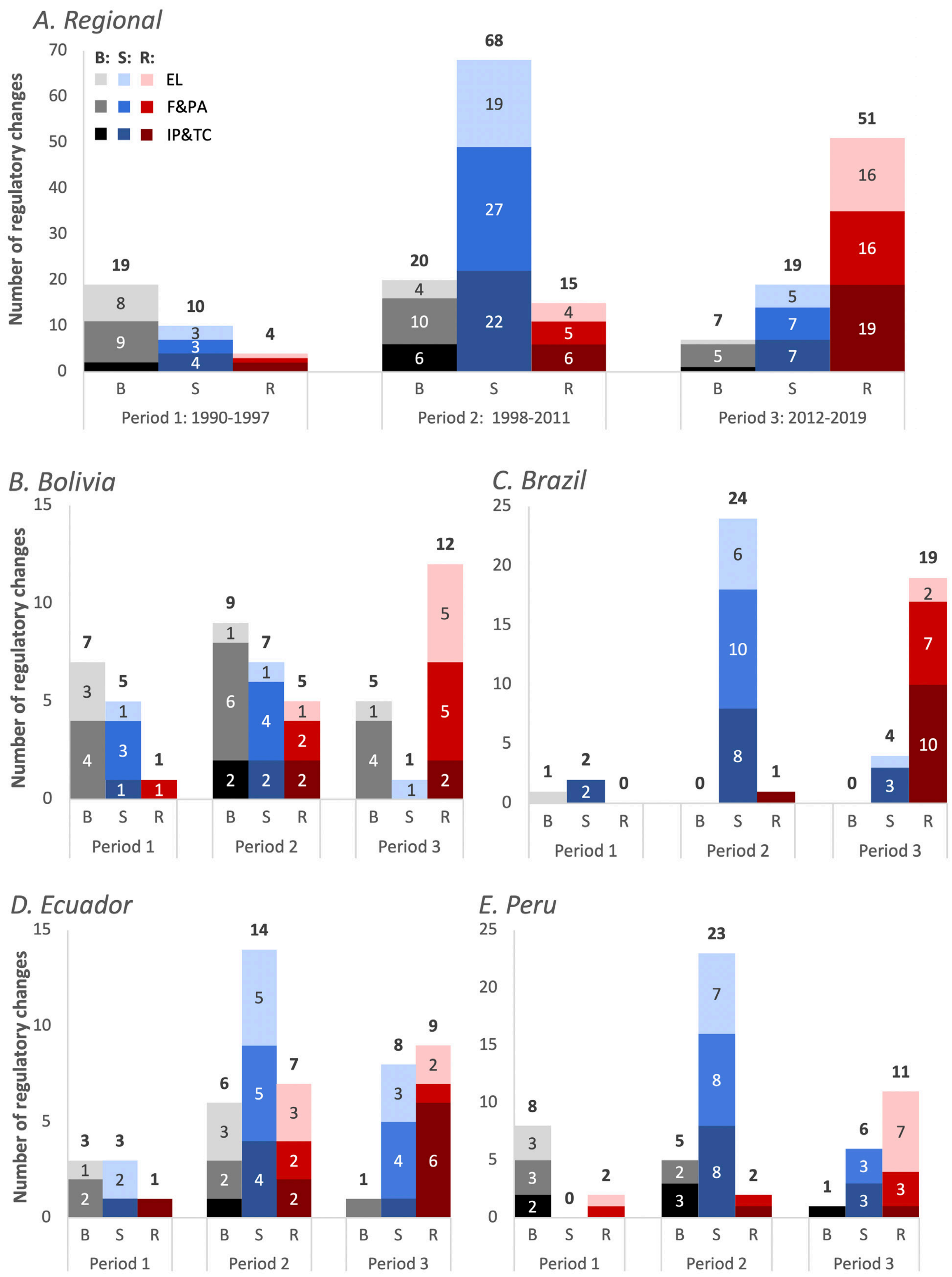
Dim.	Cat.	Codes	Sub-Codes
1.	SP	Range of social and environmental risks addressed; Range of areas or social groups protected.	Strengthening; baseline; relaxing; na
	LP	Available or required tools (e.g.: Environmental and Social Impact Assessment – ESIA) and time span.	Strengthening; baseline; relaxing; na
	ARL	Mandate (license, monitoring and oversight); Independence.	Strengthening; baseline; relaxing; na
	PCP	Stakeholder engagement, information disclosure and grievance mechanisms.	Strengthening; baseline; relaxing; na
2.	SP	Range of: areas protected (IUCN categories); forests protected (FAO categories); linking elements protected (Biological Corridors; Ecological Step Stones; Buffer zones) (Dudley & Phillips, 2006; FAO, 2020)	Strengthening; baseline; relaxing; na
	MI	Enforcement and management tools;	Strengthening; baseline; relaxing; na
	APP	System Mandate; Environmental Institution Mandate (Management and monitoring); Independence.	Strengthening; baseline; relaxing; na
	PCP	Stakeholder engagement and information disclosure	Strengthening; baseline; relaxing; na
3.	SP	Range of rights (self-determination, lands, territories and resources, economic, social and cultural rights) (see e.g. UNGA 2007; World Bank, 2017)	Strengthening; baseline; relaxing; na
	MI	Enforcement and management tools;	Strengthening; baseline; relaxing; na
	APP	Indigenous Peoples Institutions Independence and Mandate (Management, monitoring and oversight)	Strengthening; baseline; relaxing; na
	PCP	Free, Prior and Informed Consent of Indigenous Peoples; active participation in decision-making processes and related institutions (ILO 1989; UNGA 2014).	Strengthening; baseline; relaxing; na

DATA SUMMARY AND TRENDS

Figure SI1.1 shows summaries for each country, dimension and year over the 30-year period from 1990-2019. As in the main text, years are classified across three periods: 1990-1997, in which baseline regulations predominate for most countries and dimensions; 1998-2011, during which regulatory strengthening predominates; and 2012-2019, when regulatory relaxation predominates.

As described in the main text, the Observatório database classifies regulatory changes among three general directions of change: establishing baseline regulations, strengthening existing regulations, or relaxing those regulations (often referred to as “flexibilizing” in domestic policy discourse). It includes nine dimensions of socio-ecological regulation. To focus on the types of regulations most relevant to construction in the Amazon basin, this analysis relies on three dimensions of the “Observatório:” (i) Environmental licensing, (ii) Forests and protected areas and (iii) Indigenous Peoples and Traditional Communities. These dimensions were established taking the World Bank’s environmental and social framework as a reference, particularly the following standards: Standard 1 - Assessment and management of environmental and social risks and impacts; Standard 6 - biodiversity Conservation and sustainable management of living natural resources; Standard 7 - indigenous peoples/sub-Saharan African historically Underserved traditional local Communities; Standard 10 - Stakeholder engagement and Information Disclosure (World Bank, 2017). The dimension of forests and protected is a combination of two Observatório dimensions, for forests and for protected areas, respectively, but are combined here in order to give equal weight to the three resulting dimensions used in the present analysis: land (forests and protected areas), people (Indigenous peoples and traditional communities) and process (environmental licensing).

Figure S1.1: Regulatory Changes Included in the Obseratório



Key: B: Baseline; S: Strengthening; R: Relaxing; EL: Environmental licensing; F&PA: Forests and protected areas; IP&TC: Indigenous peoples and tribal communities.
Source: BPC 2022.

In practice, regulatory changes are not uniform in their breadth and impact. Although this dataset is limited to counting changes in each direction, rather than thoroughly considering the extent of each policy's impact on planned investments, it is possible to apply weights that reflect reforms' breadth: the number of policy dimensions affected by each reform. For example, Bolivia's and Ecuador's current constitutions, enacted during the study period, establish baseline regulations across all three policy dimensions considered here. Thus, in applying weights to quantitative analysis, each of these Obseratório entries may be given a frequency weight of three. The analysis below is conducted with and without these weights for the sake of robustness.

The importance of baseline, strengthening and relaxing regulatory changes across these three periods is relative rather than absolute. For example, Bolivia continued to enact a significant number of baseline regulations across all three periods and in fact these baselines form the plurality of changes in periods 2 and 3. Nonetheless, strengthening changes were more common in the second period than either the first or third, and relaxing changes were more common in the third period than in either preceding period. In contrast, Brazil has only one baseline regulation in the Observatório for these three dimensions in this study period, which was enacted in 1997, in the first time period.

It should be noted that in some cases, a given regulatory change may appear under more than one direction of change. For example, Ecuador's 2015 Acuerdo 61 is shown as strengthening some aspects of environmental licensing regulations and relaxing others. This aspect of the Observatório database is preserved for the sake of completeness.

Table A3 lists all regulatory changes used in this analysis, listed by country, year and dimension.

Table S1.3: Regulatory Changes Listed in the Observatório, Selected Dimensions and Years

A. Bolivia

Norm	Year	Dimension		
		EL	F&PA	IP&TC
Act 1275/1991 (MI, EP)	1991	S		S
Act 1333/1992 (EP, MI, PCP, APP)	1992		B	
Act 1576/1994 (EP, APP)	1994		B	
Act 1580/1994 (EP, APP)	1994		S	
Decree 24176/1995 (EP, PrL, AL, PCP)	1995			B
Act 1688/1996 (EP, APP)	1996		S	
Act1700/1996 (MI, APP)	1996		B	
Decree 24335/1996 (EP, PrL, AL)	1996			B
Decree 24733/1997 (EP, APP)	1997		S	
Decree 24781/1997 (EP, MI, PCP, APP)	1997		B	B
Ministerial Resolution 131/1997 (MI, APP)	1997		R	
Decree 25158/1998 (EP, MI, PCP, APP)	1998		S	
Decree 25532/1999 (MI, APP)	1999		R	

A. Bolivia (continued)

Norm	Year	Dimension		
		EL	F&PA	IP&TC
Decree 25929/2000 (EP, PCP, APP)	2000		B	
Act 2274/2001 (EP, APP)	2001		S	
Act 2352/2002 (EP)	2002		S	
Act 2357/2002 (EP)	2002		B	
Decree 26556/2002 (EP)	2002		B	
Decree 26736/2002 (PrL, AL)	2002			S
Act 2878/2004 (MI, APP)	2004		B	
Decree 27904/2004 (MI, APP, PCP)	2004		S	
Act 3760/2007 (EP, APP)	2007	S		
Decree 28998/2007 (MI, PCP, APP)	2007		R	
Decree 29033/2007 (MI, PCP, APP)	2007	R		R
Decree 29103/2007 (MI, EP, APP, PCP)	2007	R		
Constitution, 2009	2009	B	B	B
Decree 335/2009 (MI, EP, APP, PCP)	2009	S		
Act 31/2010 (MI, APP)	2010	B		
Act 71/2010 (EP, APP)	2010		B	
Act 300/2012 (EP, APP)	2012		B	
Decree 1696/2013 (MI, APP)	2013		B	
Act 502/2014 (MI, APP)	2014		R	
Decree 2195/2014 (MI, PCP, APP)	2014	R		
Act 741/2015 (MI, APP)	2015		R	
Act739/2015 (MI, APP)	2015		R	
Decree 2298/2015 (MI, APP)	2015	R		R
Decree2366/2015 (MI)	2015		B	
Ministerial Resolution 003/2017 (EP, PCP)	2017		B	
Administrative Resolution 029/2018 (PrL, AL)	2018			R
AJAM Regulation/2018 (EP, PCP, APP)	2018		R	R
Decree 3549/2018 (PrL, AL)	2018			R
Act 1171/2019 (MI, APP)	2019		R	
Act 1182/2019 (AL, PCP)	2019			S
Act 1205/2019 (EP, AL)	2019			B
Decree 3856/2019 (PCP, AL)	2019			R

B. Brazil

Norm	Year	Dimension		
		EL	F&PA	IP&TC
Act 8629/93 (EP, MI)	1993	S		
Decree 1175/96 (MI)	1996	S		
CONAMA Resolution 237/97 (PrL)	1997			B
Act 9605/98 (EP, MI)	1998		S	S
Act 10165/00 (EP, MI)	2000			S
Act 9985/00 (EP, MI)	2000	S	S	S
Decree 3912	2001	R		
Decree 4887/03 (EP, MI)	2003	S		
Decree 5051/04 (EP, PCP)	2004	S		S
Decree s/n 04 (APP)	2004	S		
Act 11284/06 (EP, MI, APP)	2006		S	
Act 11326/06 (PCP)	2006	S		
Act 11428/06 (EP)	2006		S	
Decree s/n/06 (EP, MI)	2006	S		
Act 11516/07 (APP)	2007		S	
Decree 6040/07 (EP, MI)	2007	S		
Decree 6514/08 (EP)	2008		S	
Decree 6527/08 (MI)	2008		S	
Act 12.187/09 (EP, MI)	2009		S	S
Complementar Law 140/11 (APP)	2011		S	S
Interministerial Ordinance 419/11 (APP)	2011	S	S	
Act 12651/12 (EP, MI)	2012	R	R	R
Decree 8765/15 (PCP)	2015	R	R	
Interministerial Ordinance 60/15 (AL)	2015			S
Act 13341/16 (APP)	2016	R		
Decree 8750/16 (PCP)	2016	S		
Decree 8889/16 (APP)	2016	R		
Act 13465/17 (EP)	2017	R		
Report Attorney General 001/2017 (EP)	2017	R		
Supreme Court Ruling – 2018 (ADI 3329) (EP)	2018	S		
Supreme Court Ruling – 2018 (RE 1.017.365) (EP, MI)	2018	S		
Act 13844/19 (APP)	2019	R	R	
Act 9759/19 (PCP)	2019		R	R
Decree 10144/19	2019	R	R	
Decree 9759/19 (PCP)	2019	R		
Decree 9806/19 (PCP)	2019		R	
Decree 9985/19	2019	R	R	

C. Ecuador

Norm	Year	Dimension		
		EL	F&PA	IP&TC
Mining Law/1991 (PrL, EP)	1991			B
Law 08/1992 (APP)	1992		B	
Law 418/1992 (EP)	1992		B	
Executive Decree 1679/1994 (APP)	1994	R		
Decree 195/1996 (AL)	1996			S
Executive Decree 625/1997 (PrL)	1997			S
Law221/1997 (APP, PCP)	1997	S		
Constitution 1998	1998	B	B	B
Executive Decree 386/1998 (APP, PCP)	1998	S		
Ratification of ILO's 169 Convention (PCP)	1998			S
Law 37 – Law of Environmental Management/1999 (PrL, AL)	1999			S
Trole II Act/2000 (PrL, EP)	2000			R
Regulation 307/2001 (AL)	2001			R
Decree 3401/2002 (PCP)	2002			R
Environmental Regulations for Hydrocarbon Operations(Regulation 389/2002)(EP, PrL)	2002			B
Law 222/2003 (MI)	2003	R	R	
Texto Unificado de la Legislacion Ambiental Secundaria (Livro VI de TULAS)/2003 (EP)	2003			B
Law 315/2004 (EP)	2004	R		
Law418/2004 (EP)	2004		S	
Ley de Gestión Ambiental/2004 (AL)	2004			S
Law 40/2006 (APP)	2006		S	
Law 67/2006 (EP)	2006	S		
Constitution, 2008	2008	S	S	S
Law 829/2008 (APP, MI)	2008		S	
Law 45/2009 (EP)	2009		R	
Hydrocarbon Law – Supreme Decree 2967/2010 (EP, PrL)	2010			S
Law 303/2010 (MI)	2010		B	
Decree 553/2011 (PCP)	2011	S		
Ministerial Agreement 95/2011 (EP, MI)	2011		S	
Decree 1247/2012 (PCP)	2012	R		
Legislative Resolution 106/2013 (EP)	2013	R	R	
Decree16/2014 (EP)	2014	R		
Law 283/2014 (EP)	2014	R		
Ministerial Agreement 95/2014 (EP, MI)	2014		S	
Acuerdo 61/2015 (AL)	2015			S,R

C. Ecuador (continued)

Norm	Year	Dimension		
		EL	F&PA	IP&TC
Executive Decree 739/2015 (EP)	2015	R		
Law 03/2016 (EP)	2016	R		
Law 829/2016 (APP, MI)	2016		S	
Law 899/2016 (EP)	2016	S		
Environmental Organic Code (COA)/2017 (PrL, EP)	2017			S
Law 245/2018 (EP, MI)	2018		S	
Executive Decree 752/2019 (RCOA)(PCP)	2019			S,R
Law 983/2019 (EP)	2019		B	
Ministerial Agreement 065/2019 (MI)	2019		S	

D. Peru

Norm	Year	Dimension		
		EL	F&PA	IP&TC
Legislative Decree 603/1990 (EP, PrL)	1990			B
Decree 008-91-TR(MI)	1991	S		
Legislative Decree 708/1991 (EP)	1991	R		
Legislative Decree 757 of 1991 (PrL, APP)	1991			R
Decree 004-92-TR(MI)	1992	S		
Decree 014-92-EM(EP)	1992	B		
Constitution / 1993	1993	B	B	B
Act 26410/1994 (APP)	1994			B
Act 26821/1997 (MI)	1997		B	
Act 26834/1997 (EP, MI)	1997		B	
Act 27308/2000 (MI)	2000	B	B	
Act 27446/2001 (PrL, APP)	2001			S
Decree 038-2001-AG(MI)	2001		S	
Decree 068-2001-PCM(EP, MI)	2001		S	
Decree 002-2003-AG(APP)	2003		S	
Act 28245/2004 (APP)	2004			S
Decree 087-2004-PCM(EP)	2004		S	
Regulation 2004 (EP)	2004			S
Act 28611/2005 (EP)	2005	B	B	
Decree 008-2005-PCM	2005	S		
Legislative Decree 1078/2005 (PrL, EP, APP)	2005			S
Act 28736/2006 (EP)	2006	S		
Decree 008-2007-MIMDES(EP)	2007	S		
Decree 006-2008-MINAM(APP)	2008		S	

D. Peru (continued)

Norm	Year	Dimension		
		EL	F&PA	IP&TC
Legislative Decree 1013/2008	2008	S	S	S
Legislative Decree 1078/2008 (EP)	2008	S		
Legislative Decree 1090/2008 (EP)	2008	R	R	
Act 29325/2009 (APP)	2009			S
Decree 008-2009-MINAM(MI)	2009		S	
Decree 19 of 2009 (PrL)	2009			S
Decree 008-2010-MINAM(MI)	2010		S	
Act 29763/2011 (EP)	2011	S		
Act 29785/2011 (EP, PCP)	2011	B		
Decree 054-2013-PCM(PrL)	2013			R
Decree 060-2013-PCM(PRL)	2013			R
Act 30230/2014 (EP, APP)	2014	R	R	R
Decree 039-2014-EM(EP)	2014		R	R
Decree 040-2014 (MI)	2014		S	
Act 30327/2015 (PrL)	2015			R
Act 30355/2015 (EP)	2015	B		
Decree 015-2016-MINAGRI(EP)	2016	S		
Resolution 184/2016 (PrL)	2016			R
Decree 042-2017-EM(EP)	2017		R	
Legislative Decree 1394/2018 (APP)	2018			R
Resolution 287-2018-MINAGRI-SEFOR-DE(MI)	2018		S	
Decree 014-2019-MINAM(EP)	2019		S	

Key: EL: Environmental licensing; F&PA: Forests and protected areas; IP&TC: Indigenous peoples and tribal communities; B: Baseline; R: Relaxing; S: Strengthening.

Source: BPC 2022.

DATA ANALYSIS

Probit and OLS regression analyses were conducted to explore the relationship between the direction of regulatory changes in Amazon basin countries during the last few decades and the dramatic rise — and subsequent fall—in export prices during and after the recent commodity boom. As explained in the main text, four basic models were developed. This section provides a broader array of results within each model, with varying configurations. These complete results are presented in Table 1.4.

Models 1 and 2 are probit models, estimating the likelihood of a given reform representing change in a strengthening (Model 1) or relaxing (Model 2) direction. These are considered separately because reforms may be strengthening, relaxing, both, or neither. These two models take the form

$$D_{ijk} = F(\beta_{1EPDjk} + \beta_2 \text{Country}_j + \text{Year}_k)$$

where

D_{ijk} is a binary variable indicating the direction of change of reform i in country j and year k. It takes a value of 1 for strengthening in Model 1 and for relaxation in Model 2,

EPD_{jk} indicates the annual change in country j's export price deflator in the year k

$Country_j$ incorporates fixed national effects, with Brazil serving as the baseline case, as it is the country with the least number of policy reforms included in the sample.

$Year_k$ reflects the year of the policy reform

Models 3 and 4 combine the strengthening and relaxation effects in OLS regression according to the formula

$$D_{ijk} = \alpha + \beta_{1EPDjk} + \beta_2 Country_j + Year_k + \varepsilon$$

where D_{ijk} indicates the net direction of regulation i in country j and year k, with a value of +1 for strengthening changes, -1 for relaxing changes, and 0 for neither or for the two cases (listed above) that each have one strengthening and one relaxing aspect. The other regressors maintain their definitions from models 1 and 2. Model 4 repeats this analysis using frequency weights reflecting the number of policy dimensions affected by a given reform, to weigh broader reforms more heavily.

The results of these analyses are shown in Table 1.4. For each model, configuration D (the most complete configuration, including country and year regressors) is shown in Figure 4 in the main text.

Table 1.4: Regression Results: Regulatory Changes and Export Price Movement

A. Model 1: Probit Regression for Determinants of Regulatory Strengthening

	A. Correlation	B. Countries	C. Years	D. Both
EPD (annual change) A	1.68*	1.74*	1.62*	1.66*
	(0.73)	(0.76)	(0.73)	(0.76)
Bolivia		-0.95***		-1.02***
		(0.29)		(0.30)
Ecuador		-0.24		-0.29
		(0.28)		(0.29)
Peru		-0.26		-0.33
		(0.29)		(0.29)
Year			-0.01	-0.02
			(0.01)	(0.02)
Constant	-0.08	0.29	18.97	30.54
	0.10	(0.21)	(23.10)	24.00
N	172	172	172	172
Pseudo-R2	0.0225*	0.0755**	0.0254*	0.0822**

B. Model 2: Probit Regression for Determinants of Regulatory Relaxation

	A. Correlation	B. Countries	C. Years	D. Both
EPD (annual change) A	-2.25**	-2.21**	-1.73*	-1.69*
	(0.80)	(0.81)	(0.82)	(0.84)
Bolivia		-0.05		0.16
		(0.29)		(0.31)
Ecuador		-0.06		-0.16
		(0.29)		(0.31)
Peru		-0.29		-0.07
		(0.30)		(0.32)
Year			0.06***	0.06***
			(0.01)	0.01
Constant	-0.45***	0.36	-121.13***	-122.32***
	0.10	(0.21)	(26.69)	(27.11)
N	172	172	172	172
Pseudo-R2	0.0387**	0.0442	0.1434***	0.1475***

C. Model 3: OLS Regression for Net Direction, Unweighted

	A. Correlation	B. Countries	C. Years	D. Both
EPD (annual change) A	1.34**	1.30**	1.19*	1.14*
	(0.48)	(0.49)	(0.48)	(0.48)
Bolivia		-0.33		-0.41*
		(0.19)		(0.18)
Ecuador		-0.05		0.12
		(0.19)		(0.19)
Peru		-0.01		0.10
		(0.19)		(0.18)
Year			-0.02**	-0.02**
			(0.01)	(0.01)
Constant	0.14*	0.25	45.63**	49.05**
	0.07	(0.14)	(15.22)	(15.31)
N	172	172	172	172
R2	0.0431**	0.0688*	0.0911**	0.1225***

D. Model 4: OLS Regression for Net Direction, Weighted by Breadth of Reform B

	A. Correlation	B. Countries	C. Years	D. Both
EPD (annual change) A	1.16**	1.18**	0.92*	0.93*
	(0.44)	(0.44)	(0.43)	(0.43)
Bolivia		-0.30		-0.40*
		(0.17)		(0.16)
Ecuador		-0.01		-0.08
		(0.17)		(0.16)
Peru		-0.02		-0.13
		(0.17)		(0.16)
Year			0.03***	-0.03***
			(0.01)	(0.01)
Constant	0.11	0.19	54.89***	58.85***
	0.06	(0.12)	(13.93)	(14.05)
N	211	211	211	211
R2	0.0320**	0.0542*	0.0990***	0.1282***

Key: A. EPD: Export Price Deflator, annual percent change. B. Breadth: number of policy dimensions impacted by each regulatory change. N values are higher for Model 4 than Models 1-3 due to the use of frequency weights.

All four configurations of all four models shown here indicate a significant relationship between regulatory changes' direction of impact and the concurrent changes in national export prices. In addition, Bolivia frequently appears to be significantly less likely to have enacted strengthening policy changes. To further explore differences among the four countries, Wald tests were performed on the results of Model 4D, for significance in difference among countries. The results are shown in Table SI1.5.

Table SI1.5: Wald Test Results for Significant Differences among Countries, Model 4D (F-statistics)

	Brazil	Ecuador	Peru
Bolivia	6.01*	3.93*	2.94
Brazil		0.25	0.64
Ecuador			0.09

As Table SI1.5 shows, Bolivia's lower propensity to enact strengthening reforms during this time period sets it apart from Ecuador and Brazil, but not Peru. However, the results in Table SI1.4 show that the results for Brazil (the baseline case) are never significantly different from those of Ecuador or Peru. Thus, it appears that Brazil and Ecuador were significantly more likely than Bolivia to enact strengthening policy changes throughout this 30-year window, while Peru followed a middle path, with no significant differences from any other country's approach. Finally, it is important to note that the significance of movement in each country's export price deflator in determining the likelihood of policies to shift toward strengthening or weakening is unaffected by these intra-regional differences, as the consistently significant coefficients for that variable in table SI1.4 show.

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SUPPLEMENTARY INFORMATION 2

Methodology and Analysis of Chinese Investments in the Amazon Basin

This working paper utilizes a unique dataset of Chinese investments in the Amazon basin. The methodology for collecting and analyzing this data is detailed in this supplement, which consists of four sections. The first section details the method for compiling the dataset and determining the geographic buffers used for each. The second section explains the methodology of spatial analysis used. The third section explores results, including an expanded set of figures detailing the results of the spatial analysis.

DATA DESCRIPTION

The research team compiled a geo-referenced dataset of Chinese investments in the Amazon basin using existing investment databases and geo-located each investment found. Sources consulted for dataset compilation are listed in Table SI2.1. To maximize the benefit of dataset overlap, a 15-year window of 2005-2019 was used for the rest of the analysis.

Table S12.1: Data Sources for Chinese Investment in the Amazon Basin

Source	Investment types	Years	Reference
China-Latin America Finance Database	Policy bank loans	2005-2021	Gallagher and Myers 2022
DeaLogic	M&As	1995-2001	DeaLogic 2022
fDiMarkets	GFDI	2003-2021	Financial Times 2022
Monitor de la OFDI de China en América Latina y el Caribe	GFDI and M&As	2000-2021	Red Académica 2022.
Painel China	GFDI and M&As	2005-2019	BPC 2022

Key: M&A: Mergers and acquisitions; GFDI: Greenfield (new) foreign direct investment

Investment types include both sovereign development finance and foreign direct investment to reflect regional governments' varying adoption of resource nationalism, as described in the main text. While China was a major driver of economic activity in the Amazon basin for four Amazon basin countries (Bolivia, Brazil, Ecuador and Peru) from 2005-2019, existing scholarship has shown that the pathway was not uniform. "Open" forms of resource nationalism are associated with attracting FDI, while "closed" resource nationalism is associated with sovereign finance.

These investments were geolocated using a stepwise process:

a) Projects were classified into four types (points, lines, polygons and none) based on their description. Projects consisting of individual buildings were located as single geographic points. Linear projects such as roads, railways and power transmission lines were located as lines. Area-based projects such as reservoirs, mines and oil and gas concessions were located as polygons. Projects without specific geographic footprints were classified as "none" and excluded from the analysis.

b) API calls to geocoding services, including Google (Overview | Geocoding API, n.d.) and OpenStreetMap Nominatim (Overview - Nominatim Documentation, n.d.), were used for point-type projects. Coordinates are used from valid responses.

c) Google Maps (The Directions API Demo, n.d.) and OpenRouteService (Openrouteservice, n.d.) were used for extracting outlines of roads and highways.

d) General Google searches are used for projects not found in step a. Several methods are used based on search results: street addresses are geocoded; coordinates are extracted from embedded maps within webpages; maps images (scanned or digital) are georeferenced and then digitized in ArcGIS 10.8.

e) Precision codes were assigned according to geolocation accuracy: 1 – exact location; 2 – within 25 km; 3 – second-level administrative boundary; 4 – first-level administrative boundary; 5 – spanning multiple first-level administrative boundaries; 6 – country; 7 – unknown. Projects with precision codes above 2 (with less specificity than a 25km radius) were excluded from the analysis.

f) Geolocated projects were double-verified by independently validating their occurrence and the month and year of their final purchase or groundbreaking date.

As a result of this process, the research team validated and geolocated 44 announced projects within the Amazon basin. Of these, 42 projects (encompassing 118 separate project sites) had progressed to final groundbreaking or purchasing by the end of 2019 and were included in the spatial analysis.

Table S2.2: Investments Included in this Analysis

	Investments					Project sites				
	BOL	**BRA**	**ECU**	**PER**	**Total**	**BOL**	**BRA**	**ECU**	**PER**	**Total**
TOTAL	7	10	9	16	42	16	21	35	44	118
By investment type:										
GFDI	1	3	3	9	16	1	4	8	35	48
M&A	2	7	2	7	18	11	17	4	11	43
Policy bank	4	0	4	0	8	4	0	23	0	27
By precision:										
1 (exact)	7	10	9	14	40	16	21	35	44	116
2 (w/in 25km)	0	0	0	2	2	0	0	0	2	2
By location type:										
Point	3	7	2	4	16	12	16	4	8	40
Line	3	0	4	0	7	3	0	26	0	29
Polygon	1	3	3	12	19	1	5	5	38	49

For each of 69 point or line-type project sites, a buffer zone for spatial analysis was chosen based on existing environmental scholarship. Research indicates that different sectors have various magnitudes of impact around project sites. The geolocated projects were grouped into eight industries: hydropower, manufacturing, mining, offices, roads, power transmission lines and wind turbines. Site selection guidelines, environmental impact assessments and research articles on development project impacts are references for buffer zone radius (Table S3).

Hydropower: Two types of hydropower projects exist in the dataset: reservoir-based hydropower projects and run of the river (RoR) hydropower projects. Although hydropower is considered renewable energy, hydropower projects still have significant environmental and social footprints. The construction of reservoir-based hydropower projects is a major driver of change in land cover and landscape patterns (Ouyang et al., 2013). Compared to reservoir-based hydropower projects, RoR hydropower projects flood small areas relative to their energy output due to having small or no reservoir and are considered more environmentally sustainable (Goodland, 1994). The impact of reservoir-based hydropower projects can be observed in areas from 2-10 km away (Ouyang et al., 2013; Zhao et al., 2013). However, few studies have done extensive environmental studies on RoR hydropower projects. Therefore, a 10 km buffer is used for hydropower projects since inappropriate buffers, if too small, may prevent an accurate assessment of the impact from hydropower projects.

Mining: Only one mining project (project id: 34) amongst the geolocated project database does not have a defined concession or lease boundary, i.e., it is point-type. A study examined the extent of mining-induced deforestation in Amazon forests revealed that forests within the 0-10 km and 40–50 km buffers experience the highest rate of deforestation and the impact is significant till 70 km from site boundaries (Sonter et al., 2017). A 40 km buffer is used for this project.

Roads, Power Transmission Lines: A comprehensive study on conservation threat to the Amazon region from power transmission lines reviewed 16 environmental impact assessment (EIA) reports for induvial transmission lines (Hyde et al., 2018). A near-consensus of a 5km buffer is determined as the suitable area to evaluate the direct and indirect impact. The same studies also compared transmission lines to other infrastructure types, including roads. The authors used the same principle to determine that a 15km buffer is suitable for roads.

Wind Turbines: Similar to roads and power transmission lines, the buffer radius is derived from literature reviews on environmental impact studies and wind farm site selection guidelines. A medium value, 4 km, is used on wind turbine projects (Peri & Tal, 2020; van Haaren & Fthenakis, 2011).

Offices and Manufacturing: few studies have examined the direct and indirect impact of offices and manufacturing projects. Geolocate offices and manufacturing projects are located in developed areas that rarely have intact forests. A 3 km buffer is used for conservative estimation. For projects with multiple sites, the same buffer radius is used for all sites associated with the project. Buffers are not applied to polygon-type projects because the boundaries are already defined. Areas within buffer zones (for point and line type projects) and polygon boundaries are defined as Project Impact Areas (PIA).

Table S2.3: Buffer Zones Applied to Point and Line Project Sites

Sector	Buffer Radius	Number of Projects with Buffers Applied
Hydroelectric	10 km	7
Mining	40 km	1
Road	15 km	3
Manufacturing	3 km	7
Office	3 km	4
Power Transmission	5 km	1
Wind Turbine	4 km	1

METHODOLOGY

Analyses of risks and changes were conducted regarding three aspects of potential environmental and social impact: risks to Indigenous territories, risks to biodiversity and changes in the rate of tree cover after project groundbreaking or purchase. These are detailed below in turn.

Indigenous Lands

Risk values of development projects to Indigenous Lands are determined using the integrated Risk to Indigenous Lands map developed by Yang et al. (2021). The Risk to Indigenous Lands map uses empirical evidence to measure development projects' direct and indirect impact on Indigenous people based on proximity and urban development metrics. The scale of impact from development projects decreases with distance. The map also assumes that developed land suffers less impact from projects due to the lack of intact lands and the high cost of land acquisition. Thus, the Risk to Indigenous Lands integrates proximity to Indigenous Lands and development using 1km cells in the following way:

$$Risks\ to\ Indigenous\ \ Lands_i = \begin{cases} IDI_i \times HFI_i, IDI_i < 1 \\ 1, IDI_i = 1 \end{cases}$$

Where IDI_i is the Indigenous distance index ranges from 0 to 1 for cell *i*, *IDI* equals 1 for cells within Indigenous Lands and diminishes towards 0 as distance to Indigenous Land increases. HFI_i is the human footprint index based on reclassified human footprint map. Low HFI_i suggests more human development in cell *i*.

Risk to Indigenous People values is summarized for each PIA polygon in ArcGIS.

Biodiversity

The number of vulnerable species and weighted range size rarity are used to assess the risk to biodiversity from development projects. Both metrics are derived from the IUCN Red List of Threatened Species (The IUCN Red List of Threatened Species, n.d.). The following seven species groups are included in this analysis: mammals, amphibians, birds, reptiles, freshwater groups, marine groups, sharks/rays/chimaeras. The spatial data (geographic ranges) of the seven species groups are downloaded and pre-processed using QGIS (3.10.8). Invalid geographic range polygons (self-intersection) go through a two-stage repairing process: Fix Geometries tool from Processing Toolbox in QGIS is used for the initial repair attempt, then a 1-millimeter buffer are added to polygons that fail the first attempt (Table S4). All invalid geographic range polygons are repaired.

THE NUMBER OF THREATENED SPECIES

Threatened species include vulnerable (VU), endangered (EN) and critically endangered (CR), as defined by IUCN Red List. Threatened species' geographic ranges are overlaid on PIA polygons. As projects with multiple sites may intersect with the same species multiple times, threatened species whose geographic ranges overlap with the PIA polygons are summarized at the site level and then consolidated at the project level.

Table S2.4: IUCN Species Groups that are Processed and Used in the Analysis (Overlaps with the Investment PIAs)

Groups	Categories						Invalid geographic ranges
	CR	EN	VU	NT	LC	DD	Fixed
Amphibians	23	50	37	26	471	46	0
Birds	12	35	121	189	2,268	2	153
Freshwater Groups	32	33	59	61	1,702	163	0
Mammals	2	21	46	44	568	82	0
Marine Groups	0	0	6	2	57	2	0
Reptiles	7	7	20	10	342	23	0
Sharks/rays/chimaeras	3	6	11	11	11	25	0

WEIGHTED RANGE SIZE RARITY

Weighted range size rarity (WRSR) (Moilanen et al., 2014; Williams et al., 1996) is used further to investigate the risk to biodiversity from development projects. Previous studies have aimed at distinguishing high-risk areas have utilized species richness to highlight biodiversity hotspots (Engemann et al., 2015; Forest et al., 2007; Gould, 2000; Reid, 1998). The common practice is rasterizing IUCN geographic ranges with high-resolution cell sizes. However, the rasterizing approach tends to overestimate the species richness value when the cell size is small. Hurlbert and Jetz suggest using 1 degree (around 110 km on a great circle) or higher resolution if rasterization is used for characterizing ecological patterns. WRSR is a more suitable method, since project buffer radii in this investment dataset are substantially narrower than one degree. WRSR is calculated in R (R Core Team, 2021) using rgdal package (Bivand et al., 2022) for project sites by each species group base on the following formula:

$$wrsr_i = \sum w_j q_{ij}$$

Where w_j is the weight assigned to species *j*, guided by severity level in the IUCN categories: critically endangered = 8; endangered = 6; vulnerable = 4; near threatened = 2; least concern = 1; data deficient = 2 (Montesino Pouzols et al., 2014). q_{ij} is the fraction of species *j* geographic range falling within the PIA polygon *i*. WRSR de-prioritize wide-ranging species and prioritize species with narrow geographic range that are proportionally impacted more by the same development project.

Change in Deforestation Rate

Hansen Global Forest Change V1.9 (Global Forest Change, n.d.) is used to estimate the changes in forest tree cover within the PIA. Hansen Global Forest Change V1.9 uses Landsat satellite imagery to produce annual tree cover loss maps from 2000 to 2021. Here are some key definitions:

- Forests are defined as locations whose tree cover makes up 25 percent or more at the cell scale (30 by 30 meters)
- Forest loss is defined as a stand-replacement disturbance (from forest to non-forest state) (Hansen et al., 2013).

To investigate the changes in trends of deforestation before and after the project establishment, Relative Change in Tree Cover (RCTC), a difference-in-difference approach, is used. Similar approaches are widely used to examine deforestation in the Amazon region between reference years (Anderson et al., 2018; Assunção et al., 2020; Prem et al., 2020). RCTC allows comparison of changes in deforestation rate for new projects (CODF and greenfield) and existing projects with changed ownership (mergers & acquisition).

$$RCTC_i = \frac{loss_{(T+3)\sim(T-1)} / tree\ cover_{(T-1)}}{loss_{(T-1)\sim(T-5)} / tree\ cover_{(T-5)}}$$

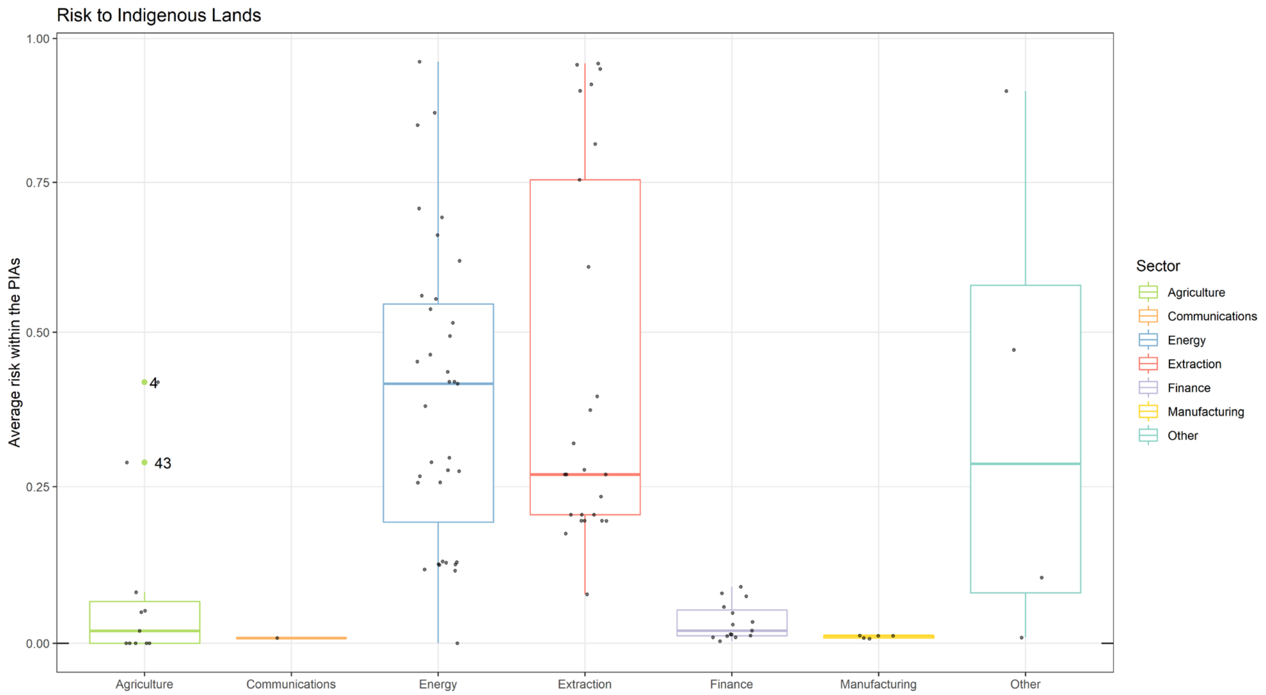
Where T is the groundbreaking date for CODF and greenfield projects or transaction date for mergers & acquisition projects. The length of "before window" and "after window" is 5 years. $loss_{T+3-T-1}$ and $loss_{T-3-T-5}$ is the forest cover loss during the "before window" and "after window" respectively. T – 1 year is used as the break of the two windows instead of is due to two reasons: the exact date (month, day) of groundbreaking/transaction date is unavailable for some projects; the date is used to determine forest state (forest/non-forest) is uncertain for Hansen's Global Forest Change dataset. Using T – 1 year ensures constructions or post-transaction activities have little impact on forest cover RCTC is calculated for every geolocated project site.

RESULTS

This section displays an expanded set of results tables from the main text.

Figure S2.1: Chinese Projects' Risks to Indigenous Territories in the Amazon Basin

A. Distributed by Sector



B. Distributed by Country and Sector

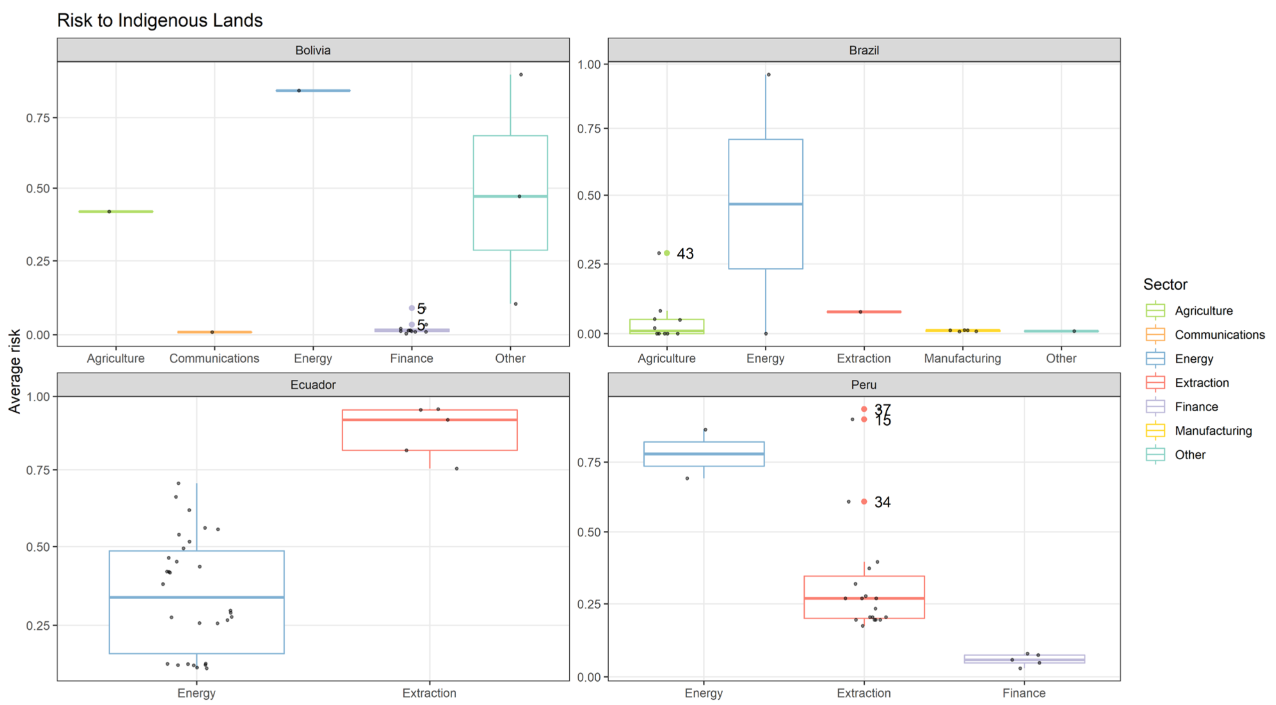
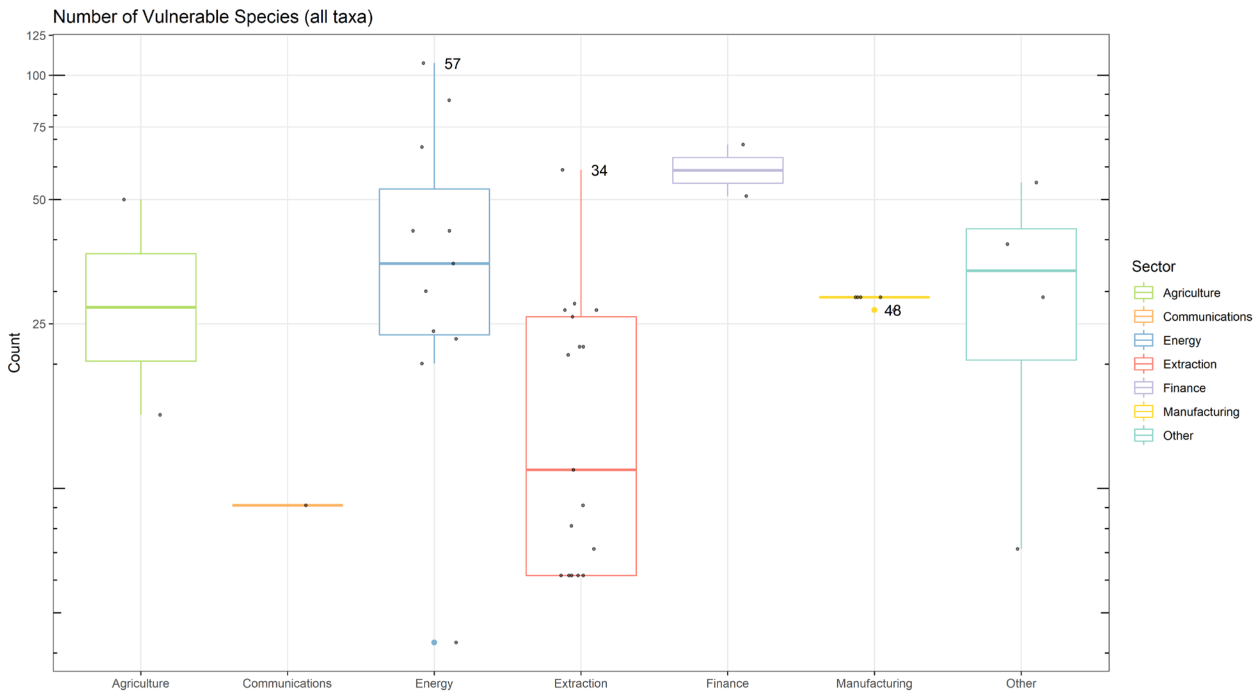


Figure S2.2: Number of Threatened Species (VU, EN, CR) within Study PIAs

A. Distributed by Sector



B. Distributed by Year

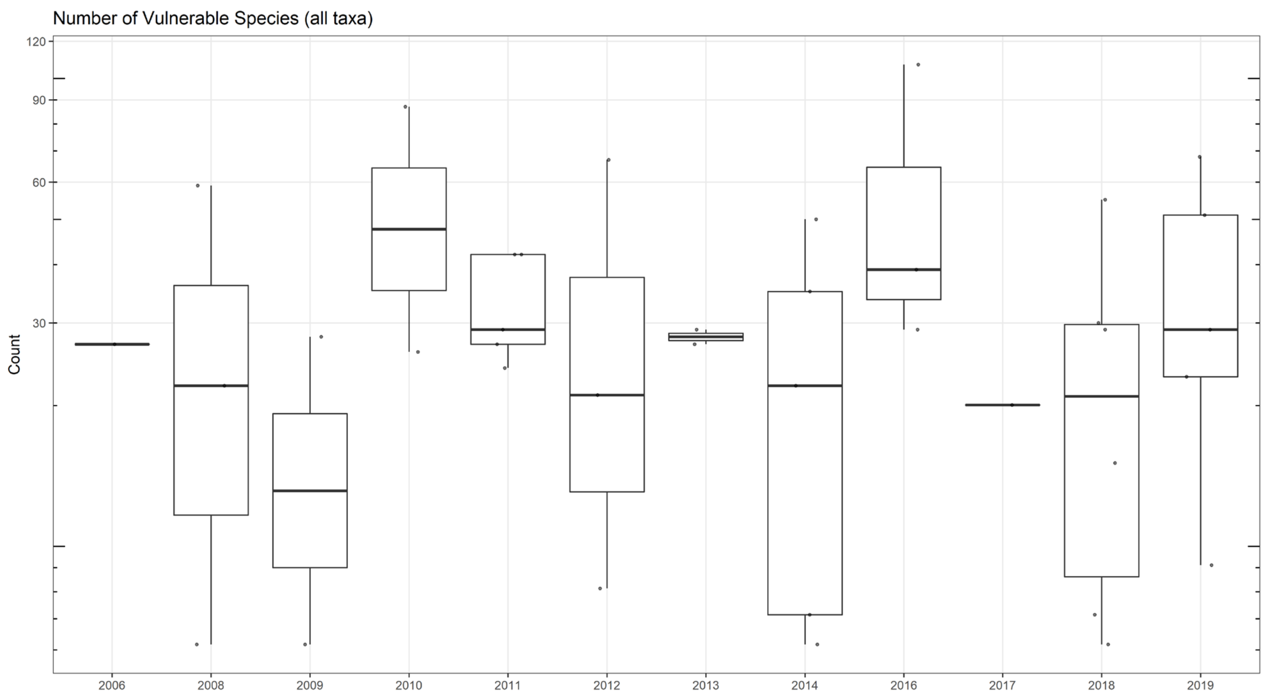
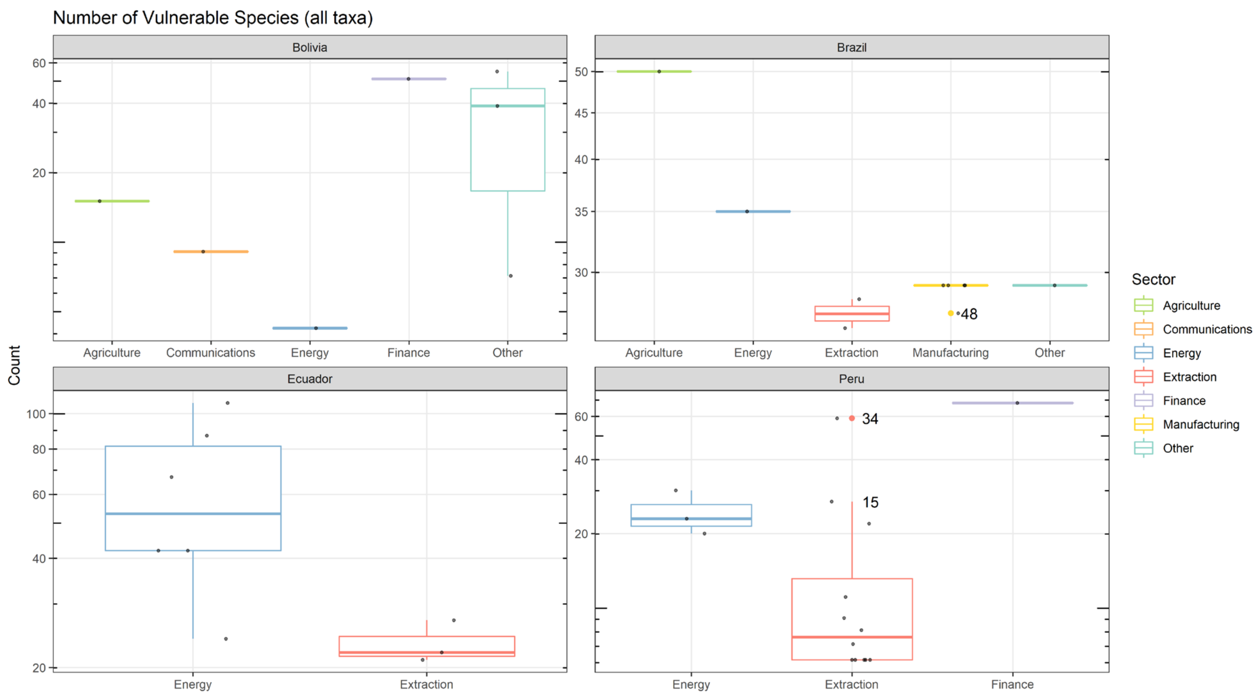


Figure S2.2, Continued: Number of Threatened Species (VU, EN, CR) within Study PIAs

A. Distributed by Sector and Country



B. Distributed by Country and Year

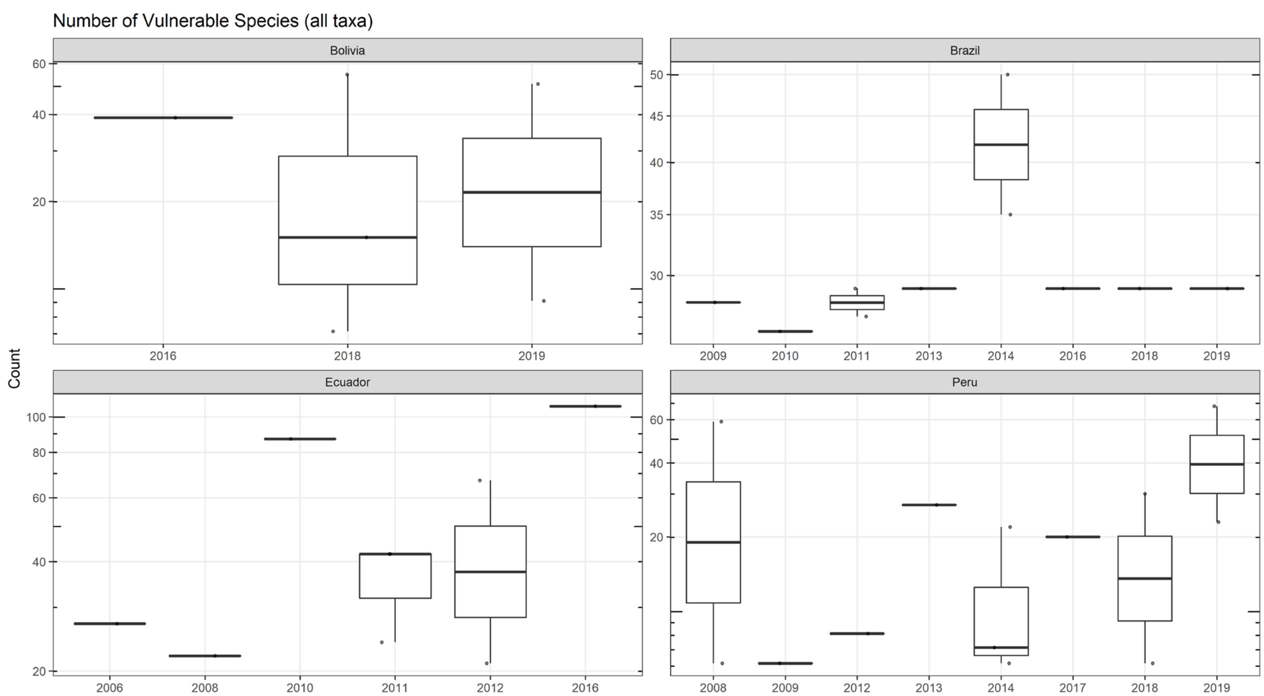
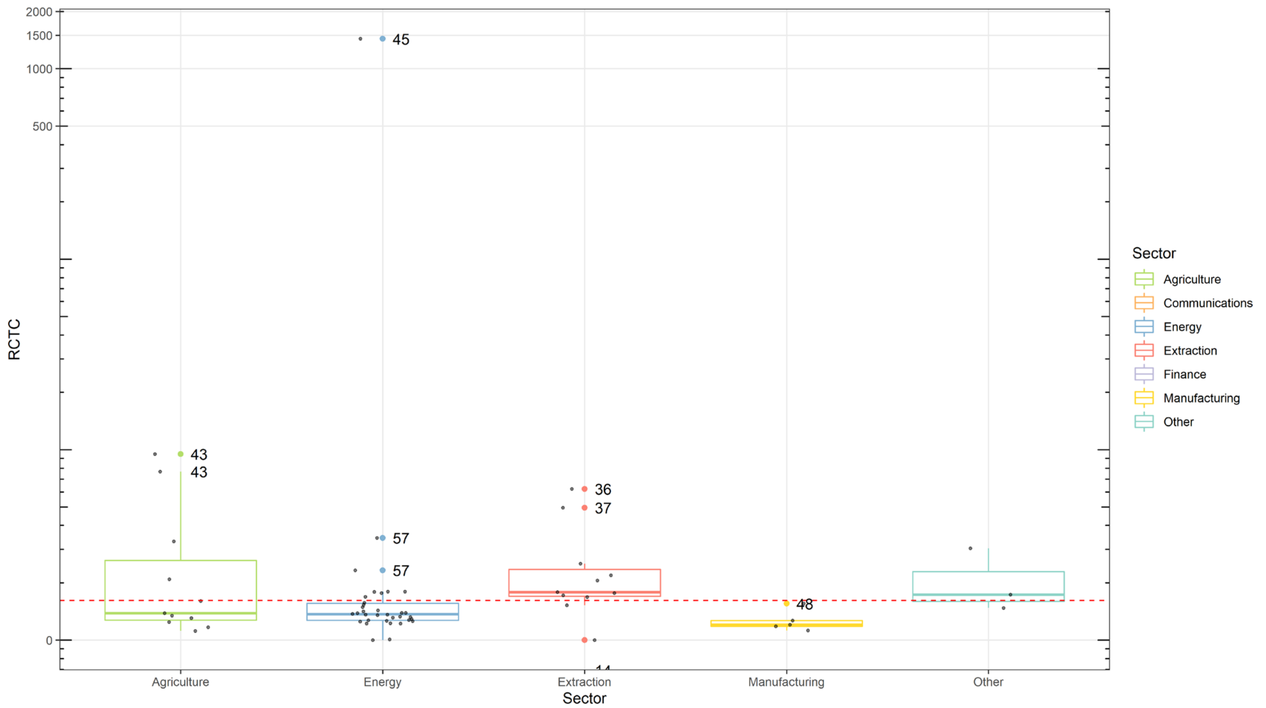
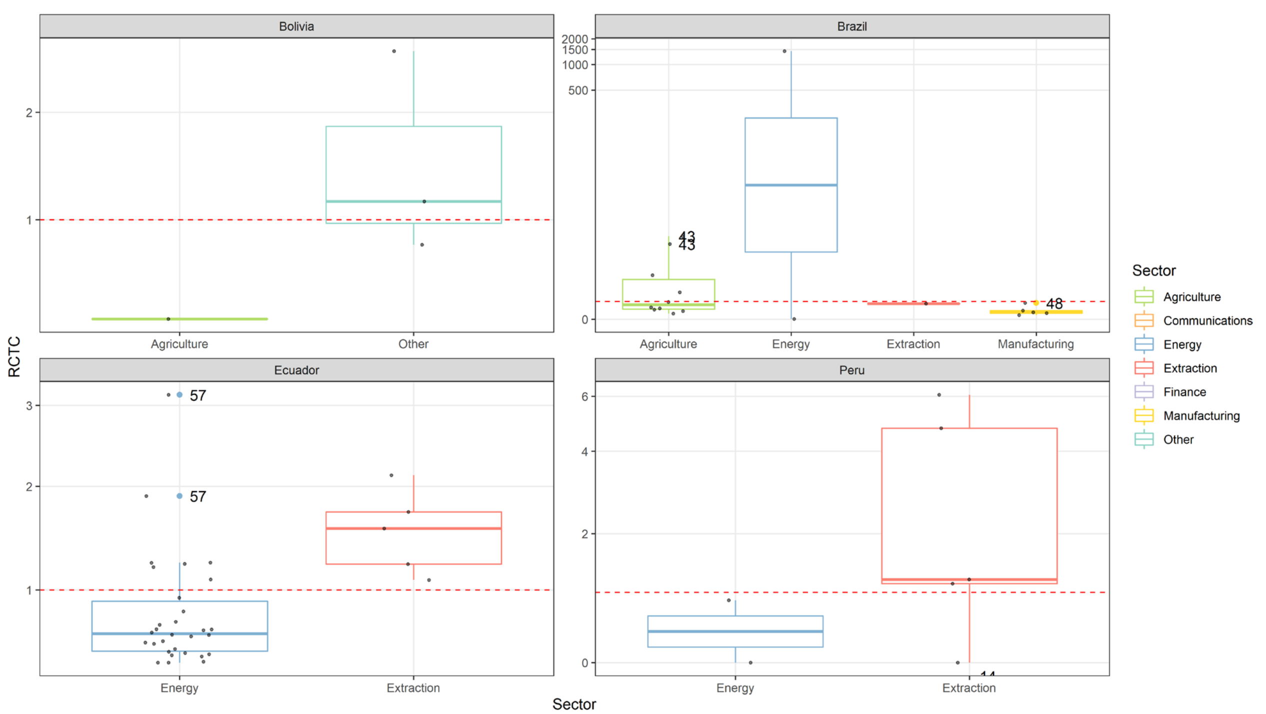


Figure S2.3: Relative Change in Tree Cover within Study PIAs

A. Distributed by Sector



B. Distributed by Country and Sector



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