

Mapping corporate ties between ultra-processed food and petrochemical industries

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ABSTRACT

The global expansion of ultra-processed foods (UPFs) has been highly dependent on petrochemicals for agricultural inputs and single-use plastic packaging. However, despite this reliance, corporate ties between food and petrochemical industries have not been studied. Using network analysis, we explore connections between the world's leading 30 UPF and 50 petrochemical corporations, finding a high degree of interdependence and coordination. These connections span *ownership* (common shareholders and subsidiaries), *governance* (common board members and directors) and *political* ties (common interest groups including trade associations, lobby groups and multistakeholder initiatives). Of the 1,500 possible cross-industry corporate pairings (30 x 50), we found ties between 1,380 (92%). We sub-analyse connections held by the top five plastic producing and polluting UPF corporations: Coca-Cola, PepsiCo, Nestlé, Danone, and Unilever to reveal their positions in this global cross-industry network. Our findings shed new light on a political economy that may be limiting global efforts to end plastic pollution and transform food systems for improved human and planetary health.

INTRODUCTION

The global expansion of ultra-processed foods (UPFs) relies on petrochemicals as both feedstock and energy, from agricultural inputs to single-use plastic packaging. The political economy of UPFs has, as a result, been characterized by economic interdependencies between the petrochemical industry and transnational food companies. Despite the close ties between these industries, corporate networks across petrochemicals and food have received surprisingly limited attention within the scholarship on food systems and global environmental politics.

This article responds to this gap by examining the economic and political ties between leading petrochemical and UPF corporations, using network analysis to identify *ownership ties* (common shareholders and subsidiaries), *governance ties* (common board members and directors) and *political ties* (membership of common interest groups including trade and business associations, lobby groups and multistakeholder initiatives). Based on this analysis, we highlight the high degree of interdependence and coordination between petrochemical and UPF sectors, in which economic ties are complemented by extensive political coordination via corporate sustainability initiatives and multistakeholder partnerships.

This article makes two key contributions to current debates on the global environmental politics of food. First, using corporate network analysis, the results show the high levels of integration between industries within the global plastics value regime. Second, and situating this analysis within current debates over plastics pollution, we argue that the depth of political-economic ties between petrochemical and UPF corporations has often been obscured, limiting scrutiny of a shared interest in maintaining and expanding production of petrochemicals. The article is structured as follows. The remainder of the Introduction provides an overview of UPFs and the political economy of plastics. The Results present our findings, followed by a Discussion of their implications. Finally, the Methods describe how the study was conducted.

The political economy of ultra-processed foods, petrochemicals and plastics

UPFs are transforming diets with serious consequences for human and planetary health. Overweight and obesity have doubled in the last three decades and could affect half of adults worldwide by 2050¹. The manufacture of UPFs contributes to the triple planetary crisis of biodiversity loss, climate change and pollution^{2,3}.

The NOVA classification system, widely used to categorize foods based on the extent and purpose of their processing, defines UPFs as “branded, commercial formulations made from cheap ingredients extracted or derived from whole foods and combined with additives”⁴. UPFs include sugar-sweetened beverages, many processed meats, convenience meals, breakfast cereals, sweets, and snack bars. These products are displacing minimally processed foods that have long comprised the basis of many traditional dietary patterns^{4–6}. Diets high in UPFs are associated with increased overweight and obesity, type 2 diabetes, cardiovascular disease and all-cause mortality^{4,7}. Meanwhile, environmental pressures associated with UPFs, including unsustainable land-use and energy-intense production practices, greenhouse gases emitted from farming, processing and global distribution, with extensive use of packaging, exacerbate biodiversity loss, climate change and pollution^{8,2,9}. As these harms unfold, UPF production and consumption continue to expand, fueled by product formulations

designed to maximise palatability, shelf life, and convenience and which remain inexpensive for consumers, yet highly profitable for manufacturers^{10,11}. In 2023 alone, global sales of UPFs were more than USD \$1.9 trillion¹².

Fossil fuels provide the direct feedstocks and energy required to produce petrochemicals, whose products have been integral to the scale and profitability of UPF value chains¹³. These products include synthetic fertilizers, pesticides and agricultural plastics used to produce raw ingredients¹⁴; chemical food additives such as colours and preservatives¹⁵; and plastics in the form of processing equipment, machinery, storage containers, packaging, and other items throughout retail, household consumption and waste management¹⁶ (Figure 1). Many of the chemicals found in UPFs - including phthalates, bisphenols, and PFAS commonly used for packaging long-shelf-life UPFs - are known endocrine disruptors implicated in multiple disease outcomes^{15,17}. Fossil fuel subsidies and the externalisation of environmental costs have contributed to artificially low market prices for plastics. Alongside the introduction of disposable packaging in the 1970s this has enabled the global expansion of UPFs¹⁸ and fuelled the growing plastics pollution crisis¹⁹. Food and beverage packaging dominates marine plastic pollution²⁰ and the five largest corporate plastic users and polluters across global sectors are all major UPF-producing companies - Coca-Cola, PepsiCo, Nestlé, Danone and Unilever^{21,22}.

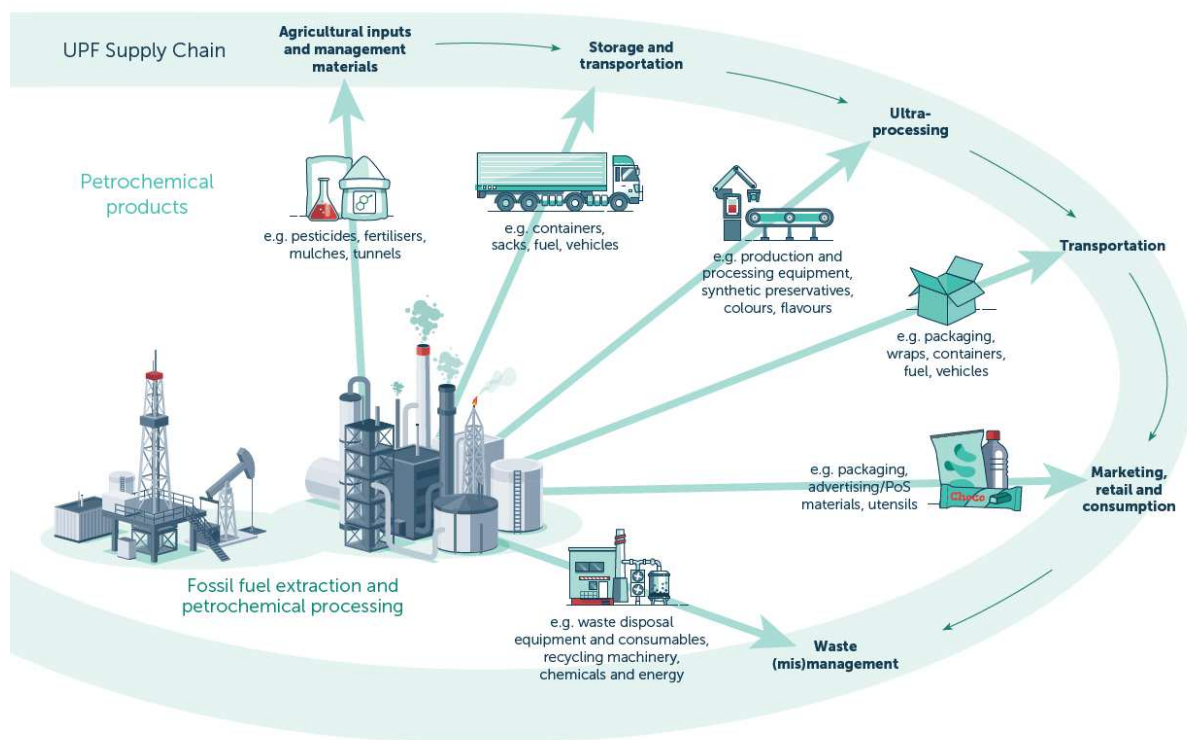


Figure 1: Petrochemicals in the ultra-processed foods supply chain

In addition to more than 142 million tonnes of plastic packaging waste produced each year²³, greenhouse gas emissions across plastics life cycles alone could reach 4.2 gigatons by 2040²⁴. Evidence shows elevated risks of leukaemia, respiratory issues, adverse birth outcomes and premature mortality among communities on the frontlines and fencelines of petrochemical production²⁵ and chemical additives emitted across plastics life cycles have been linked to USD \$3.74 trillion in adverse population health costs²⁶. The market for plastic product and packaging manufacturing is currently

worth more than USD \$7 billion a year ²⁷, with global plastics production set to rise by 70% by 2040 ²⁸.

Reflecting their substantial roles as commercial determinants of health ²⁹, corporations within the global petrochemicals regime and UPF industries have faced mounting regulatory, legal and public pressure to address the escalating crisis of plastics pollution, climate change and diet-related non-communicable diseases ^{30–32}. Mapping the extent and nature of ties between ‘upstream’ petrochemical corporations and ‘midstream’ consumer-facing UPF corporations is therefore important to understanding the coalitions (or blocs) of actors that may be tying these industries together.

Prior research has explored the nature of corporate networks among petrochemical corporations ^{33,34}, and UPF corporations ³⁵, respectively. These have found deep structural networks *within* these industries spanning common **ownership, governance and political ties**, which reflect different means of corporate coordination and economic lock-ins. Ownership ties include common shareholders, investors and jointly owned subsidiaries. Governance ties may take the form of individuals who concurrently or recently serve as directors or board members for multiple companies across sectors. Finally, political ties can manifest through corporate membership of common interest groups, trade associations and MSIs which function in part to shift and normalise public narratives.

In this article, we examine the extent (number of corporations with any ties across sectors), range (number of inter-industry connections) and nature (distributions of corporate tie types) of interconnections between the top 30 UPF manufacturing corporations and the top 50 petrochemical corporations ³⁴, as defined by industry sales rankings in 2019 and 2021 respectively. We explore *ownership ties* (common shareholders and subsidiaries), *governance ties* (common board members and directors) and *political ties* (membership of common interest groups including trade and business associations, lobby groups and MSIs), through which strategic corporate alignment, mutual dependence, and coordinated policy influence may be operationalised. We further unpack these networks for a subset of the top five plastic producing and polluting UPF corporations as identified through brand audits of environmental plastic pollution from 2018–2022 ²²: Coca-Cola, PepsiCo, Nestlé, Danone, and Unilever. These five corporations exemplify the wider UPF industry's dependence on petrochemical inputs and infrastructure and facilitate closer analysis of the potential implications of corporate interconnection.

We discuss the implications of our findings in relation to efforts being made to address the human health and environmental harms posed by these major industries. Overall, our study contributes to broader debates around the political economy of food systems and the multiscale actions needed to address global challenges.

RESULTS

We found evidence of a highly integrated network of corporate ties between UPF and petrochemical industries, in the form of shared ownership, governance, and political linkages. All 30 UPF corporations and all 50 petrochemical corporations included in our analysis were connected to multiple corporations across the two sectors (**Figure 2a**). More than half the petrochemical companies (n=28)

had at least one corporate tie to every UPF producer included in our analyses. Even the least connected UPF corporation was linked to 34 unique petrochemical corporations (68% of those included) (Figure 2a). Of the 1500 possible cross-sector corporate pairings (i.e. 30 x 50), we identified ties between 1380 pairs of corporations. These connections were predominantly political, through membership of common interest groups (n=1190, 79% of 1500 possible cross-sector corporate pairings). This was followed by ownership ties in the form of common shareholders (n=878 corporate pairings) and common subsidiary ownership (n=44 corporate pairings), and then by governance ties via common directors or board members (n=39 pairings) (**Figure 2b**). Full data are provided in **Supplementary Data**.

In terms of political ties, all UPF corporations (n=30, 100%) were members of common interest groups that included petrochemical industries. Just four out of 50 (8%) petrochemical corporations included were not found to share this form of tie with any included UPF corporation. More than half (n=83, 56%) of all interest groups identified in our analyses had members from both industries and unique UPF-petrochemical industry pairs were often linked through their common membership in multiple interest groups (median count of interest groups linking each pair=3.8, IQR=3.0). Common interest groups connected individual UPF corporations to a median of 41 (IQR=7.8) petrochemical corporations, and each petrochemical corporation to a median of 30 (IQR=6.0) unique UPF companies (Figure 2b).

Shared ownership ties were identified between most UPF and petrochemical corporations. Common shareholders linked 24 UPF to 44 petrochemical corporations, forming 878 pairs (58.5% of 1500 possible pairs). Of these pairs, corporations were interconnected by an average of 109 individual shareholders. More than half of all identified shareholders in UPF and petrochemical corporations were found to have shareholdings across both industries. On average (median), UPF corporations were linked to 40 (IQR=6.0) petrochemical corporations through common shareholders; whereas petrochemical corporations were connected with a median 21 UPF corporations (IQR=2.0) (Figure 1b). In contrast, subsidiary co-ownership was restricted to smaller groups of corporations with fewer unique ties. Whilst half of all included corporations (48% of 80) were found to co-own at least one subsidiary, this typically connected each corporation with just one (for UPF corporations, IQR=4.0) or two (for petrochemical corporations, IQR 2.0) others who co-owned a median average of 7.4 (IQR 1.2) subsidiaries per pair. Overall, only 0.7% (n=290) of all 43,263 identified subsidiaries were co-owned by both UPF and petrochemical industries (Figure 2b).

Governance ties in the form of common board members or directors were the least common form of corporate tie, underlying 39 unique UPF-petrochemical industry pairs in our data (2.6% of total possible pairs). Overall, just 0.1% (n=35) of all 41,207 board members and directors were found to be common to both industries. Where these ties existed, they were proportionally more pervasive amongst UPF corporations (n=17/30, 57%) than for petrochemical industries (n=14/50, 27%). These ties typically comprised one person serving as a corporate board member or director of corporations in both sectors; when such ties were present, UPF corporations were connected to a median of 2 petrochemical corporations (IQR=2.0), while petrochemical corporations were connected to a median of 2.5 UPF corporations (IQR=3.0) (**Figure 2b**).

Ownership, governance and political ties frequently co-existed in the same pairs of UPF and petrochemical industries, particularly among the largest and most globally integrated corporations. Of the 1380 cross-industry paired corporations, more than half (51%) were connected through one of more tie types, while 41 (3%) were connected through three or more tie types (Figure 2a). One relationship - between International Fragrance Flavours and Dupont - included all four possible tie

types (Figure 2a). When the number of distinct tie types was summed across each petrochemical corporation's 30 UPF pairings, Bayer had 57 ties, jointly second with Eastman Chemical and DuPont, behind Ecolab (n=58). Five UPF corporations, Kellanova, Mondelez, PepsiCo, Unilever and Nestlé, were connected to Bayer through three tie types: common shareholders, board members/directors and interest-group memberships. Sixteen further UPF corporations had common shareholders and interest-group memberships with Bayer. Bunge had a common board member/director and interest-group memberships; while seven corporations had only common interest-group memberships. Uni-President – an international food conglomerate based in Taiwan – had only common shareholders with petrochemical corporations. Bayer held no common subsidiaries with any UPF corporations in our sample.

Looking across the full sample, 683 of the 1,185 pairs with common interest-group memberships (57.6%) also had common shareholders, 38 (3.2%) had common board members/directors and 31 (2.6%) had common subsidiaries. Board member/director-linked pairs also frequently overlapped with other ties: 38 of the 39 such pairs (97.4%) held common interest-group membership and 28 (71.8%) had common shareholders. Full pair-level data and tie-combination summaries are provided in **Supplementary Data**.

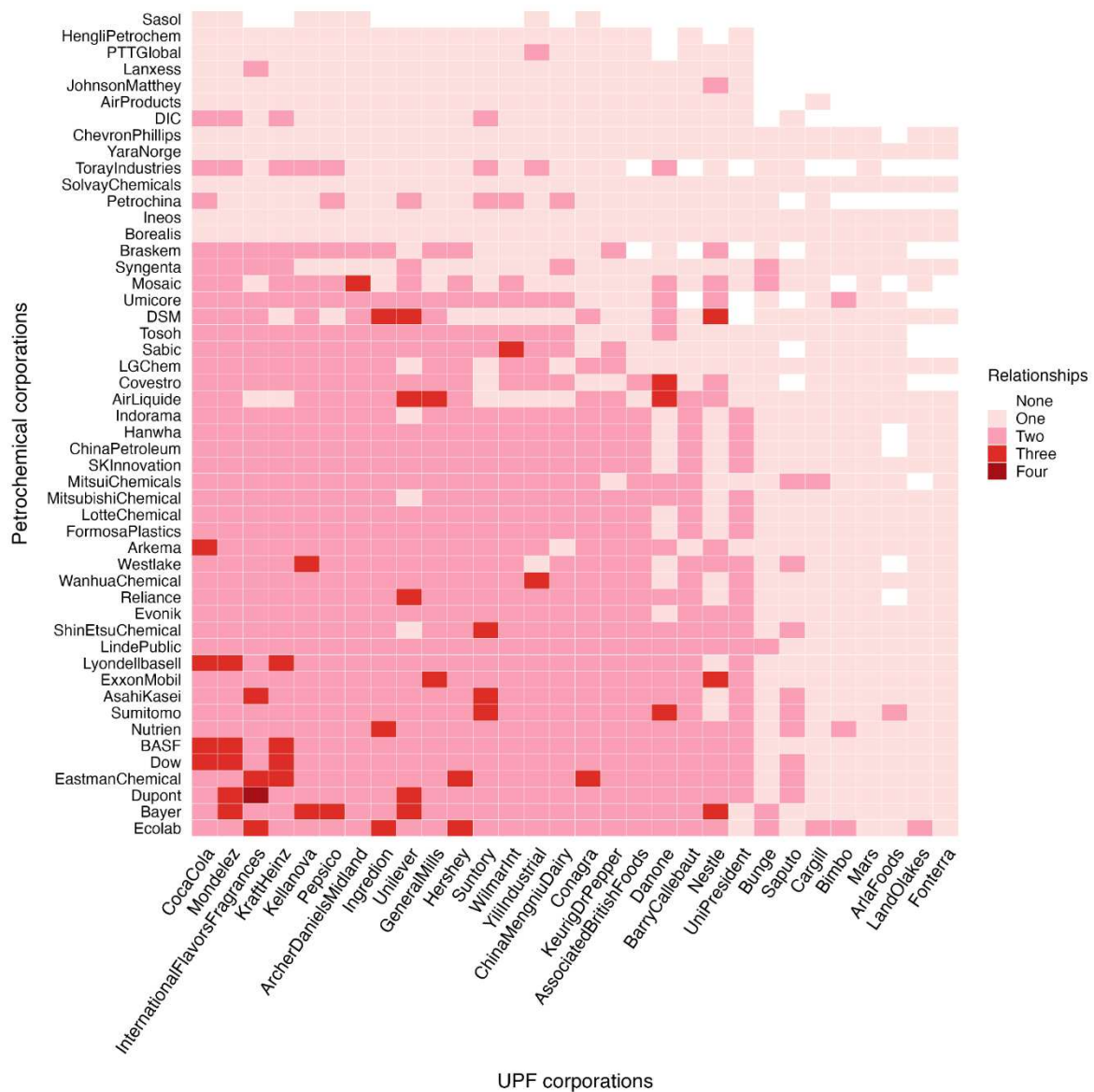


Figure 2a. Heatmap illustrating common ownership, governance and political ties between the 30 UPF corporations and the 50 petrochemical corporations. Each cell represents a corporate pair, shaded according to the number of distinct tie types linking the two companies. The color gradient represents the number of common tie types (up to a maximum of four): light pink for a single common tie type (e.g., a common shareholder, subsidiary, director, or interest group), dark pink for two common tie types, medium red for three, and dark red for four.

Tie type		Count of corporations with at least one cross-sectoral corporate tie by type		Median number of corporations tied to each individual corporation across sectors by type		Count of unique cross-sector pairs by corporate tie type	Median number of ties between unique cross-sector pairs by type [IQR]	Total count of cross-sectoral individuals, groups or entities by tie type
		UPF n (%) [*]	Petro n (%) ^{**}	UPF Median (IQR)	Petro Median (IQR)	All n (%) ^{***}	All Median (IQR)	All n % ^{****}
Ownership	Shareholders	24 (80.0)	44 (88.0)	40.5 (6.0)	21.0 (2.0)	878 (58.5)	108.8 (31.0)	3,566 (54.4)

	Subsidiaries	16 (53.3)	22 (44.0)	1.0 (4.0)	1.5 (2.0)	44 (2.9)	7.4 (1.2)	290 (0.7)
Governance	Board members/ Directors	17 (56.7)	14 (28.0)	2.0 (2.0)	2.5 (3.0)	39 (2.6)	1.2 (0.0)	35 (0.1)
Political	Interest groups	30 (100.0)	46 (90.0)	41.0 (7.8)	30.0 (2.0)	1190 (79.3)	3.8 (3.0)	83 (55.7)

Figure 2b. Summary statistics of the four types of relationships connecting UPF and petrochemical corporations. Columns report the proportion of ultra-processed food (UPF, n=30) and petrochemical (n=50) corporations engaged in each tie type, and the proportion of the 1500 possible UPF–petrochemical pairs that are linked. We present the median number of corporations linked to opposing industry corporations, with the Interquartile range in brackets [IQR]. In the final column, we report the proportion of tie types common across the two industries. *Percentage calculated using total number of included UPF corporations as the denominator (n=30), ** Percentage calculated using total number of included petrochemical corporations as the denominator (n=50), ***Percentage calculated using total number of possible cross-sector pairs as the denominator (n=1500), ****Percentage calculated using the total number of shareholders, subsidiaries, board members/directors, and interest groups across UPF and petrochemical industries included in these analyses: shareholders (n=6,556), subsidiaries (n=43,263), board members/directors (n=41,207), interest groups (n=149)

Corporate ties between the top five plastic polluting UPF corporations and the petrochemical industry: sub-group analysis

Coca-Cola, PepsiCo, Unilever, Danon and Nestlé have previously been identified as the top five plastic polluting UPF corporations ²². We found that each of these UPF corporations held at least one form of corporate tie with the overwhelming majority of 50 petrochemical corporations included in our analyses. Coca-Cola was connected to all (n=50, 100%) and even Danone as the least interconnected was linked to 47 petrochemical corporations (94%) (**Table 1**). All forms of corporate tie connected these two industries, including common ownership, governance, and political ties. Of the five UPF corporations, only Coca-Cola was not found to have common board members/directors, and only PepsiCo was not found to co-own subsidiaries with petrochemical corporations (Table 1).

UPF Corporation	Count of petrochemical corporations linked by any tie type	Ownership		Governance	Political
		Shareholders	Subsidiaries	Board members and/or directors	Interest groups
	n (%)*	n (%)*	n (%)*	n (%)*	n (%)*
Coca-Cola	50 (100%)	44 (88%)	6 (12%)	0 (0%)	42 (84%)
PepsiCo	49 (98%)	42 (84%)	0 (0%)	2 (4%)	42 (84%)
Nestlé	48 (96%)	23 (46%)	1 (2%)	4 (8%)	42 (84%)
Danone	47 (94%)	28 (23%)	1 (2%)	2 (4%)	42 (84%)
Unilever	49 (98%)	37 (74%)	1 (2%)	5 (10%)	42 (84%)

Table 1: Number of petrochemical corporations linked to the top five plastic polluting UPF corporations by corporate tie type. Top five plastic producing and polluting UPF corporations (left hand column) according to (Cowger et al, 2024) arranged by highest average percent of branded items polluting the environment identified through brand audits. Petrochemical corporations included in our analyses are the 50 leading petrochemical corporations as identified in (Tilsted & Bauer, 2024). *Percentage calculated using the total 50 corporations included in our analyses as the denominator.

For Coca-Cola, common shareholders tied the UPF producer to more petrochemical corporations than its political ties in the form of membership of common interest groups, in contrast with the trend seen amongst the wider 30 UPF corporations. Between types of ownership, the predominance of shareholder ties over joint ownership of subsidiaries was consistent with the wider network. Common shareholders connected these five UPF corporations with between 23 (Nestlé) and 44 (Coca-Cola) petrochemical corporations, respectively (Table 2). Subsidiary ownership represented substantially

fewer cross-industry ties overall, with notable differences between corporations. Coca-Cola was linked through co-ownership of subsidiaries with six different petrochemical corporations, whilst others were connected to one each (Unilever, Danone and Nestlé) or none at all (PepsiCo). Industries were less frequently tied through governance via common board members/directors. Coca-Cola held no cross-industry ties of this nature, whereas Unilever and Nestlé were connected to five and four petrochemical corporations in this way. PepsiCo and Danone were each connected to two petrochemical corporations through common board directors/members (Table 1).

Visualising ownership and governance ties as a network map reflects a densely interconnected structure (Figure 3). The map illustrates the centrality of Coca-Cola and PepsiCo, reflecting both the greater total number of petrochemical corporations they are tied to, and the strength of these connections as a function of the number of ties between each paired corporation. The links between Coca-Cola and PepsiCo and major petrochemical producers, including Dow, Dupont, ExxonMobil, and Westlake, are especially pronounced (Figure 3). These interconnections are mainly founded through common shareholders (Table 2). Danone, Unilever, and Nestlé are clearly well connected to a range of petrochemical corporations in this system, albeit with fewer common shareholders linking each pair (Table 2).

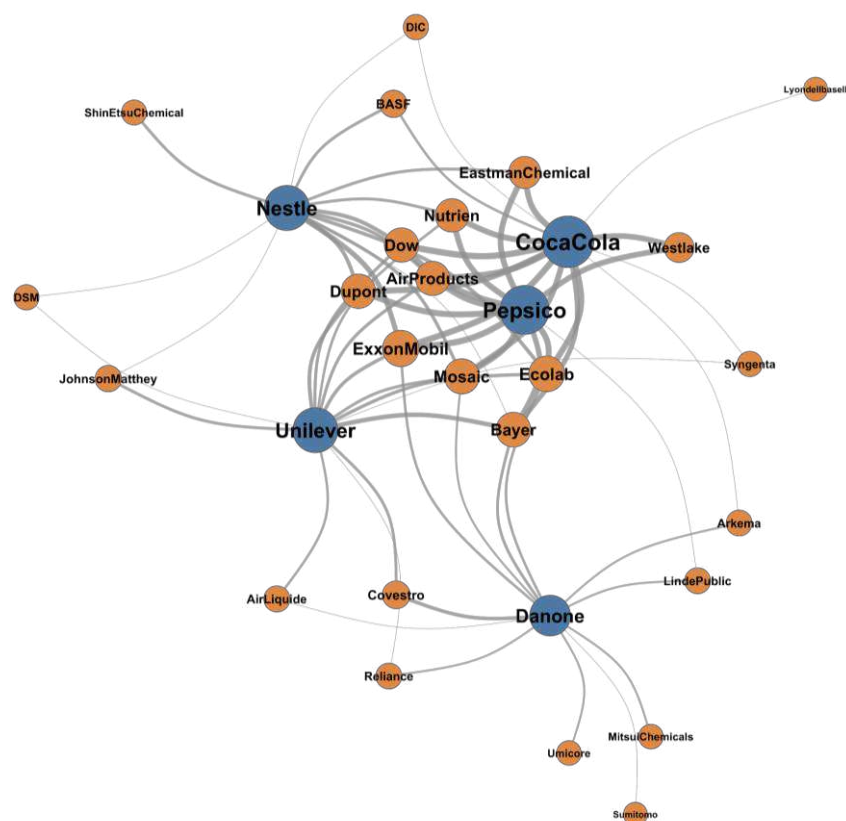


Figure 3. Network of ownership and governance links between ultra-processed food (UPF, blue) and petrochemical corporations (orange). Connections are formed through common shareholders, subsidiaries, and board members/directors. Each connection (edge) between two corporations represents the total number of ownership and governance ties they share, which is the sum of their common shareholders, subsidiaries, and board members/directors. Line thickness reflects the log-transformed weight of ties ($\log(\text{weight})+1$), applied to reduce the dominance of shareholder connections, which can number in the thousands, relative to the typically smaller counts of subsidiaries or directors. To highlight the most salient financial relationships, shareholder ties were limited to the top ten petrochemical corporations

with the greatest shareholder overlap for each of the five leading UPF plastic polluters. The size of each firm's node indicates its overall connectedness in the broader network, reflecting both the quantity and strength of its ties.

Politically, common interest groups linked all five UPF producers with exactly the same 43 petrochemical corporations, representing 86% of those included in our analyses. We found a total of 70 interest groups in which these corporations participated or shared membership (Figure 4), representing 84% of all identified interest groups (n=83) common to the broader data set of 30 UPF and 50 petrochemical corporations. Leading interest groups in terms of the number of cross-sector corporate pairings included the World Benchmarking Alliance (155 pairs), United Nations Global Compact (140), and Science Based Targets initiative (105), the World Economic Forum (80) and the World Business Council for Sustainable Development (68). The remaining interest groups provided platforms for cross-sector corporate pairings ranging from 55 to 1.

Among the 70 interest groups represented in the top-five subanalysis, the largest category comprised multi-stakeholder institutions, sustainability initiatives, NGOs and donors (n=39, 55.7%), followed by industry or business associations (n=26, 37.1%), petrochemical industry associations (n=3, 4.3%) and food-and-beverage industry associations (n=2, 2.9%). Across all 83 cross-industry interest groups in the full sample, the corresponding counts were 43 (51.8%), 27 (32.5%), 10 (12.0%) and three (3.6%), respectively (Supplementary Table 1).

MSIs home to the greatest number of cross-sector pairs of UPF producers and petrochemical corporations includes the World Benchmarking Alliance, UN Global Compact, Science-Based Targets Initiative, and the Round Table on Sustainable Palm Oil. The five organisations in this category that bridged the greatest numbers of top-five-UPF–petrochemical pairs were the World Benchmarking Alliance (155 pairs), United Nations Global Compact (140), Science Based Targets initiative (105), CEO Water Mandate (55) and Roundtable on Sustainable Palm Oil (48). These counts indicate common participation in the same forum or initiative, they do not by themselves demonstrate coordination or shared policy positions.

Finally, our analyses show that most common interest groups (n=38, 54% of all interest groups identified) are headquartered close to global centres of political influence such as Beijing (n=2), Brussels (n=14), Geneva (n=5), London (n=3), New York (n=4) and Washington D.C. (n=10), underscoring their proximity to regulatory decision-making and geopolitical influence.

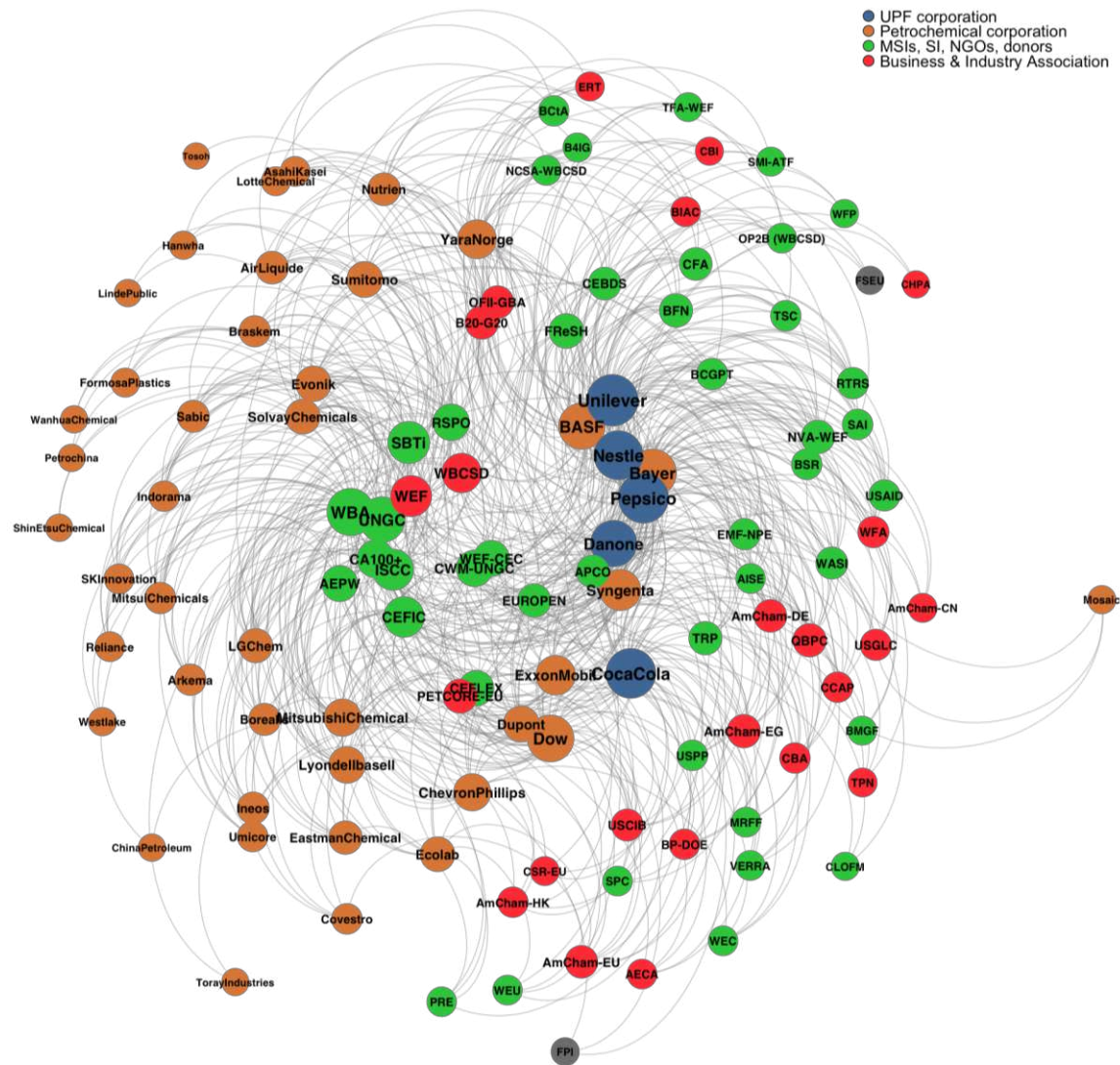


Figure 4: Common interest groups between top-5 plastic polluting UPF corporations (from Cowger et al., 2024) and petrochemicals from Tilsted & Bauer, 2024. This network only includes groups with ties to corporations in both sectors. Nodes are sized by the total number of connections. Node size reflects different attributes: corporation nodes are sized by their number of memberships in groups, while group nodes are sized by a balance index that gives higher weight to groups with an equal share of member corporations from both the UPF and petrochemical industries.

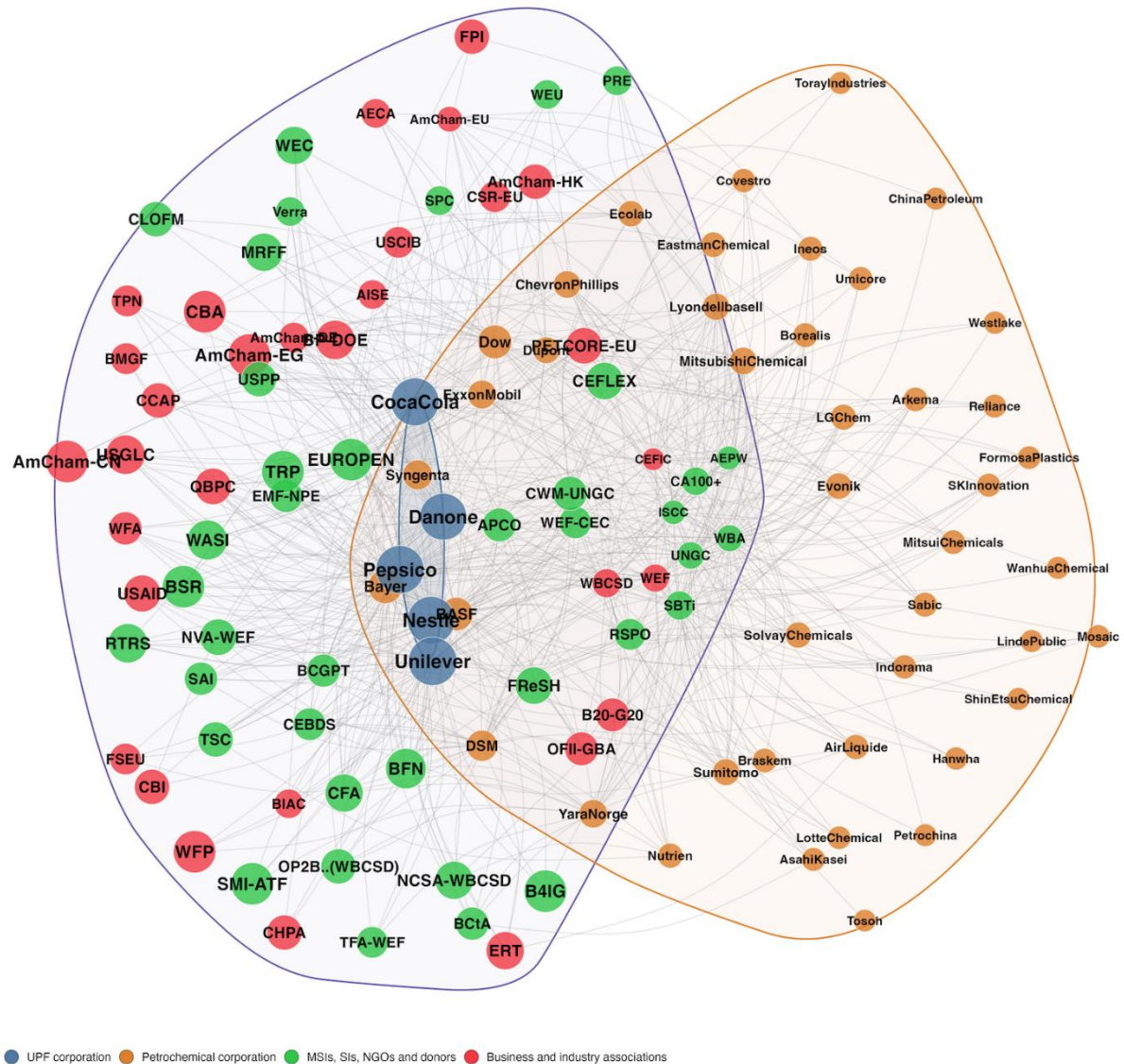


Figure 4 ALTERNATIVE VIEW: Common interest groups between top-5 plastic polluting UPF corporations (from Cowger et al., 2024) and petrochemicals from Tilsted & Bauer, 2024. This network only includes groups with ties to corporations in both sectors. Nodes are sized by the total number of connections. Node size reflects different attributes: corporation nodes are sized by their number of memberships in groups, while group nodes are sized by a balance index that gives higher weight to groups with an equal share of member corporations from both the UPF and petrochemical industries.

DISCUSSION

This study illustrates the central role of UPF corporations within the global plastics value regime. Our corporate network analysis of economic and political ties between petrochemical and UPF industries show high degrees of interdependence and coordination, evidenced by a wide range of common shareholders, subsidiaries, board interlocks, and interest groups. The extensiveness of these ties is reflected in the fact that over 90 percent of corporate actors within the petrochemical-UPF network share at least one political-economic connection

While the extent of political-economic networks between sectors that depend on petrochemical plastics is not surprising, these ties are often obscured in current debates over the global plastics crisis, notably around negotiations toward a UN environmental agreement on plastics pollution. As studies of global plastics treaty negotiations have highlighted, UPF companies have sought to distance themselves from the fossil fuel and petrochemical industry ^{36,37}. Throughout plastic treaty negotiations, UPF corporations have taken a ‘pro-regulatory’ stance, calling for an agreement that includes harmonized global regulation of ‘extended producer responsibility’ schemes ³⁷. As part of this strategy, UPF corporations have voiced support for binding global targets for reductions in virgin plastics reduction and the phasing out of ‘avoidable’ plastic products. The most high-profile campaign has been led by the Business Coalition for a Global Plastics Treaty - which includes Coca-Cola, Nestlé and Unilever in partnership with the Ellen MacArthur Foundation and World Wildlife Fund - that has urged governments that ‘business needs global rules’ ^{38,39}. This strategy has involved positioning the fast-moving consumer goods sector - and particularly UPF corporations - as constructive voices in multilateral negotiations, distancing themselves from the fossil fuel and petrochemical industry. As one Business Coalition representative noted in an interview with the *Financial Times*, ‘the [oil and gas] sector are looking at plastic as being the next opportunity for the industry [...] that’s really problematic for the rest of us’ ⁴⁰. This ‘part of the solution’ discourse ⁴¹ has extended to the corporate sustainability commitments, with both Coca-Cola and PepsiCo having stated their commitment to ‘decoupling’ growth from the use of fossil-based virgin plastics ⁴².

As we have shown, petrochemical and UPF industries are deeply interconnected across economic and political dimensions. It is possible to imagine that UPF companies are currently working to extricate themselves from petrochemicals, undoing a dependence on fossil-based plastics. However, there is little evidence to suggest that fossil-based plastics *are* being meaningfully phased out. As Mah ⁴³ observes, the marine plastics crisis sparked a wave of corporate interest in the ‘circular economy’ for plastics, with UPF companies among the first to announce voluntary pledges to reduce virgin plastic use. Over the past five years, many of these targets have been missed, revised, or abandoned. In 2024, Coca-Cola backtracked on a commitment to transition 25% of global drinks sales to refillable, returnable or reusable containers ⁴⁴, while PepsiCo, Nestlé and Unilever missed similar targets to increase reuse and reduce single-use plastic packaging ^{45–49}. Indeed, several UPF corporations have actually increased their use of virgin plastics, undermining claims to be decoupling business models from fossil fuels.

In this regard, efforts by UPF companies to present themselves as phasing out fossil-based plastics creates the impression of distance from the petrochemical industry, while avoiding significant reductions in single-use plastic use. Such strategies obscure the ties and interdependencies that the present analysis reveals. Given shared material interests and a long history of collaboration ^{17,19}, such networks would seem inevitable. Nevertheless, the depth and extent of corporate networks across these industries is arguably overlooked in current debates over the global plastics crisis.

The cross-industry economic ties that we have found suggest that it is plausible that policy, regulation or legal actions designed to limit consumption of UPFs (i.e., front-of-package labelling, marketing restrictions, SSB taxes) could affect the demand for plastics and thus the profits of petrochemical corporations, and could trigger resistance from both industries. Simultaneously, policy, regulation or legal actions targeting plastics ^{50,51} could affect UPF-producing corporations. In this sense,

policymakers designing UPF, petrochemical or plastics regulations independently of one another may face a broader coalition of opposition than they anticipate or are aware of. An example of this may be in Kenya where Coca-Cola and local plastics manufacturers coordinated to oppose an eco-levy and plastics tax in Kenya ⁵².

For policy processes to truly address the full life cycle of plastic, or the growing health burden of UPFs, our data shows that corporate interdependencies must be recognised in order to fortify these spaces from any actors associated with either industry ^{53,54}.

Limitations

While this study provides new insights, there are a number of limitations to consider when interpreting the findings. First, we collected interest group membership data as reported by corporations or interest groups on their websites. We were not able to access undisclosed memberships, meaning our data likely underreports these corporate ties. Second, the categorisation of interest groups is subjective and likely entails some overlaps. For instance, entities such as WWF (an NGO) could fall under many groupings according to the different activities they perform. However, as stated in the Methods, we sought to categorise each entity according to the predominant type of activity their specific activities aligned with. Third, our board-member/director analysis was restricted to the boards of the focal parent corporations and did not include boards of their subsidiaries; it therefore likely underestimates governance ties across the two corporate groups. Fourth, given its scope and exploratory nature, our study didn't explore qualitative differences among the ties. E.g., some shareholder ties could be the result of so-called 'passive investment' strategies. This is an important area for future work to untangle. Fifth, our network visualisations assign equal importance to the three tie types relating to ownership and governance (common subsidiaries, board members/directors, and shareholders), so the apparent strength of relationships reflects the number of these ties rather than qualitative differences in their significance. Finally, to ground our study, we selected the top 50 industry petrochemical leaders by global sales revenue in 2019, as compiled by Tilsted & Bauer ³⁴ using data from Chemical and Engineering News. Among these corporations may some - such as DSM - who are transitioning away from petrochemicals in their core business.

Conclusion

This study demonstrates the depth of political and economic ties between UPF and petrochemical corporations in the global plastics value chain. In doing so, it highlights the shared material and political interests of corporate actors within these sectors. The lock-in of single-use plastics forms a barrier to more progressive ambitions within corporations or among shareholders ⁵⁵, with such structural constraints likely to delay efforts to transition to food systems that are more healthy, sustainable and just ⁵⁶.

At this critical moment for evidence-informed policymaking and public awareness around both UPFs and plastics, states and the world stand at a pivotal crossroads. New investments in petrochemical and plastic architecture will further enable UPF supply chains, while lack of policy action on UPFs will undermine plastic pollution efforts. The allure and illusion of downstream plastic pollution measures such as recycling could lock people and the planet into an unhealthy, unsustainable and costly future. The empirical analysis presented above suggests that disentangling from fossil-based plastics demands transformative changes to business-as-usual, including the phase-out of single-use plastics, dietary shifts away from UPFs, and wholesale transitions to safe and sustainable reuse models. These shared strategies would present co-benefits for the environment and human health. While radical

change is possible, it is likely to require state-led interventions over petrochemical plastics production at national-level, and through global governance mechanisms. As such, our findings support the growing majority of member states, civil society groups, scientists, and Indigenous Peoples calling for ambitious and science-based action on plastic pollution⁵⁷ and each the articulated need for ‘multiscalar’ and cross-sectoral efforts address interlinking challenges and struggles⁵⁸.

METHODS

Sample selection

We assembled a cross-industry sample of the 30 leading UPF corporations according to total global sales revenue in 2021, as identified by Slater et al., 2024³⁵ through Euromonitor International’s Passport database. For petrochemical corporations, we selected the top 50 industry leaders by global sales revenue in 2019, as compiled by Tilsted & Bauer (2024)³⁴ using data from Chemical and Engineering News. The total combined list of the 80 UPF and petrochemical corporations included in our analysis is available in Supplementary Data.

Definition of corporate ties

Corporations can be interconnected in different ways. We examined ties including shared ownership (common shareholders and subsidiaries), governance (common board members and directors) and political ties (membership of common interest groups including trade and business associations, lobby groups and MSIs), through which strategic corporate alignment, mutual dependence, and coordinated policy influence may be operationalised.

Ownership ties:

1. **Common shareholders:** Common shareholding occurs when the same investor holds shares in both UPF and petrochemical corporations. Concentrated cross-sector ownership by large asset managers may confer influence over corporate governance across multiple sectors⁵⁹ (Braun, 2021). Although some of the largest asset managers, such as BlackRock, Vanguard and State Street, are described as “passive” because they primarily track indices, they can still exercise governance influence through proxy voting and engagement with corporate decision-makers. Our analysis maps overlapping ownership but does not assess whether or how these investors exercise influence; examining the role of asset-manager capitalism in shaping cross-sector corporate strategy is an important direction for future research.
2. **Common subsidiaries:** In line with Tilsted & Bauer (2024)³⁴, we define subsidiaries broadly as all downstream entities listed by Orbis under a corporation’s subsidiary structure, including majority-owned subsidiaries, joint ventures, associates, and minority-owned affiliates for which ownership shares may be partial or undisclosed. This approach does not rely on the strict accounting definition of a subsidiary (i.e., >50% ownership), which would preclude identification of entities jointly owned by more than one corporation. Instead, it captures a wider set of formalised ownership ties that reflect material, financial, and strategic interdependencies between firms. Within high capital intensive sectors, such as the plastics, packaging, and food manufacturing, such shared ownership structures are common mechanisms for pooling risk, securing supply chains, and maintaining influence over key technological and infrastructural assets. An illustrative example was Continuum Recycling

Limited, the joint venture established in 2014 by Coca-Cola Enterprises Ltd (CCE) and ECO Plastics.

Governance ties:

3. **Common board members and directors:** We conceptualise board ties broadly to include both (i) board interlocks, where an individual simultaneously serves on the boards of at least one UPF and one petrochemical corporation, and (ii) revolving-door movements, where directors transition from a UPF to a petrochemical board (or vice versa) within a 10 year period. In both cases, directors occupy positions of strategic oversight, governance, and long-term planning, making these appointments important channels of corporate connectivity. A substantial literature on interlocking directorates shows that such ties facilitate information exchange, strategic alignment, and coordinated responses to market or regulatory risks ^{60,61}. Furthermore, studies of the global corporate elite demonstrate how overlapping and mobile board careers help knit together transnational business communities, extending influence across sectors and jurisdictions ^{62–65}. In the context of the UPF–petrochemical nexus, we therefore treat both concurrent and short-lag cross-industry appointments as meaningful governance ties that may help preserve shared commercial interests, specifically the expansion of plastic-dependent supply chains.

Political ties:

4. **Common interest groups:** Common interest groups refer to organisations or initiatives in which both UPF and petrochemical corporations hold membership. These include industry-specific associations (i.e. petrochemical or food and beverage), broader/cross-cutting industry or business associations, multi-stakeholder initiatives, sustainability initiatives, non-governmental organisations (NGOs) and donors. This broad category of groups serve multiple strategic functions for industry, including shaping public narratives, advancing public-private partnerships, and extending corporate influence across regulatory and governance environments ^{29,66}. Common interest groups may legitimise shared positions on issues such as plastics, environmental sustainability and public health policy.

Data sources

Two complementary data-collection streams were used to identify ties between UPF and petrochemical corporations. We used Moody's Orbis database to retrieve shared ownership, board and group-structure records for each of the 80 corporations in our sample (accessed on 7th of November 2024). Moody's Orbis aggregates official corporation registry filings and other authoritative sources across more than 200 jurisdictions and assigns unique identifiers to corporations and persons. To identify political ties we searched open-source databases and industry websites.

Ownership ties

1. **Shareholders:** Moody's Orbis lists named direct owners and ultimate owners, often with percentage holdings and filing dates for each focal corporation. Corporate owners and large institutions are captured. Moody's Orbis does not provide a single global minimum inclusion threshold, as thresholds depend on jurisdiction and filing rules. However, very small retail holdings and positions held through omnibus or nominee accounts are commonly absent or aggregated by the custodian, and are therefore excluded from these data. We retrieved all named direct and ultimate owners with their Moody's Orbis investor identifiers, without imposing an ownership-percentage filter at extraction. The effective lower bound is therefore whatever each registry

discloses. Each shareholder is identified by its Moody's Orbis investor identifier; a pair of UPF-petrochemical corporations is coded as shareholder-linked if the two corporations share at least one such identifier.

2. **Subsidiaries:** Moody's Orbis lists legal entities within group structures with ownership percentages and Moody's Orbis corporation identifiers, for up to ten levels of depth in the corporate group, allowing us to identify distant or layered subsidiary ties. For each UPF or petrochemical corporation, we retrieved the group ownership tree and included subsidiaries where the recorded equity stake was $\geq 1\%$ or recorded as positive, down to the 10th level. When percentages were missing but a subsidiary relationship was present in Moody's Orbis, we included the subsidiary in our data. A UPF-Petrochemical pair is subsidiary-linked if both corporations hold an equity stake in the same registered subsidiary (matched on Moody's Orbis company ID).

Governance:

3. **Board members and directors:** Moody's Orbis lists board members and directors with roles, dates and unique person identifiers. We extracted all individuals coded as current board members or directors as of our search date, with the primary aim of identifying current, simultaneous appointments across UPF and petrochemical boards. Manual verification of apparent overlaps, however, revealed a small subset in which the individual had in fact left the first board before joining the second. Rather than discarding these sequential ties, we retained them to capture the "revolving door" dynamics defined in our theoretical framework. These sequential cases (16 in total) demonstrate a high degree of temporal proximity, with the director or member typically joining the second board within one year of leaving the first, and they account for approximately 30% of shared directors in our final list. By including these alongside explicit simultaneous interlocks, our dataset provides a more comprehensive view of governance interdependencies, capturing both ongoing coordination and the strategic transfer of human capital between the UPF and petrochemical sectors.

These data provide named, registrable *ownership* and *governance* ties between our sample of corporations. However, they do not include unrecorded beneficial owners, small retail holders below disclosure thresholds, opaque nominee accounts or undisclosed contractual arrangements. Similarly, subsidiary coverage can lag filings and may be incomplete for private entities; while person records can be incomplete in some jurisdictions. These limitations bias our measures toward conservatively measured, documentable links.

Political ties

4. **Common interest-groups:** To identify political corporate ties we used LobbyFacts.eu as a starting point. We then searched corporate websites, annual and sustainability reports, association registers and public participant lists for multilateral processes relevant to plastics and packaging. We looked for evidence of formal membership of petrochemical and UPF corporations in these interest groups. Where we found common memberships, we extracted the names of all corporate members. We complemented this search with data from investigative repositories U.S. Right to Know and OpenSecrets. We applied snowball sampling until saturation was reached and no new organisations appeared. Names were standardised to a canonical label per organisation. Where possible we captured the headquarters of each interest group.

We categorized each identified common interest group inductively, adapting the framework developed by Slater et al. (2024), into four sub-categories:

- 4.1. Petrochemical industry association:** associations that represent petrochemical and plastics industry corporations (eg. International Council of Chemical Associations, American Chemistry Council, European Petrochemical Association, Royal Association of the Dutch Chemical Industry);
- 4.2. Food and beverage (UPF) industry associations:** associations that represent corporations food industry corporations, including those with business interests in UPF systems (eg. American Beverage Association, FoodDrinkEurope, Foodservice Packaging Institute, Australian Food and Grocery Council);
- 4.3. Industry or Business association:** cross-sector associations that bring together corporations from different industries to promote favourable operating environments, global trade and finance, and collaborations on development and sustainability (eg. Confederation of British Industry, European Round Table for Industry, Federation of German Industries, Consumer Goods Forum, World Economic Forum, World Business Council for Sustainable Development, American Chamber of Commerce to the European Union, Business at OECD);
- 4.4. Multi-stakeholder initiatives, sustainability initiatives, non-governmental organisations (NGOs) and donors:** business collaborations or NGO-led programmes focused on sustainability, circularity and plastics governance, including platforms that set targets, coordinate actions or advocate shared positions (eg. Ellen MacArthur Foundation; The Recycling Partnership; EUROPEN, European Organization for Packaging and the Environment; Packaging and Recycling Alliance for Indonesia Sustainable Environment; World Benchmarking Alliance; Science Based Targets initiative; United Nations Global Compact; Business for Nature; Business Coalition for a Global Plastics Treaty. Our data also include foundations and NGOs that may be affiliated in some way with corporations, such as the American Red Cross, Bill & Melinda Gates Foundation and World Wildlife Fund.

Entities may in reality fall into multiple ‘types’ of common interest group but for the purpose of our analyses we assigned each initiative to the most closely aligned unique category, based on information provided in public websites. Membership was recorded as of 2024, recognising that organisations and member lists change over time.

Data cleaning and harmonisation

All matching across corporations and intermediaries used Moody’s Orbis identifiers where available. Organisation names for interest groups were standardised by lower-casing, removing punctuation and harmonising common aliases. For board members/directors we included only individuals listed as current on 31 October 2024. For shareholders we retained all named direct and ultimate owners as provided by Moody’s Orbis. For subsidiaries we treated Moody’s Orbis child identifiers as unique entities; only pairs with co-ownership of the same legal entity were counted as a subsidiary link.

Data analysis

We analysed these data using network analysis, in which UPF and a petrochemical corporations are considered connected if they share at least one tie of any type, as captured in Moody’s Orbis or official membership lists of interest groups. For example, if Nestlé and BASF both list BlackRock as a shareholder, they are linked through a shareholder tie; if both appear on the member roster of FoodDrinkEurope, they are connected through an interest group tie. The weight of corporation connections reflects the number of distinct ties of any kind underpinning that relationship. These ties are visualized in network graphs and described narratively.

We conducted a sub-analysis of networks between the petrochemical industry and five leading UPF corporations (Coca-Cola, PepsiCo, Nestlé, Danone and Unilever), identified by Cowger et al., (2024)²² as the world's top plastic producers and polluters based on brand audits of environmental plastic pollution from 2018–2022.

Visual features of the network maps were used to convey additional structural information. Industry node size is proportional to each corporation's degree (number of ties), highlighting those that occupy more central or influential positions. Edge thickness reflects tie weight (such as the number of shared shareholders, subsidiaries, or board members), thereby indicating where inter-industry linkages are stronger or more redundant.

Because the three tie types operate on very different numerical scales, we normalised edge weights in Figure 3 using a log transformation. Corporations may share thousands of shareholders but typically only a small number of directors or subsidiaries. Without adjustment, shareholder ties would overwhelm the visualisation and obscure governance or subsidiary connections. We therefore rescaled shareholder edges as $\log(\# \text{ shareholders}) + 1$. This compresses extreme values while maintaining relative differences, ensuring that all tie types fall within a comparable range and can be meaningfully interpreted alongside each other.

To further focus the visualisation, shareholder ties in Figure 3 were restricted to the ten petrochemical corporations with the greatest shareholder overlap with each of the top-five UPF plastic polluters. Without this threshold, the map would expand to include many peripheral petrochemical firms connected only by minimal overlap, thereby obscuring the core structure of the network. By filtering out corporations sharing only a small number of investors, we highlight the most substantively relevant relationships, acknowledging that sharing a single shareholder carries far less significance than sharing several hundred or several thousand.

In Figure 4, we connect two categories of nodes: corporations and interest groups. Corporate nodes are sized by their number of affiliations. Interest-group nodes, however, are scaled using a balance weight that captures how evenly each group draws members from both the UPF and petrochemical industries. For every group, we calculated the proportion of UPF members (p_{UPF}) and the proportion of petrochemical members ($p_{Petrochem}$), and defined the balance weight as

$$1 - |p_{UPF} - p_{Petrochem}|$$

This weight ranges from 0 (membership drawn entirely from one sector) to 1 (equal representation of both). In practice, because the network visualisation includes only groups with members from both industries, the balance weight never reaches zero. Groups with a more even split between UPF and petrochemical corporations therefore appear larger, reflecting their role as cross-industry convenors, whereas those whose memberships are more heavily concentrated in one sector appear smaller. Nodes are coloured by entity type, distinguishing UPF corporations, petrochemical corporations, business and industry associations, multi-stakeholder initiatives, sustainability initiatives, NGOs, and donors.

Software

Analyses were conducted in R 4.3.1. Data wrangling used dplyr and tidyr; network measures and maps used igraph and ggraph. Full code and data outputs are provided in the Supplementary Data.

DATA AVAILABILITY

Data and metadata used to produce the primary analyses can be accessed from the following link:
https://drive.google.com/file/d/18ZOwpqi9Q9rZBF6T9lwS8fHJ_1-sR7Tw/view?usp=drive_link
(also uploaded)

CODE AVAILABILITY

Original code used to produce the primary analyses can be accessed from the following link:
https://drive.google.com/file/d/18ZOwpqi9Q9rZBF6T9lwS8fHJ_1-sR7Tw/view?usp=drive_link
(also uploaded)

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ETHICS DECLARATIONS

The authors declare no competing interests.

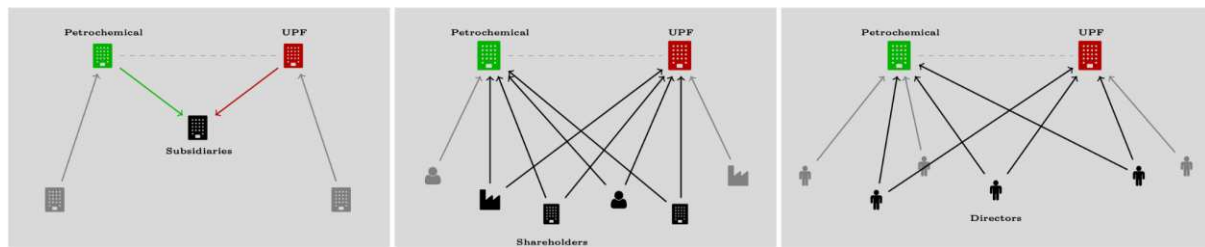
ADDITIONAL INFORMATION

N/A

SUPPLEMENTARY INFORMATION

Group Type	Count	Proportion
Multi-stakeholder institutions, sustainability initiatives, NGOs and donors	43	0.52
Industry or Business association	27	0.33
Petrochemical industry association	10	0.12
UPF industry association	3	0.36
Total	83	1.00

Supplementary Table 1: Frequency and Proportion of Interest Group types.



Supplementary Figure 1: Schematic illustration of how direct ties between ultra-processed food (UPF) and petrochemical corporations were inferred. The diagram shows how links to third-party entities—such as shared shareholders, board directors, or subsidiaries—create structural dependencies between corporations in different sectors. Corporations are treated as directly connected when they are tied to the same intermediary, allowing us to construct inter-corporate networks from underlying relational data.

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