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Mapping financial flows linked to critical ecosystems*




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Large-scale ecosystem breakdown poses systemic macroeconomic and financial risks due to the loss of key ecosystem services, including carbon sequestration and regional climate regulation, upon which swathes of economic activity relies. Land use change and degradation, particularly to produce agricultural commodities, is a major driving cause of nature loss. We examine the financial flows associated with land-use and plantation agriculture in two ecosystems – the Brazilian Amazon rainforest and tropical peatlands in Indonesia – where breaching ecosystem 'tipping points' (ETPs) could have systemic and irreversible impacts. We use supply chain data to identify 39 'ETP-risk' companies linked to these areas and connect them to a newly constructed granular dataset of financial flows covering lending and capital markets (equity and debt issuances) activities over the past decade.

We find flows to these companies were facilitated by a relatively concentrated group of commercial and investment banks, presenting a possible intervention point for central banks and financial supervisors to influence sustainability transitions and reduce the financial risks posed by nature loss. In the case of the Brazilian Amazon, flows were associated with institutions headquartered mainly in high income economy financial hubs whilst for Indonesia flows were predominantly from institutions headquartered in the surrounding region. There was significant heterogeneity in the sensitivity of ETP-risk firms to external financial flows with some firms being highly leveraged but others having high retained earnings and low debt burdens, potentially insulating them from finance-based measures to reduce their environmental impacts, including (macro)prudential regulations. This latter case, combined with the challenges of connecting a globalised financial system to on-the-ground impacts through networks of multinationals and their subsidiaries, suggests that (global) policy coordination across financial, fiscal, and environmental policy spheres will be needed to decrease harmful economic pressures on ecosystems with tipping points.

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Introduction

Large-scale ecosystem breakdown poses major economic and financial risks at regional and global levels and have, as a result, caught the attention of economic and financial policymakers such as central banks and ministries of finance (Power et al., 2022; Lagarde, 2024; NGFS, 2024). Ecosystems such as tropical rainforests provide globally important ecosystem services, including supporting food and material provision, carbon sequestration and regional climate regulation, upon which swathes of human activity relies (IPBES, 2019).

As with other complex systems, ecosystems are subject to 'tipping point' dynamics (Willcock et al., 2023). These are thresholds beyond which a small additional perturbation triggers non-linear changes that qualitatively alter the state of a system, powered by self-amplifying feedback loops (Lenton et al., 2023). Passing such thresholds would rapidly undermine the planet's resilience to shocks and permanently degrade biodiversity (Parmesan et al., 2022; Ripple et al., 2023).

Climate change is an important driver of such 'ecosystem tipping points' (ETPs) (Armstrong McKay et al., 2022). However, there are other, more proximate, causes of resilience loss. In particular, land use change and degradation associated with agriculture – such as deforestation for livestock and drainage in preparation for crop growth – are just as key as climate drivers (Lenton et al., 2023). Though its impacts are location-specific, land-use change also has *global* drivers that interact in complex ways (Marques et al., 2019). While the role of international demand and trade patterns has been studied extensively (e.g., Pendrill et al., 2022), research on interactions with financial actors remains more limited.

This policy note summarises a recent working paper (Marsden et al 2024b), in which we studied firms linked to land use change, and the financial flows that support them, in two critical ecosystems: the Brazilian Amazon rainforest and Indonesian tropical peatlands. These two ecosystems currently sequester carbon equivalent to over 20 years of CO2 emissions based on current rates (Lenton et al., 2023; Marsden et al., 2024a) and modulate important regional weather conditions including rainfall patterns (Taufik et al., 2020; Wang-Erlandsson et al., 2022; Liu et al., 2023). Their collapse would have serious implications for limiting global heating to well below 2 degrees Celsius, increase the likelihood of other tipping points (Ripple et al., 2023), and would have potentially catastrophic regional impacts (Marsden et al., 2024a).

In the Brazilian Amazon, cattle production for beef is the major direct driver of deforestation, followed by soy production (Haddad et al., 2024). Palm oil and pulp wood (to produce pulp and paper) plantations have been the primary drivers of deforestation in Indonesia and continue to expand on peatlands (Page et al., 2022).

Previous research on exploring financial interactions with ecosystems with tipping dynamics has mapped the equity holdings – financial *stocks* or exposures – in key firms (Galaz et al., 2018a). In this paper, we extend this approach to explore the financial *flows* that enable new and ongoing activity, which allows us to include new types of financial assets and more effectively cover state- and privately-owned companies, where there is poorer disclosure of equity ownership. The importance of these financial flows to, and the impact of finance-based measures on, companies depends, in part, on their internal financing capabilities and we conduct financial ratio analysis to shed light on this.

Our analysis is a contribution towards informing macroeconomic and financial policymakers about financial drivers of ecosystem loss, which in turn may result in systemic macro-financial impacts. It also provides insights into potential sources of transition risks for financial institutions facilitating these flows, as new environmental policies and legislation are developed to halt and reverse nature loss.

Methodology

To identify companies linked to land use (change and degradation) in the two ecosystems under examination, we used data from Trase Supply Chains (TSC) (see Trase, 2024). This links companies exporting beef and soy from Brazil and wood pulp and palm oil from Indonesia to subnational regions of production and environmental metrics. By using export data, TSC largely identifies agricultural traders: midstream actors who process and distribute agricultural and forestry products. Despite not always being involved in on-the-ground land use change, traders remain highly relevant to our research question as they are the common link that connects smaller-scale domestic producers to global markets and exert significant market power (Grabs et al., 2024).

We used metrics of exposure, through supply chains to deforestation (land-use change) and plantation agriculture (land use) in the Brazilian Amazon and Indonesian peatlands respectively. We aggregated land use (change) up to the corporate group level - parent companies mapped by TSC that own or control subsidiaries in the TSC data – and identified those linked to a significant proportion of land use (change) as "ETP risk" companies, defined as a minimum of 1 per cent of the total (excluding domestic consumption) for each ecosystem/commodity. This led to the identification of 39 companies which, collectively, were associated with 85-95 per cent land use (change) associated with the commodities in scope.

We traced financial flows to ETP risk companies, covering both bank lending (including syndicated loans) and capital markets (equity and debt) issuance activity by financial institutions, mainly commercial and investment banks. We sourced these data from the London Stock Exchange Group's Deals Business Intelligence Data (LSEG, 2024), with the final dataset spanning 1 January 2014 to 31 December 2023. Poor coverage of bilateral deals means our data is likely biased towards syndicated deals in larger markets.

We consider capital markets facilitation together with lending despite the qualitatively distinct role that banks play in these transactions, where they typically do not provide capital from their own balance sheets. This is because it still represents a source of financial risk to banks, and also plays a critical role in providing market access to companies through securitisation, underwriting, and advisory services (Maio et al., 2023). In any case, syndicated loans do not consistently remain on bank balance sheets, which prevents any clear-cut distinction (Haselmann and Wachtel, 2011; Cohen et al., 2021). This approach is in line with similar studies of financial flows by the United Nations (UNEP, 2023) and recommendations by the ECB on banks' climate targets and disclosures (Maio et al., 2023).

We analysed overall financial flows to ETP-risk companies by covering the entire legal hierarchy of ETP risk companies. Since some companies operate across multiple business lines and regions, not all flows will be specifically directed towards activities associated with land use change in the regions we focus on. However, since financial capital is fungible, in principle any external finance provided to one part of a business can be transferred to elsewhere in the structure. Large corporate groups typically have well developed internal capital markets that can be used to direct finance from more creditworthy subsidiaries towards those engaged in riskier behaviour that makes it difficult for them to access external finance directly (Casey, 2014).

Finally, to understand the potential impact of restricting financial flows on ETP-risk company activity, we conduct a series of financial ratio analyses on the balance sheets of those with available data. This includes debt-to-asset ratios, retained earnings and interest coverage ratios, which indicate sensitivity to changes in external funding conditions and cost-of-capital (Davidson, 2020). We compared firm results for the above metrics to a range of industry and global aggregates.

Findings

Analysis of financial flows between 2014 and 2023

Our analysis found 39 mainly multinational ETP-risk companies with diversified business models linked to most of the land use change in the Brazilian Amazon and plantation agriculture (land use) in Indonesian peatlands. The exception was the Brazilian beef sector where the majority of firms were domestically based and focused solely on the meat trade.

Of the 39 identified, we could trace financial flows to 24 companies. The remaining 15 were all domestic, focused companies linked to Brazilian beef and Indonesian palm oil. The three companies linked to Indonesian palm oil represented 8.4% of palm oil plantations on peatlands in our data. By contrast, the 12 companies linked to Brazilian beef accounted for 54.3% of Amazon cattle deforestation in our data.

The most important source of finance was syndicated loans, accounting for 63.1-70.3% of financial flows over the study period (Table 1). Corporate bond issuance was much more significant than equity issuance for new capital markets issuances, making up 28.0-30.6% of financial flows.

Table 1. Financial flows to ETP-risk companies in the Brazilian Amazon and Indonesian peatlands between 2014-2023, adjusted to 2014 US dollars

1a) Brazilian Amazon: financial flows to ETP-risk companies, 2014-2023.

Category	Total (2014 US $m)	Proportion
Overall	455,534	100.0%
Breakdown by asset class		
Syndicated loans	320,155	70.3%
Capital markets issuance	135,379	29.7%
Bond issuance	127,495	28.0%
Equity issuance	7,884	1.7%
Breakdown by commodity		
Soy	411,260	90.3%
Beef	44,274	9.7%

1b) Indonesian peatlands: financial flows to ETP-risk companies, 2014-2023.

Category	Total (2014 US $m)	Proportion*
Overall	60,247	100.0%
Breakdown by asset class		
Syndicated loans	38,038	63.1%
Capital markets issuance	25,162	36.8%
Bond issuance	18,463	30.6%
Equity issuance	3,746	6.2%
Breakdown by commodity		
Palm oil	60,247	100.0%
Wood pulp	15,051	25.0%

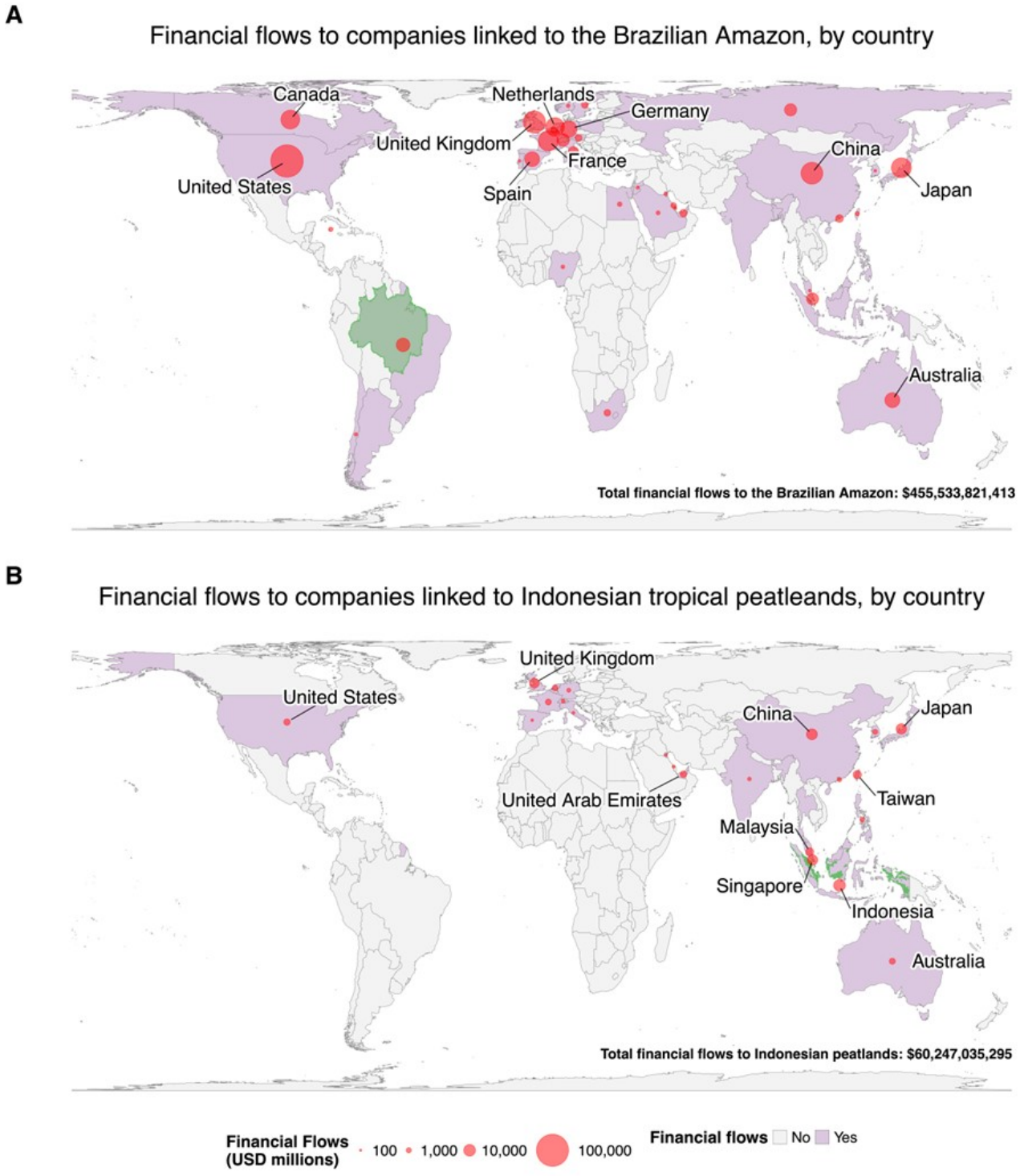
*Figures sum to >100% due to overlap between commodities

Most finance provided to ETP-risk companies had no restrictions placed on its use-of-proceeds –73.7% and 66.9% of financial flows were general corporate purpose finance for the Brazilian Amazon and Indonesian peatlands respectively. Financial flows tagged 'sustainable'[1] were 5.5-6.3% of the total between 2014 and 2023, increasing in importance over time. However, most of these sustainable financial flows were not strictly ringfenced – the majority were unrestricted, tagged as general corporate purpose or working capital instruments. Instruments where use-of-proceeds are typically ringfenced, such as green bonds, were only 0.2-1.2% of the total.

The geography of institutions providing and facilitating financial flows to ETP-risk companies differed substantially between the Brazilian Amazon and Indonesian peatlands. For the former, institutions headquartered in Europe, North America, and Asia provided and facilitated 40.9%, 29.0%, and 21.4% of flows respectively (Figure 1). Brazilian headquartered institutions played only a limited role – 3.1% of the total - and only 3.9% of flows overall were attributed to Latin American institutions. All the top five countries – the USA (22.7%), UK (9.7%), China (9.1%), Japan (7.8%), and France (7.7%) – were in entirely different geographic regions to the Amazon biome.

[1] This encompasses explicitly labelled sustainable financial instruments such as green bonds and sustainability-linked financing, as well as any finance where the borrower's industry code is one of 30 sustainable codes marked by LSEG.

Figure 1. Financial flows to ETP risk companies in the Brazilian Amazon and Indonesian peatlands, by country. Top ten countries labelled. Ecosystem boundaries filled in green.



By contrast, financial flows to ETP-risk companies linked to Indonesian peatlands had a much stronger domestic dimension. Institutions headquartered in Asia facilitated 76.1% of flows, with a further 16.9% facilitated by UK institutions. Indonesia accounted for 17.5% of financial flows and of the top five countries, three were in Asia (China – 14.0%, Japan – 11.9%, Singapore – 11.7%), followed by the UK (9.7%).

We found that a small number of institutions provided and facilitated most financial flows to ETP-risk companies. Out of 238 financial institutions, the top 50 institutions, the top 50 institutions accounted for 86.3% of financial flows to companies linked to the Brazilian Amazon, with the top ten accounting for 35.5% (Figure 3). For companies linked to Indonesian peatlands, out of 154 institutions, the top 50 facilitated 83.6% of financial flows and the top ten (or 6.5% by count) accounted for 42.8%.

Flows were largely attributed to private financial institutions, with the top institutions concentrated in a handful of financial centres. These were the United States, European Union, and UK for the Brazilian Amazon case, and Japan, Indonesia and the UK for the Indonesian peatlands. Respectively, 13.0% and 20.7% of financial flows were attributed to institutions ultimately owned by governments for the Brazilian Amazon and Indonesian peatlands – primarily by the Chinese or Indonesian governments (Figures 3-4).

For many of the most implicated financial institutions, financial flows to ETP-risk companies were small relative to their overall activities. Using 2023 data, we compared financial flows to ETP-risk companies to overall lending and capital markets flows for the top ten financial institutions implicated in each ecosystem. Financial flows were less than 1% of overall flows for nine of the top 10 financial institutions for the Brazilian Amazon (less than 5% for the remaining institution). For the Indonesian peatlands, financial flows were less than 1% for five of the top 10 companies for the Indonesian peatlands (less than 6% for a further four, but close to 50% for the remaining institution).

These financial flows imply that balance sheet exposure to ETP-risk companies is likely to be small for the most important financial institutions, though this will depend on the structure and maturity profile of individual instruments and whether they were securitised. Relatively small financial exposures to ETP-risk companies would suggest that financial institutions may be unlikely to view these as posing major risks to their balance sheets, and so they may not act in a timely fashion to mitigate potential transition risks. Given the systemic importance of the Brazilian Amazon and Indonesian peatlands, there is a macroprudential case for policy interventions (such as differentiated capital buffers or exposure restrictions) based on the risks these companies pose to the entire financial system, even if individual exposures are small. To assess the potential effectiveness of such interventions, we considered how sensitive ETP-risk firms were to external financing.

Figure 2. Brazilian Amazon – Institutions providing and facilitating financial flows to companies linked to deforestation. Institutions with a government ultimate parent marked with asterisks.

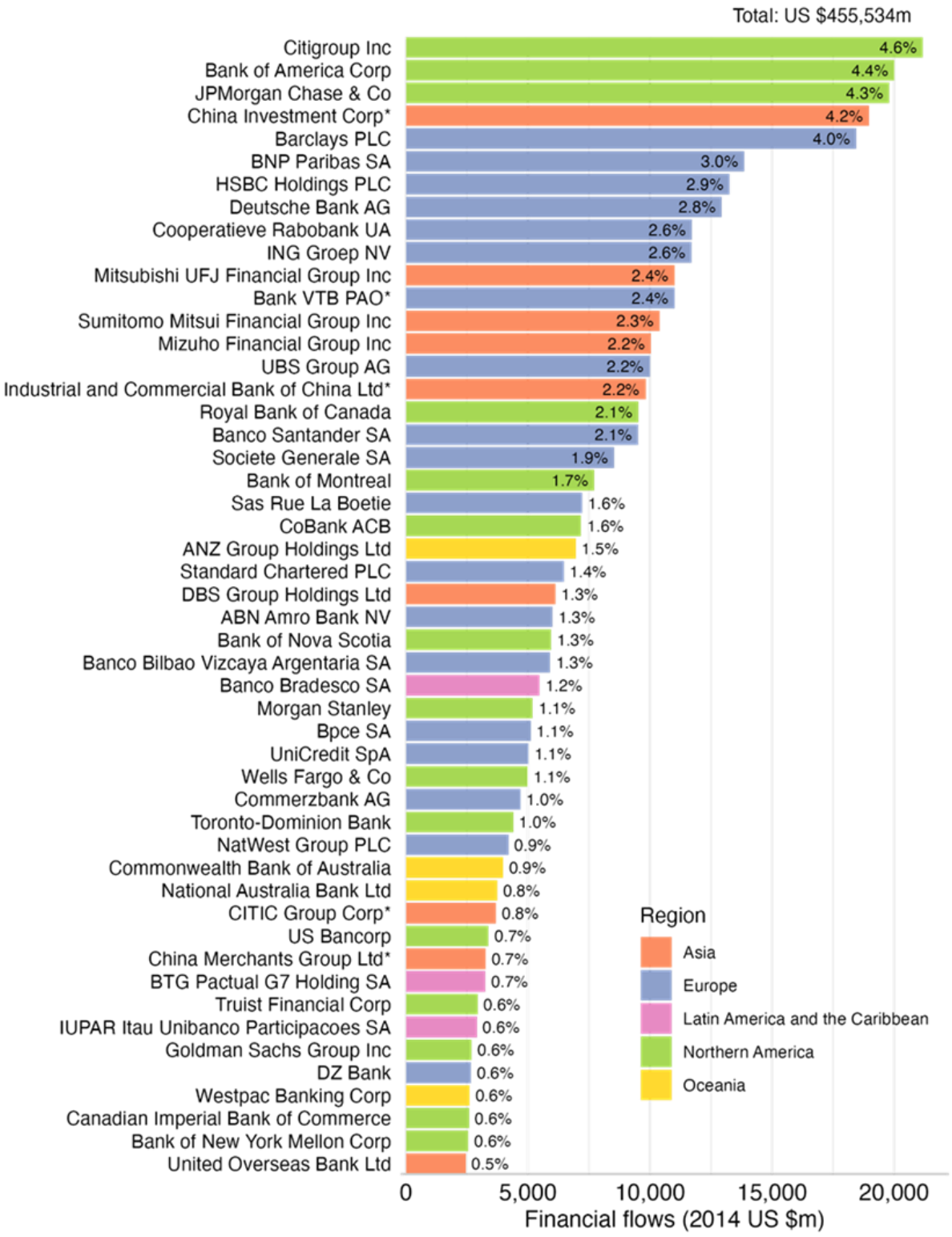
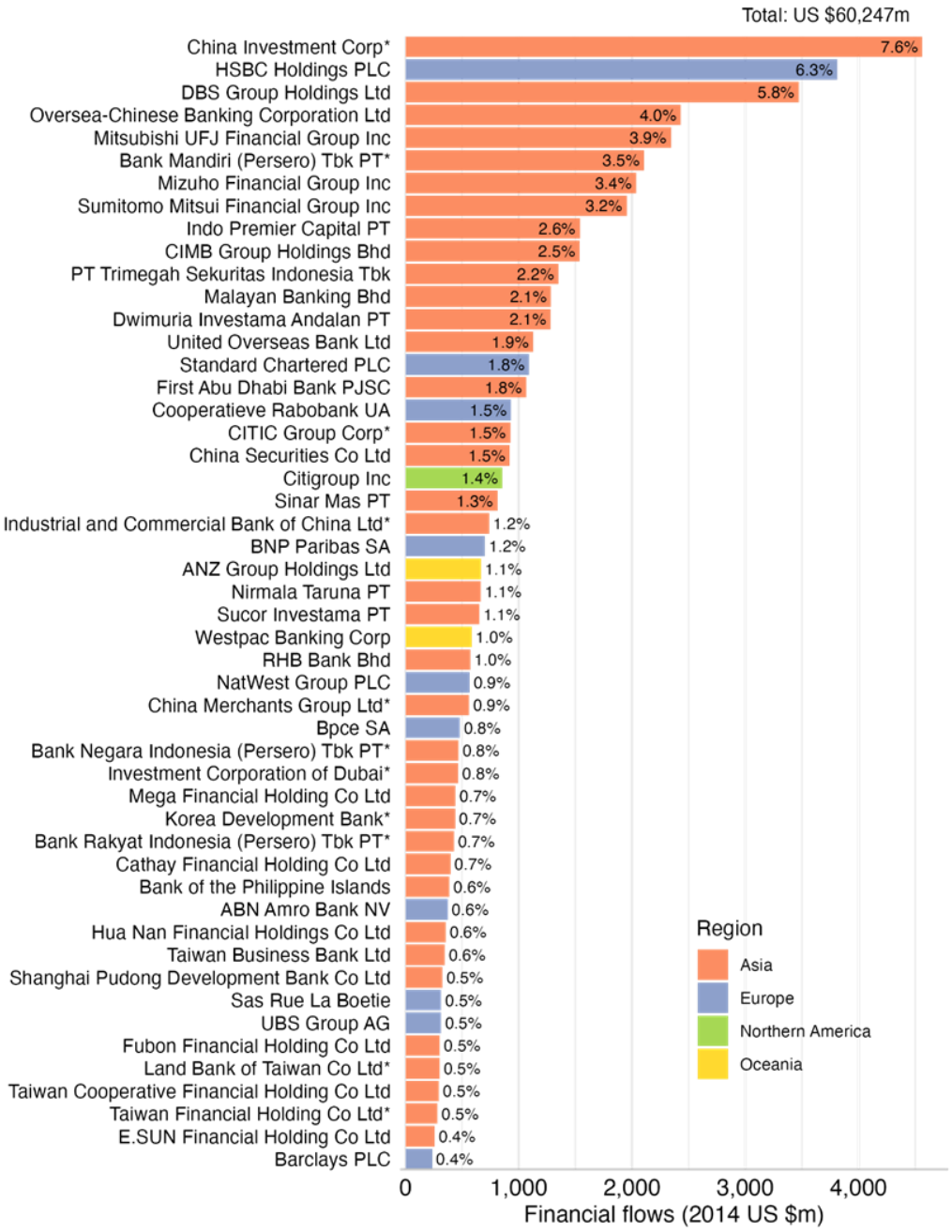


Figure 3. Indonesian peatlands - institutions providing and facilitating financial flows to companies linked to land use on peatlands. Institutions with a government ultimate parent marked with asterisks.



Analysis of potential sensitivity of firms to changes in external financing conditions

(Macro)prudential interventions – based on the transition or systemic risk profiles of ETP-risk companies – would make external finance more difficult to access and/or costly, in addition to improving the resilience of the financial system. This could influence the activities of these corporates and play an indirect role in reducing their contributions to environment-related risks. We examined three different financial ratio metrics for a subset of ETP-risk companies for which data was available, to estimate their potential sensitivity to changes in external financing conditions and compared this to a range of industry averages. We found a significant degree of heterogeneity in these ratios, by sector (Table 2). In the Brazilian beef sector, companies had debt-to-asset ratios in 2023 that were well above the global-, emerging markets-, and consumer non-cyclicals averages. They also had low retained earnings to total assets compared to other ETP-risk companies. Several palm oil, and pulp and paper, companies also had higher-than-average debt-to-asset ratios; low or negative retained earnings; and interest coverage ratios below industry averages. This combination of factors suggests greater sensitivity to negative changes in external financing conditions.

Table 2. Financial ratio analysis of ETP risk companies with available data for 2023

ETP-risk company	Sector(s)	Entity name	Total debt to assets	Retained earnings to assets	Interest coverage ratio
Industry averages					
Global non-financial	-	-	0.27	-	5.81
Emerging markets non-financial	-	-	0.23	-	5
Global consumer non-cyclical	-	-	0.23	-	3.98
Brazilian Amazon					
Archer Daniels Midland	Soy	Archer-Daniels-Midland Co	0.15	0.43	6.21
Bunge	Soy	Bunge Global SA	0.19	0.48	6.3
Chs	Soy	CHS Inc	0.13	0.13	9.78
Cofco	Soy	Cofco Corp	0.3	0.09	-4.58
Glencore	Soy	Glencore PLC	0.26	0.24	4.14
Jbs	Beef	JBS SA	0.51	0.05	0.67
Marfrig	Beef	Marfrig Global Foods SA	0.43	0.02	0.21
Minerva	Beef	Minerva SA	0.75	0.04	1.26
Indonesia peatlands					
Astra Agro Lestari	Palm oil	Jardine Matheson Holdings Ltd	0.23	0.33	6.03
Astra Agro Lestari	Palm oil	Astra Agro Lestari Tbk PT	0.14	0.6	4.9
Astra Agro Lestari	Palm oil	Astra International Tbk PT	0.21	0.42	14.22
First Resources	Palm oil	First Resources Ltd	0.13	0.59	24.57
Kuala Lumpur Kepong (Klk)	Palm oil	Batu Kawan Bhd	0.33	0.21	4.32
Royal Golden Eagle*	Palm oil; Wood pulp	Toba Pulp Lestari Tbk PT*	0.66	-1.21	-0.6
Sime Darby	Palm oil	SD Guthrie Bhd	0.17	0.46	9.76
Sinar Mas	Palm oil; Wood pulp	Golden Agri-Resources Ltd	0.33	0.36	2.03
Wilmar	Palm oil	Wilmar International Ltd	0.5	0.2	0.98

*Toba Pulp Lestari Tbk PT (TPL) is listed here as being associated with Royal Golden Eagle (RGE) group, as per TSC data. However, RGE and TPL maintain that they are independent entities. See Marsden et al. (2024b).

However, the balance sheets of other ETP-risk companies indicate they could be relatively insulated from changes in external financing conditions due to a low reliance on external debt finance, high retained earnings (likely arising from significant profits) and strong interest coverage ratios compared to industry averages. This included most of the companies associated with Brazilian soy and some palm oil companies. Many of these companies appeared to have decreased their reliance on external financing, and particularly debt, over the study period.

Discussion and policy implications

Our findings support recent research framing land use and degradation as a globally systemic driver of nature loss, characterised by complex cross-scale interactions and teleconnections (Folke et al., 2019; Grabs et al., 2024). We build upon this research by showing that land use dynamics linked to agriculture in Brazil and Indonesia are not just driven by physical flows (e.g., trade in commodities) but are also associated with financial flows across various asset classes. Domestically headquartered financial institutions played only a minor role in our data for the companies linked to Brazilian Amazon; instead, financial institutions headquartered in the United States, Japan and Europe were particularly prevalent. Flows linked to domestically headquartered institutions were more important for the Indonesia peatlands, however Chinese state investment banks were also important. Financial flows attributed to EU-headquartered financial institutions, when considered collectively, accounted for an even greater proportion than the US for the Brazilian Amazon. This stands in stark contrast to the bloc's efforts to reduce the deforestation associated with its physical import of agricultural commodities, including from Brazil (Titley, 2024). Overall, our data illuminates a distinct set of geographies that should be engaged in managing the risks of ecosystem tipping points in the Brazilian Amazon and Indonesian peatlands.

Our results illustrate a challenge in tracing how finance links in practice to environmental degradation (Meyfroidt, 2016). We found very few financial flows that could be directly traced to harmful activities in the specific ecosystems we focused on. Instead, most financial flows were provided as funding for general corporate purposes and other unrestricted forms. These flows were in turn mediated through a complex set of intermediaries, often diversified and multinational corporations, before reaching actors directly involved in deforestation. Here, as in previous research exploring the nexus between finance

and the ecological impacts of agriculture (Galaz et al., 2018; Clapp, 2019; Ouma, 2020), causes and effects are essentially "distanced" through a network of supply-chain and financial linkages making tracing causality based on the available data very difficult.

Greater long-term disclosures of how capital is distributed across a company's subsidiary structure, including extractive activities, could be a first step to determining causality (Galaz et al., 2018). However, we suggest that there may be fundamental limitations to tracing specific "negative" financial flows. Our data demonstrates how financial capital can be fungible within a corporate structure with significant intracompany lending and cross-subsidization. The difficulty in tracing specifically harmful financial flows to target with policy measures suggests that a more discretionary view needs to be taken of involvement in ecologically harmful activities, including in ecosystems with tipping points, at the level of the corporate group. A precautionary approach (Chenet et al., 2021; Kedward et al., 2022) would suggest that any finance, including general corporate purpose, to an ETP-risk company could be a source of risk until it fully reorientates itself away from such activities.

However, the heterogeneity in the internal financing capacity of ETP-risk companies suggests that reorienting financial flows cannot be seen as a silver bullet to unilaterally preventing their expansion. Financial flows are only one part of a broader macroeconomic and institutional context that encourages land use pressures in some of the world's most critical ecosystems (Althouse and Svartzman, 2022). Tougher environmental regulation, higher taxes on the profits of the ETP-risk companies, removal of subsidies, and industrial policy reforms focussed on developing more sustainable export industries are likely needed in coordination with financial reforms to encourage a transition to more sustainable business models.

This is clearly a complex policy challenge which merits further research. Our contribution in this paper has to been to show the potential for financial reforms to support this process. Network analysis of the key real- and financial- firms identified in our study could help better identify sources of risk and enable more strategic interventions. Given the potentially systemic economic and financial risks posed by the collapse of these ecosystems, economic policymakers with a long-term view of these threats – in particular macroprudential policymakers – are well-placed to coordinate with others as part of a wider precautionary policy approach to prevent ecosystem tipping points being passed.

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