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Unpacking the complexity of the UK plastic packaging value chain: A stakeholder perspective

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ABSTRACT

The pace to achieving a sustainable plastics economy remains noticeably slow. This could be due to a lack of understanding of the role and importance of stakeholder dynamics in the plastic packaging system. Therefore, this study aims to unpack and assess the role of stakeholders in improving the plastics recycling rate and circularity in the UK, using polyethylene terephthalate (PET) drinks bottles value chain as a case study. Via the theoretical lens of stakeholder theory the study identifies and groups the stakeholders in the PET drinks bottles value chain, and tries to make sense of, and analyse, their complex interactions via the use of the Complex Value Optimisation for Resource Recovery (CVORR) systems thinking approach. This integrated approach reveals, that even though external stakeholders (e.g. NGOs, trade associations) engage with internal stakeholders (e.g. suppliers, consumers, investors), and vice versa, at different levels and scales in promoting the circularity in the PET drink bottles value chain, there is a strong drive in incentivising the production and consumption processes. This is driven by the significant lobbying power of internal stakeholders operating upstream of the PET bottles value chain (i.e. producers and brand owners), that is supported by financial institutions, and which, strongly influences national and local government policies and decision-making processes. Meanwhile, the waste management processes are short-sighted, being unable to gain improved momentum and increase the PET bottles recycling rates. This dynamic conceals, and somewhat retains, the prevailing resistance in removing the infrastructural, regulatory and technological lock-ins. A collaboration between internal and external stakeholders is paramount to sustainably managing PET drinks bottles in the UK and achieving a transition to a sustainable circular plastics economy. Creating a level playing field and fostering a closer collaboration between all stakeholders involved in the system can aid the development of new value networks, and support new policy interventions that can improve circularity in the plastic packaging sector.

1. Introduction

The increasing production and consumption of plastics used in the food packaging sector, and the subsequent plastic packaging waste generation and mismanagement, have raised global concerns and highlighted the need to reduce, remediate and prevent plastic waste and pollution (Iacovidou et al., 2020). In response, there has been a series of plastic industry efforts and government interventions to boost plastics circularity, and decrease their impact on

Abbreviations: BPF, British Plastics Federation; CEP, Circular Economy Package; C-M, Consumption to management; CVORR, Complex Value Optimisation for Resource Recovery; DRS, Deposit Return Scheme; EC, European Commission; EFSA, European Food Safety Agency; EoL, End-of-life; EPR, Extended producer responsibility; ESG, Environmental, Social and Governance; EU, European Union; FCM, Food Contact Materials; IAP2, International Association for Public Participation; LAs, Local authorities; MBT, Mechanical biological treatment; NGOs, Non-governmental organisations; P-C, Production to consumptiom; P-C-M, Production-consumption-management (entire value chain); PERN, Packaging Waste Export Recovery Note; PET, Polyethylene terephthalate; PRN, Packaging Waste Recovery Note; PRO, Producer responsibility organisation; rPET, Recycled PET; SSPP, Smart Sustainable Plastic Packaging; ST, Stakeholder theory.

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the environment (Iacovidou et al., 2020; Evans et al., 2020). The European Union (EU), following the first Circular Economy Directive (EC, 2015), has set ambitious goals to boost plastics circularity. In the UK, there is now a set of strategic plans, frameworks and actions published by the UK government that aim to tackle and address plastic waste and pollution, such as the 25 Year Environment Plan (HM Government, 2018a), the Resources and Waste Strategy (HM Government, 2018b), and the UK Plastics Pact (WRAP, 2018). Yet, the pace of change remains alarmingly slow, and solutions promoted or implemented regionally and globally are highly fragmented and mostly insufficient, whilst they may create lockins (Crippa et al., 2019). A holistic understanding of the dynamics involved in the plastic packaging system is needed to seize the multi-dimensional benefits of transitioning to a sustainable circular plastics economy. At present, there is little research that has directly addressed this objective (Iacovidou et al., 2020).

Studies have concentrated on assessing the function and end-of-life (EoL) fate of plastic food packaging (Geyer et al., 2017; Luijsterburg and Goossens, 2014; Hahladakis and Iacovidou, 2018; Narancic et al., 2018), and focused explicitly on the life cycle environmental and human health impacts of plastics production, use and management (Groh et al., 2019; Williams and Wikström, 2011; Velis and Cook, 2021; Karbalaei et al., 2018), rarely expanding on economic and social impacts (Hahladakis and Iacovidou, 2019; Iacovidou et al., 2020; Su et al., 2020). A small number of studies focused on the social dimensions and role of media in reducing plastic waste and pollution (Rhein and Schmid, 2020, Compagno, 2020), or on the chemical additives used in fine-tuning the properties of plastic packaging and their impacts on the terrestrial and marine environment (Bradney et al., 2019; Hermabessiere et al., 2017; Hahladakis et al., 2018b). Most recently, studies have also documented the generation and impact of micro- and nanoplastics for the global environment and society (Karbalaei et al., 2018; Chang et al., 2020; Hu et al., 2019). Other studies have delved into exploring the introduction of alternative materials, so-called bioplastics, and their lifecycle impacts (Gerassimidou et al., 2021; Bishop et al., 2021; Escobar and Britz, 2021). Whilst the findings of the above research are unquestionably important, the chain of processes (i.e., value chain activities and performance) and structures (i.e., formal / informal networks of actors) created and shaped by the relations between stakeholders in a system from production and distribution, to EoL management – need to be closely examined. This would shed light on ways to effectively orchestrate the flows of *complex value* across the plastic packaging system. C*omplex value*, refers to the *measurable benefits (positive value) and impacts (negative value) in the environmental, economic, social and technical domains as influenced by the political dimensions (*e.g.*, political discourse, policy instruments, policymaking)* (Iacovidou et al., 2017).

Therefore, understanding the types and roles of stakeholders involved in the plastic food packaging system is a prerequisite to unpacking systemic, complex value (Iacovidou et al., 2020). S*takeholders* here refer to any group or individual involved in the value chain, who has an interest, and can affect or is affected by the plastic food packaging value chain, after Freeman (2010; see also first ed. 1984) and Friedman and Miles (2006). From that perspective, the conceptual analysis of the power relationships between stakeholders involved in the plastic food packaging system, and evaluation of the multifaceted processes evolved via their relations at regional level, play an important role in understanding and addressing the plastic waste and pollution problem (Fazey et al., 2014; Weichselgartner and Kasperson, 2010). *Power relationship* refers to the exchanges / interactions between two or more stakeholders, indicating the extent to which one stakeholder is able to arouse in other stakeholders the need to engage in activities that would not be taken otherwise (Tang and Tang, 2012). *Dynamics* refer to the changing attributes, roles, perceptions and intentions of stakeholders involved in the system (de Blois and De Coninck, 2008) leading to cause and effect relationships that evolve and change over time (Iacovidou et al., 2020). Dynamics and power relationships are intertwined, and are hereafter called *power dynamics*.

In the plastic food packaging system, spatial and temporal granularity per polymer type is necessary for unravelling the power dynamics involved in the complex plastic packaging value chain (Iacovidou et al., 2020). This is because production, use/consumption and management of plastic packaging is determined by the properties and application of each polymer type, in addition to: stakeholder heterogeneity (Mercure et al., 2016); interconnectivity (i.e. a large and an increasing number of relationships between stakeholders (Grösser, 2017)); high-level nonlinearity (i.e. unpredictable effects from different stakeholder networks (Thomas et al., 2016)); and spatial-temporal variations (i.e. correlation between commodity, business and geographical-temporal conditions arising from overlapping governance structures, administrative boundaries and changes over time (Zhang and Chang, 2021), that mobilise and affect plastic packaging flow in the value chain (New_InnoNet, 2016)).

Polyethylene terephthalate (PET) is the most commonly used plastic packaging for the containment of beverages, e.g. carbonated drinks, still drinks, fruit juices and bottled water, and accounts for 70% in the total soft drink production (BPF, 2021b). The widespread prevalence of PET bottles in the beverage sector arises from a range of favourable properties such as flexible, hygienic, strong, lightweight, shatterproof, and freshness retention (BPF, 2021b). PET drinks bottles is one of the cleanest plastic waste streams, making PET drinks bottles one of the most widely collected plastic packaging material for recycling globally. Even though the levels of collection and recycling of PET drink bottles can vary widely from one region to another, there is a general preference for diverting PET bottles from landfill, incineration with energy recovery, and mechanical biological treatment (MBT) processes to recycling. In the UK specifically, in 2017, the recycling rate of PET drink bottles was estimated around 67% (Valpak, 2017), while the recycling rate of total plastic packaging did not exceed 47% (DEFRA, 2020).

Using the PET drinks bottles value chain in the UK, this study aims to explore the impact of power dynamics between stakeholders on achieving a sustainable plastics economy. Specifically, the study identifies the main stakeholders involved in the PET drinks bottles value chain, examines their respective roles, and assesses how the power dynamics between them affect on the ability of PET bottles to circulate back in the system. Herewith, the study seeks to address an important research gap that has remained largely underexplored. Whilst, PET drink bottles are amongst the top ten littering items in the UK (UKMMAS, 2015), and a portion of it may still end up in the residual waste bin, and subsequently, in landfills, incineration, or MBT facilities, these points of 'complex value loss' are considered to be outside the scope of the present study. Here, our focus is on the management of PET bottles via recycling (as in mechanical reprocessing). The analysis consists of the following tasks: i) provide a preliminary conceptualisation of all stakeholders in the UK PET drinks bottle value chain (Section 4.1); ii) group stakeholders according to their role and map them across the PET bottles recycling value chain (Section 4.2) and iii) examine how the power dynamics between stakeholders are driving and shaping activities within the UK PET bottles value chain (Section 4.3). Two theoretical frameworks are combined to unpack the complexity of the PET drinks bottles value chain, described in Section 2: i) stakeholder theory, a stand-alone framework that is widely used in social sciences for the identification of stakeholders (Freeman, 2010); and ii) the Complex Value Optimisation for Resource Recovery (CVORR), a newly developed stand-alone approach that com-

bines multi-disciplinary theories and tools to holistically assess a system (Iacovidou et al., 2020). We posit that this novel, integrated approach can unveil the dynamics and other multifarious aspects that enable and/or hamper the recycling of PET drinks bottles, and in turn, generate insights for future research and guide circularity interventions. This work supports a better understanding of how the various policy interventions, current and planned, need to be coordinated to deliver the desired outcomes.

2. Literature review

2.1. Regulatory framework of PET bottles management in the UK

This section presents the current legislative framework on the management of plastic packaging waste and PET bottles specifically. It underpins the critical role of authorities in achieving the targets and objectives set. The European Strategy for plastics in a Circular Economy (EC, 2018a) entails that, by 2030, all plastic items shall be reusable and recyclable, and that recovery, sorting and recycling technologies shall be developed and introduced, including food-grade recycled plastic packaging. The Directive 852/2018 on packaging and packaging waste, mandates that 50% of plastic packaging waste shall be recycled by 2025, and 55% of plastic packaging shall be recycled by 2030 (Directive 2018/852). According to Directive 904/2019, from 2025 PET bottles placed on the market shall contain at least 25% of recycled plastic, and, from 2030 PET bottles shall contain at least 30% of recycled plastic (Directive 2019/904). Considering the increase in plastic production and consumption, and the challenges confronted in reaching the above targets, the EU released in 2020 the New Circular Economy Action Plan (EC, 2020a). This plan introduces further targeted measures for packaging waste including the restriction of intentionally added microplastics and the development of labelling and certification measures. For this purpose, the EC report "A Circular Economy for Plastics" highlights the current existing limits for plastic waste recovery and recycling, including the pending approval of plastic recycling processes from the European Food Safety Agency (EFSA) (Crippa et al., 2019).

Concurrently, the EU has begun to harmonise, design and complete regulations related to food contact materials (FCM). Food contact material Regulation 1935/2004 (EC 1935/2004) and Regulation 2023/2006 (EC 2023/2006), which was amended by regulation 282/2008 (EC 282/2008), consider aspects of safety. They look at the traceability of recycled plastic content used in FCM and consider the implications of recycled content use on human health, the environment, and products' market. The above-mentioned requirements are consolidated in Regulation 10/2011 (EC 10/2011), which defines specific requirements for plastic FCM. These regulations merge in a new European strategy – the Farm to Fork strategy (EC, 2020b) – that aims, amongst other aspects, to scrutinise FCM legislation to enable and improve the use of sustainable packaging material, including recycled and reusable packaging.

The impact of using recycled content in new plastic FCM have been emphatically discussed in many studies (Matthews et al., 2020; Hahladakis and Iacovidou, 2019; Paletta et al., 2019), with authors arguing that the levels of additives present has to be thoroughly explored to mitigate potential consequences on human health and food quality. Regarding this concern, a communication from the European Commission (EC) [COM/2018/032] highlighted that chemical substances should be forbidden when risks are evaluated indicating that products legally produced may contain substances that later may be forbidden, and therefore, the generated waste may contain forbidden substances (EC, 2018b). These 'legacy substances' constitute a barrier to transitioning in circular economy indicating the need to develop decision making process that support recycling of these wastes considering the financial benefits of recycling against disposal (EC, 2018b).

The UK is now outside the EU and is currently developing new environmental protection strategies and/or upgrading existing transposed EU regulations on waste. Nonetheless, new FCM regulations and national standards will need to comply with the regulatory requirements of food products traded with the EU (HM Government, 2018b). EU regulations that will be maintained, are: the compliance of recycling facilities with EU regulation 2023/2006 and controls of recycling plants in compliance with the EU regulation 882/2004 (No. 704, 2019). Specifically, the UK government announced that '*the EU (Withdrawal) Act 2018 will ensure existing EU environmental law continues to have effect in UK law after we leave the EU, providing businesses and stakeholders with maximum certainty. This includes any commitments from the Circular Economy Package (CEP) in relation to waste and recycling that are part of UK legislation when we leave (p. 113) (HM Government, 2018b)*'.

Moreover, in 2018, the UK government published its 25 Year Environment Plan ("A green future: our 25 year plan to improve the environment" (HM Government, 2018a) and the Resources and Waste Strategy (HM Government, 2018b) aiming to eliminate avoidable plastic waste by 2050. *Avoidable plastic waste* is defined as waste that could have been reused, recycled or composted. The UK government asserted its intention to deviate from the current market towards reusable and recyclable plastics by strengthening the extended producer responsibility (EPR) for packaging. They are aiding this via imposing a tax on plastic packaging produced with less than 30% of recycled plastics, and introducing a deposit return scheme (DRS) for drink containers (Smith, 2021).

In spite of our regional (UK) focus, stakeholders outside the UK (England) boundaries may also affect the production, distribution, use and management of the PET bottles. These stakeholders will be included in our analysis.

2.2. Theoretical framework of PET bottles management in the UK

Initially, the study makes use of stakeholder theory to identify and group stakeholders into categories according to their interests, priorities and roles (Hörisch et al., 2014). This is then integrated into the CVORR approach that further maps stakeholders according to their position and roles in the value chain. Drawing on the integrated systems thinking framework, the study uncovers the power dynamics between stakeholders that act upstream (i.e. stages occurring at the production-consumption) and downstream (i.e. stages occurring at the consumption (disposal)-management) of the PET drinks bottles value chain, and explores their influence in promoting plastics recycling and circularity in the UK.

2.2.1. Stakeholder theory

The stakeholder theory has been gaining increased attention in sustainability and circular economy research, policy and practice (Chiappetta Jabbour et al., 2020; Ihlen and Berntzen, 2007; Lindgreen and Swaen, 2010; Sarkis et al., 2011), due to the ever-increasing importance in underpinning the vast number and role of stakeholders in complex systems (Freeman et al., 2010; Friedman and Miles, 2006). The theory has evolved within the management field to understand the way businesses operate and their impact on value creation and sustainability, and to inform businesses on ethics, responsibility and accountability in protecting the environment (Freeman et al., 2010). As a concept it originates from the epistemological foundations of systems theory and corporate social responsibility (Ackoff, 1988; Freeman and McVea, 2001), which together can aid an improved understanding of the multi-dimensional impacts of stakeholders' activities, and the design of effective strategies and interventions (Porter, 2008). This signifies

that stakeholder theory is, in fact, perfectly suited to the identification and understanding of the complex array of stakeholders involved in a resource recovery system. *Resource recovery* refers to the processes wherein waste generated at all stages of production and consumption, either in the form of natural resources or man-made materials, components, products, are recovered and maintained in the system. According to the stakeholder theory (Freeman, 2010), many definitions emerged over the past years to describe and group stakeholders in a business environment (e.g. industry and commerce); yet the pragmatic approach put forth by Freeman et al. (2010) makes clear that stakeholders can be grouped based on their purpose into:

i) those whose interest(s) emerge via their direct involvement (day to day activities) in the business (Harrison, 2003) – or "*those groups without whose support, the business would cease to be viable*" (Freeman et al., 2010), and are therefore conceived as parts of a company, commonly referred to as internal stakeholders (Harrison, 2003), or primary stakeholders (Freeman et al., 2010). Internal stakeholders include: shareholders (or owners) who own a company or part of it through shares of stock, have a financial stake in the business and expect some form of financial return from them; suppliers who provide services or produce raw materials and in return receive part of financial return from products and services; customers or product consumers who purchase the product of the company for personal use and receive the benefit from products and services; and employees who are hired by the company to conduct a specific task under terms of employment and put their livelihoods at stake; and
ii) those whose interest(s) emerge via their indirect involvement in the business; hence, they are not part of a company but they affect or are affected by its activities, commonly referred to as external stakeholders (Harrison, 2003), or secondary stakeholders (Freeman et al., 2010). Most common external stakeholders are: financial institutions (Banerjee et al., 2003); government (national and local government departments and agencies, and bodies that have a legally recognised regulatory function (ISO, 2019) that give rights to internal stakeholders (e.g. to build facilities) and in turn benefit from the tax base and socio-economic contribution of a business; non-governmental organisations (NGOs) (charitable, not-for-profit or non-profit organisations with a public interest objective related to social or environmental concerns (ISO, 2019) that keep businesses accountable for their responsibilities and accountabilities towards sustainability; consumers advocates, related to the preservation of consumers rights; unions, organisations that negotiate with businesses and usually represent workers (e.g. trade unions); associations that are membership organizations to promote the interests of their members – businesses or entrepreneurs from a specific industry area (Boleat, 1996); competitors indicating the relationship amongst companies that provide similar goods or services to the same group of consumers; media, communication channels that provide public awareness of the product; and research institutions that provide research services to a specific scientific field.

We distinguish between two types of investors: (a) *financial* investors, who are primarily interested in the financial risk-return aspects of an entity's securities and their portfolio-fit – this group can be subdivided into two subgroups: retail-investors and institutional investors; and (b) *strategic* investors, who are primarily interested in the operational capabilities and goods and services of their investee companies that are relevant for their own production processes. The latter group we refer to as 'shareholders'. Retail-investors are those who buy stocks from traded companies as part of their portfolio and sell to consumers (retailers) or other companies (wholesalers); and institutional-investors, such as banks, savings and loan associations and insurance companies, who invest the money of their clients to buy securities or assets (CFI, 2021). In this study, institutional-investors were included under '*financial institutions*'. Thereby, with 'investors' we refer to retail-investors.

Fig. 1 depicts a typical map of internal and external stakeholders based on their action and influence within the business environment, commonly used in the stakeholder theory to describe the structure of large complex organisations (Freeman, 2010).

The International Association for Public Participation (IAP2) has developed an internationally recognized model that describes the influence of stakeholders on public decision-making, known as IAP2 spectrum (I2S, 2021b). Specifically, the IAP2 spectrum is used to identify the participation of internal and external stakeholders at different levels of engagement in complex issues and challenges (Salvioni and Almici, 2020), depending on their communication strategy, and time span of the relationships that stakeholders establish with one another (Bammer, 2019). Based on their relationships, stakeholders are able to influence the direction of decision-making, and related processes, which differ according to the type of engagement (Salvioni and Almici, 2020; Bammer, 2019).

The IAP2 is a useful approach to exploring the engagement of stakeholders in complex research problems (Bammer, 2019). Stakeholder engagement is defined as "*the process used by an organisation to engage relevant stakeholders for a clear purpose to achieve agreed outcomes (p.34)*" (AccountAbility, 2015). The IAP2 has previously been used to assess stakeholder engagement in transitioning to circular economy at a company level (Salvioni and Almici, 2020). Here, we adopted this spectrum to explore stakeholder engagement in a resource recovery system (i.e. PET drinks bottles) (I2S, 2021b; Bammer, 2019). In Table 1, we illustrate the way IAP2 spectrum is used to indicate the processes with which, internal stakeholders engage external stakeholders, and vice versa, in transitioning towards sustainable resource recovery systems. Table 1 is thereafter used in explaining interactions between stakeholders (Section 4.3).

2.2.2. Complex value optimisation for resource recovery (CVORR) approach

CVORR is *"a novel systems thinking approach that helps in understanding and reforming natural resources and waste management systems (p.13)"* (Iacovidou et al., 2020). It seeks to understand and assess system dynamics, drivers and barriers of sustainable complex value creation across any resource recovery system (Iacovidou et al., 2020). It has been proven a reliable tool in assessing the circularity of the plastic packaging system, and in generating insights on stakeholders interrelationships and their multi-dimensional impacts on resource recovery systems (Iacovidou et al., 2020).

The CVORR tool aids a systemic analysis by scrutinising the mass and monetary exchanges and other 'transaction' dynamics (e.g. permits, certificates of compliance with regulations or quality standards etc.) between all stakeholders involved directly and indirectly in the resource recovery system. Within the CVORR tool, a step-wise framework is used to collect and synthesise relevant information within five interacting spheres, called the *five levels of information*. This framework allows the conceptualisation of complex value (Iacovidou et al., 2020), and further encapsulates the role(s) of relevant stakeholders operating therein. These interacting spheres are as follows:

- *1st level: Natural environment and provisioning services – refers to the natural flows and provisioning services ability to maintain and enhance living systems;*
- *2nd level: Technologies, infrastructure and innovation level – refers to infrastructure and innovation level of transforming waste into secondary resource;*

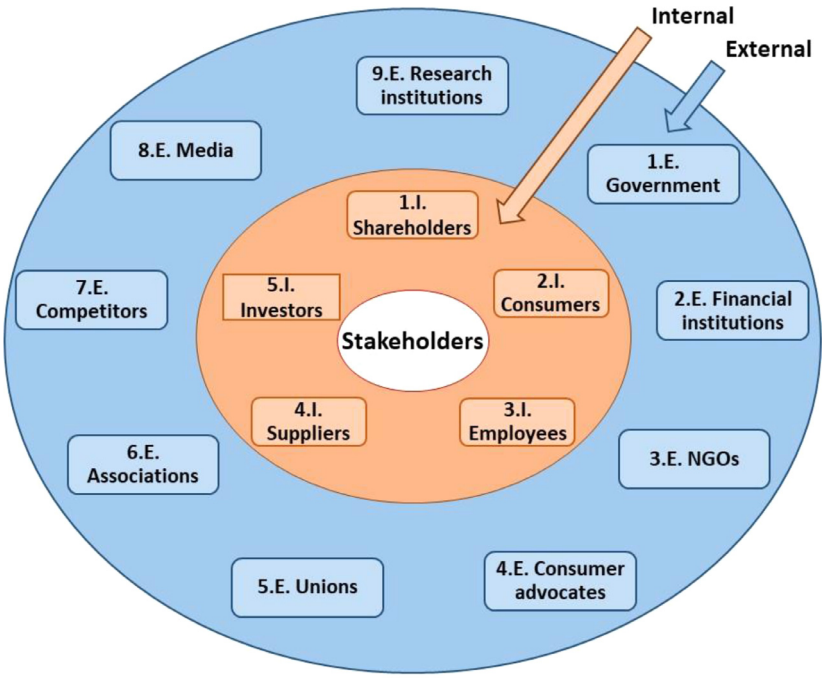

Fig. 1. Stakeholder mapping according to internal and external categories based on stakeholder theory adapted from Freeman (2010). In the following text, we refer to stakeholder categories using the codes in front of categories.

Table 1
Types of external stakeholders' engagement adjusted to the context of a whole value chain, based on IAP2 spectrum. The stakeholder influence in the system increases as the engagement moves down from 'Inform' to 'Empower'. Adapted from (I2S, 2021b; Dinges et al., 2017; Asari, 2019).

Type of engagement	Level of communication	Means of communication	Role in the system
Inform	One-way: no invitation to respond	Bulletins, letters, brochures, reports, websites, speeches, conferences and public presentations	Provide the system with balanced and objective information helping internal stakeholders to understand the problem, alternatives, opportunities and/or solutions
Consult	Limited two-way: ask questions and another stakeholder answers	Surveys, focus groups, meetings with selected stakeholders, public meetings, and workshops	Obtain feedback from internal stakeholders and advise on how their input can influence the system improvement
Involve	Two-way or multi-way engagement: learning takes place on both sides	Multi-stakeholder forums, advisory panels, consensus-building processes, focus groups, and online engagement tools	Work directly with internal stakeholders throughout the process of improving the system to ensure that stakeholders issues and concerns are understood and considered
Collaborate	Two-way or multi-way engagement: joint learning and decision-making on both sides	Joint projects, joint ventures, partnerships, multi-stakeholder initiatives, and online collaborative platforms	Partner with internal stakeholders for the development of mutually agreed alternatives and joint plans of actions for the identification of the preferred solution
Empower	Two-way or multi-way engagement: actively contribute to the achievement of outcomes	Integration of stakeholders into governance, strategy and operations of the system	Delegate final decision-making to internal stakeholders on a particular issue in the system

- *3rd level: Regulatory framework and political landscape – refers to government priorities, law enforcement, policy and decision-making procedures;*
- *4th level: Business practices, and the market – refers to the activities performed by businesses and influenced by market forces;*
- *5th level: User practices – refers to patterns of behaviour related to meeting human needs and values.*

The way different stakeholders interact with one another can determine the complexity of the system, and can reveal how their power dynamics influence the sustainability culture, political processes, competition, shared responsibilities, and integration of circular business models in the PET drinks bottles value chain, amongst others. Understanding how the power dynamics between stakeholders affect the (enabling) conditions at each of the five interacting spheres (levels of information), can highlight opportunities and barriers in creating complex value, and develop mechanisms aimed at leveraging stakeholder engagement towards sustainable resource recovery.

3. Methodology

Drawing on stakeholder theory we classify (internal vs external) and group (according to their roles) stakeholders involved in the PET drinks bottles system in the UK, and map them along the value chain, differentiating between upstream (design, production and consumption) and downstream (disposal, collection, sorting and mechanical reprocessing) processes. We then examined the power

relationships between stakeholder groups by employing the CVORR approach and synthesising evidence on their roles and interactions on promoting sustainability in the plastics packaging system. This integrated approach is supported by a narrative literature review on the role of stakeholders in increasing the sustainability of the UK plastic packaging value chain.

The search strategy was designed and implemented in two stages as follows: 1) selection and use of keywords in scientific databases, such as Scopus, Web of Science and Google Scholar, to source information related to PET materials, components and products (e.g. "PET", "plastics", "PET bottles", "packaging", "beverage bottles", and "water bottles"), lifecycle processes (e.g. "production", "recycling", "processing", "mechanical pre-processing", and "consumption"), type of stakeholders (e.g. "Petrochemicals industry", "plastic producers", "trade association", "NGOs", "regulators", "customers", "government", "authorities" and "organisation"); and 2) information collation and mapping of external stakeholders based on their communication across the PET bottles recycling value chain in the UK, i.e. partnerships, collaborations, and funding relationships. Via this stage, we were able to identify and cross-checked the existence of stakeholders that were not identified with the use of keywords. Personal communication with representatives from the most prevalent stakeholder groups in the value chain of PET bottles in the UK (i.e. waste management industry and DEFRA) provided guidance on compiling the list with the most important external stakeholders involved in the system.

While internal stakeholders have specific incentives across the PET drinks bottles system (i.e., profit motive for suppliers, shareholders, employees and investors, and convenience for consumers (Iacovidou et al., 2020)), the incentives of external stakeholders are multi-dimensional and depend on the *type of engagement* (Table 1), the *level of information* (Section 2.2.2) and the *stage of the value chain where they are most active*. Based on this hypothesis, we identified and mapped all external stakeholders across the UK PET drinks bottles production-consumption-management (P-C-M) system, considering their purpose of establishment, the regional spectrum of their activity (e.g. UK-based, European and international level), and membership, using information obtained from their websites.

The list of external stakeholders that are highly involved in the UK's PET drinks bottles P-C-M system, focusing on recycling, was formed by grouping them according to the criteria below:

i contribution to which /each stage of the PET drinks bottles lifecycle (e.g. from production to consumption (P-C), from consumption to management (C-M), and entire value chain (P-C-M));
ii type of engagement (Salvioni and Almici, 2020; Bammer, 2019) that was specified according to IAP2 spectrum and their activities (Section 2.2.1); and
iii the sphere in which they operate and sustainability pathway, using the CVORR '*five levels of information*' framework (Section 2.2.2).

It must be noted, that unions (5.E) that are mostly related to framework agreements; competitors (7.E) that refer to shareholders of plastic material, component, and product value chains other than of PET drink bottles; and media (8.E) that due to their pervasive nature may be used by other external stakeholders as a means to advance their agendas (Banerjee et al., 2003), are not included in our mapping. With this methodological approach we captured the complex interactions and relationships of stakeholders involved in the PET drinks bottles system in the UK. We were able to generate insights into the way these (inter relationships) affect the system's performance, and to highlight important communication and strategy gaps, which are presented, described and discussed in Section 4.

We need to clarify that this work constitutes a conceptual analysis of the role of stakeholders in the complex system of PET drinks bottles in the UK and therefore the grouping of external stakeholders following the above-mentioned criteria was based on a stand-alone investigation of social networks of stakeholders (preliminary assessment). Future research could verify these findings by collecting more evidence from primary sources through stakeholder interviews, following a stakeholder analysis, which can yield insights into the motivation and interests of stakeholders in achieving resource efficiency in the PET drinks bottles value chain in the UK.

4. Results and discussion

4.1. Mapping internal stakeholders across the PET bottles value chain

Internal stakeholders (Fig. 1) involved in the PET drinks bottles value chain can be grouped into different categories as they move from upstream to downstream parts of the system, due to their transposable roles. According to Freeman et al. (2010), accounting for the changing roles of stakeholders as we move from upstream to the downstream part of the system is the right approach to understanding the dynamics in the system (Freeman et al., 2010). For example, upstream of the PET drinks bottles value chain (i.e. supply chain), PET pellets/ preforms/ bottles producers could be the suppliers to drinks manufacturers, whilst drinks manufacturers could be the producers to brand owners when the analysis is on their in-between relationship; yet all of them can be grouped as shareholders when looking at the entire upstream system. Meanwhile, recyclers are considered as suppliers of recycled PET (rPET) to PET drinks bottles manufacturers upstream of the system either in pellets or preforms (through preform producers), while downstream, recyclers become the main shareholders (producers of rPET preforms or pellets).

In Fig. 2, we map out the main internal stakeholders involved in the upstream and downstream parts of the PET bottles value chain that constituted the basis for the investigation of power dynamics of all stakeholders involved in the system. It is worth noting, that the categorisation of external stakeholders remains constant across the PET bottles system, and their participation is defined by the stage in which they mostly operate (e.g. production, consumption, management).

This mapping exercise uncovered several hurdles with the allocation of internal stakeholders to different types relating to their: changing roles from upstream to the downstream parts of the value chain (as opposed to external stakeholders); material / product ownership (i.e., PET raw and secondary material / PET bottles); and complex value creation. To address these challenges, we adopted a two-tier classification system for stakeholders when discussing their power dynamics:

- Tier one (T1) – refers to the role of stakeholders upstream of the PET bottles value chain;
- Tier two (T2) – refers to the role of stakeholders downstream of the PET bottles value chain.

Table 2 provides a classification system for T1 and T2 stakeholders.

It must be emphasised, that while multinational corporations (e.g. Coca-Cola) are included in T1 *Shareholders*, these are business organisations whose activities are located in more than two countries and employ both internal and external stakeholders to serve their interests. For simplicity, these are analysed as Shareholders and we refrained from analysing them as external stakeholders.

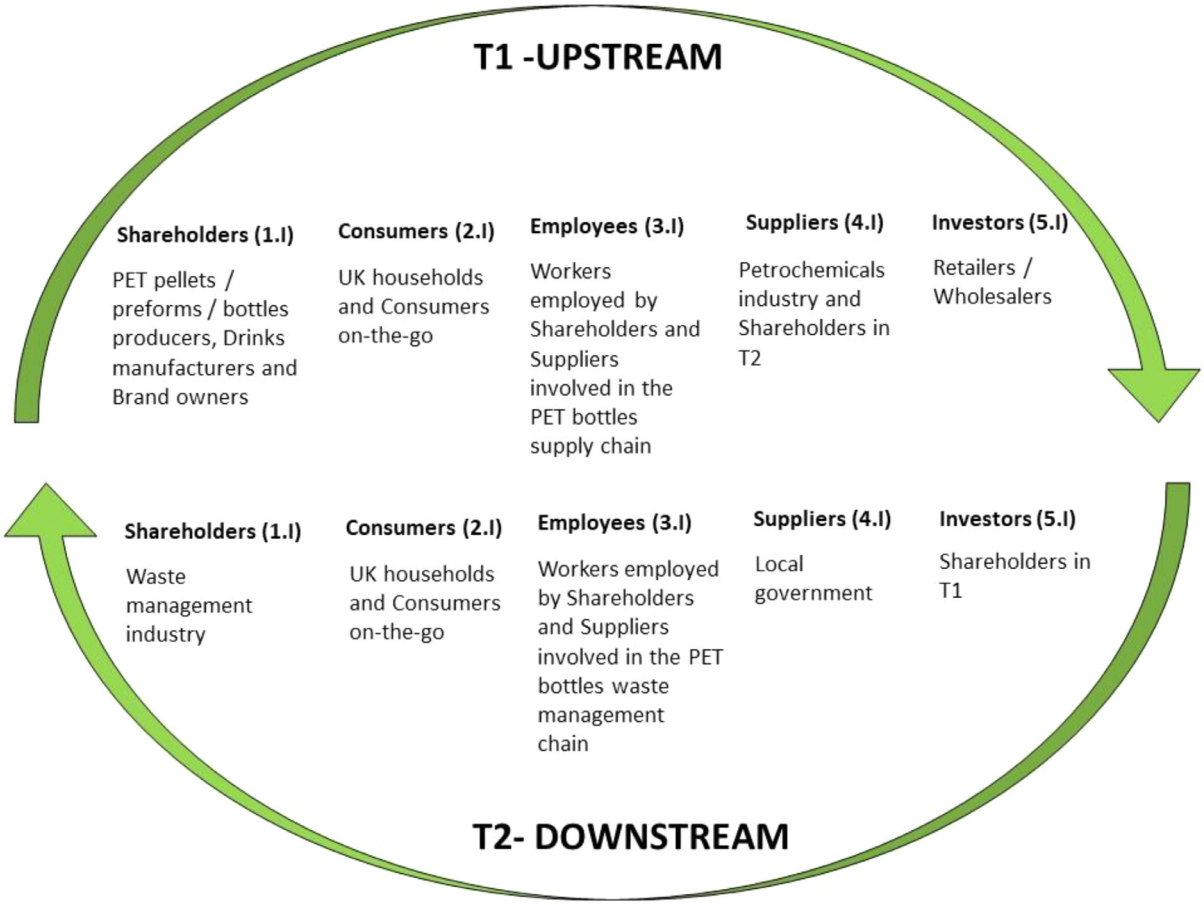

Fig. 2. Main internal stakeholders upstream and downstream across the system of PET bottles, after the stakeholder theory (Freeman, 2010).

4.2. Power dynamics of stakeholders involved in the PET bottles lifecycle in the UK

Efficient and effective communication and collaboration between all stakeholders needs to take precedence to ensure a sustainable complex value creation in the PET drinks bottles value chain. Like Porter (1997) suggests, an effective collaboration that aligns the interests of all stakeholders involved in the value chain can establish a "system of cooperation" where value is created and sustainability is promoted (Porter, 1997). Freeman et al. (2010) suggest that we should not see the interests of each stakeholder in silo, but realise that these are inherently "tied together" and only when viewed as such they can promote value creation in the system (Freeman et al., 2010).

In the UK plastic packaging value chain, we are far from achieving a "system of cooperation"; as stakeholder interests are not viewed as joint ventures. Employing the CVORR tool, Iacovidou et al. (2020) highlighted that to date stakeholders appear to act in silos, and there is a fragmented communication amongst them. Barrowclough and Deere Birkbeck (2020) argued that in a well-functioning system, stakeholders should collectively identify processes and mechanisms at regional, national and global level to collaboratively harness opportunities to reduce plastic pollution, and to properly assess the decision-making outcomes. This is in line with Umuhoza et al. (2019) who suggested that real progress can be driven by the wide variety of intergovernmental and industry efforts, strategic partnerships, the environmental advocates involved in the PET bottles lifecycle (Umuhoza et al., 2019).

In Fig. 3 we present the interrelationships between the prevalent stakeholders' operating in the UK PET bottles value chain. The PET bottles value chain is largely dominated by multinational corporations, which control significant financial and physical assets and provide thousands of jobs. This gives shareholders (1.I) significant lobbying power and leverage in negotiations with the government (1.E); hence, they can influence the system at large (Gomes, 2005). *Lobbying* is defined as the process by which certain groups (e.g. shareholders) influence political decision-making processes by communicating ideas and information relevant to a certain issue to policy-makers (Ihlen and Berntzen, 2007, Jaatinen 1999).

The extent to which shareholders upstream and downstream of the PET value chain (1.I) recognize and integrate environmental issues within their business activities is determined by forces, such as the public's concerns (hence, consumer bargaining power and demands, and changing behaviour/ attitude) (Porter, 1997), regulatory forces (driven by changes in the political and regulatory landscape), competitive edge in the market (controlled via supply-demand dynamics, and substitutability) and top management commitments towards sustainability goals (managers that wield political force and mediate support to shareholders for a certain target) (Lopes de Sousa Jabbour et al., 2020; Banerjee et al., 2003).

4.2.1. T1 Stakeholder dynamics

In T1 (Fig. 3), the dominant stakeholders are the petrochemicals industry (T1–4.I) and producers and brand owners (T1–1.I) who are primarily driven by profit. Therefore, their decisions over the design, production and material use in the PET preforms (incl. pellets) and/or bottles production are primarily influenced by factors that minimise operational costs and maximise sales (Freeman, 2010). For example, producers (T1–1.I) are likely to choose materials based on criteria for profit maximisation driven by increased

Table 2
Navigation system to the position, role and type of stakeholders involved in the PET drinks bottles value chain in the UK, and description of stakeholders' category adapted in this study.

Classification	Group	Category as in ST*	Role of stakeholders in the context of the study	Type adapted in this study
T1	Internal	Shareholders (1.I)	Producers, i.e., PET pellets, preforms, and / or bottles producers and drink manufacturers, and Brand owners.	Producers and Brand owners (1.I)
		Consumers (2.I)	UK households and consumers on-the-go.	Same as in ST
		Employees (3.I)	Workers employed by *Shareholders* and *Suppliers* involved in the PET bottles supply chain.	Same as in ST
		Suppliers (4.I)	Companies that produce and distribute raw materials to *Shareholders* (includes, oil producers, petrochemical companies / PET resin producers, and additives manufacturers and reprocessors)	Petrochemicals industry (4.I) and reprocessors (which for clarity will be referred to as *T2–1.I*)
		Investors (5.I)	Retailers and wholesalers of PET drinks bottles products and promotion to influence their purchase	Retailers / Wholesalers (5.I)
T1 and T2	External	Government (1.E)	National government operators and supranational bodies that regulate the supply of PET drinks bottles and PET bottle waste management	National government (1.E); Supranational bodies (1.E)
		Financial institutions (2.E)	Support financially the activities of *Shareholders* (T1, T2) and *Suppliers* (T1)	Same as in ST
		NGOs (3.E)	Activist organisations that raise public awareness and pressure government in relation to the disposal and proper EoL management of PET bottles	Same as in ST
		Consumer advocates (4.E)	Organisations that aim to protect human health from risks related to the use of PET bottles (migration of additives and health impacts related to FCM)	Advocacy groups (4.E)
		Unions (5.E)	Organisations that protect the rights of *Employees* (T1, T2) in the PET bottles value chain (e.g. trade unions)	Not included
		Associations (6.E)	Membership organisations build by PET shareholders to disseminate and preserve the interests of their members (e.g. technological improvements, actions to reach legislative targets, product promotion, and increase the transition in circular models).	Trade associations (6.E)
		Competitors (7.E)	Other companies that produce products with similar purpose use (e.g. HDPE bottles).	Not included
		Media (8.E)	Communication channels for public awareness related to the transition of PET bottles system in circular economy (e.g. marine plastic pollution and green products advertisements).	Not included
		Research institutions (9.E)	Research organisations (universities and funding agencies) that address challenges and drive innovations related to integration of circular models in PET value chain.	Same as in ST
T2	Internal	Shareholders (1.I)	Mechanical reprocessors of PET bottles plastic waste and producers of rPET pellets and preforms (may also involve the collection and sorting activities)	Waste management industry (1.I)
		Consumers (2.I)	UK households and consumers on-the-go.	Same as in ST
		Employees (3.I)	Workers employed by *Shareholders* and *Suppliers* involved in the PET bottles waste management chain.	Same as in ST
		Suppliers (4.I)	Local government that is responsible for the collection and management of post-consumer PET bottles (could be insourced or outsourced)	Local government (4.I)
		Investors (5.I)	Shareholders in *T1*	T1–1.I

*Stakeholder theory.

market share and decreased operating costs, while brand owners (T1–1.I) are likely to design their drinks bottle based brand image, enhanced reputation, and marketability drivers. Both producers and brand owners (T1–1.I) are influenced by factors related to supply-chain optimisation processes, such as size, and logistics (way of transport and storage). Petrochemicals industry (T1–4.1.) meddles with the supply-demand dynamics as they are coerced to promote their interests and prevent disruptions to their core business processes (Porter, 2008), due to infrastructural lock-in. This lock-in, which is often ignored, prolongs the need for crude oil extraction and refinery, and maintains the petrochemicals industry market share via a continuous oil demand, which tactfully condemns any attempts (e.g. via policy making) to move away from, or reduce the use of, petrochemicals (Ebner and Iacovidou, 2021). This is evident by the current situation emerged due to COVID-19; the glut of cheap oil produced was in high demand by the producers of virgin plastic resins, as it lowered the cost of virgin plastic production and consequently, the prices for virgin plastics that, in turn, led to a boost in competition in the market (Ebner and Iacovidou, 2021). Furthermore, financial institutions (2.E) put pressure on the Petrochemicals industry (T1–4.1) and even more so on the producers and brand owners (T1–1.I) to adhere to the maximisation of shareholder wealth (Freeman et al., 2010). In response, they financially support producers and brand owners (T1–1.I) on developing and holding strong lobbying positions in which they can provide policy-makers with insights and information, and in turn influence policy development (Ihlen and Berntzen, 2007).

Due to these dynamics, the P-C system of the PET bottles value chain is naturally-evolved and self-sustaining, e.g., by producers and owners (T1–1.I) acting upon their best self-interest. This enables PET drinks bottles producers and brand owners (T1–1.I), petrochemical industry (T1–4.I), and retailers/ wholesalers (5.I) to maximise their profit, while securing the provision of an aesthetically appealing, economically attractive and convenient PET drinks bottle to the consumer (2.I). The harmonisation of regulatory requirements that producers and brand owners (T1–1.I) need to adhere to, is monitored by the UK government (1.E), supranational legislative bodies (1.E), trade associations (6.E), NGOs (3.E) and advocacy groups (4.E) promoting further the evolved marketing of PET drinks bottles. As a result, the adoption of competitive sus-

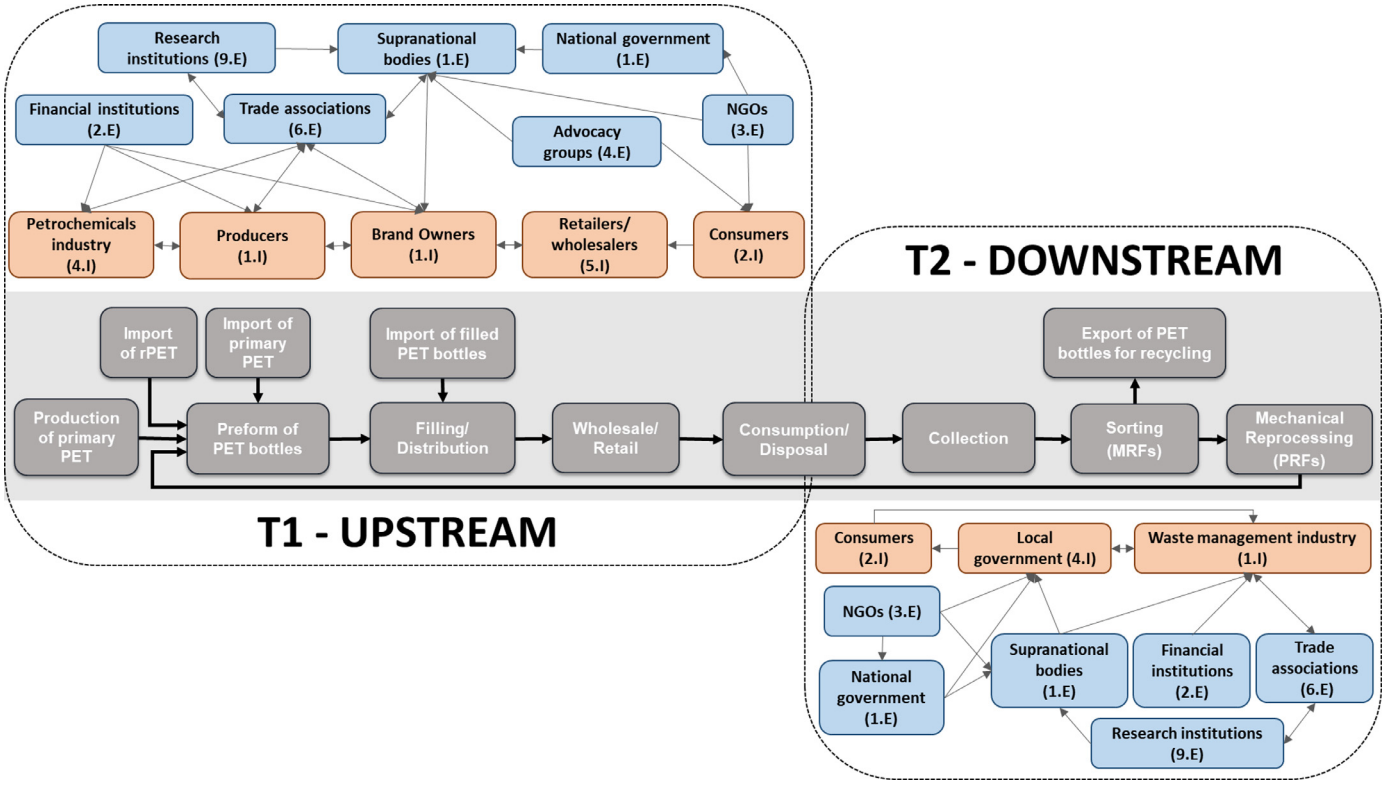

Fig. 3. Depiction of the relationships between the most important internal (n.I) and external (n.E) stakeholders upstream (T1) and downstream (T2) of the PET drinks bottles value chain in the UK.

tainable management strategies in the PET drinks bottles value chain is primarily promoted by external stakeholders. For example, the UK government banned single-use plastic such as straws, stirrers and cotton buds (in effect since October 2020), and proposed a ban on single-use plastics plates and cutlery; yet, these decisions are unlikely to turn the tide on virgin plastic resins demand. Moreover, NGOs (3.E) efforts are placed towards considerably increasing public awareness, creating a sense of responsibility and helping consumers change their behaviour, in order to achieve a reduction in PET bottles consumption and proper disposal (Porter, 1997).

4.2.2. T2 Stakeholder dynamics

In T2 (Fig. 3), we observe a change in the roles of upstream stakeholders (i.e. shareholders in T1 become investors in T2), and the introduction of new internal stakeholders (i.e. waste management industry in the role of shareholders). Notwithstanding the efforts of the waste management industry to influence decision-making processes relating to single-use plastic ban, plastic waste trade and recycling infrastructure development, these are often at odds with the ideas put forward by producers and brand owners. This undermines the ability of the plastics recycling industry to perform within their profit margins, which could impact on their financial stability. For example, the steep decline in oil prices caused by COVID-19 has lowered considerably the demand for recycled plastic material, and has put at risk the financial stability of the recycling industry and the waste management industry (T2–1.I) as a whole. Disruptions in the ability of the waste management industry (T2–1.I) to return a profit, could result to a potential reduction in the number of operating facilities, cuts in jobs, and compromise investments in new plants and technologies (Ebner and Iacovidou, 2021). This could effectively enhance the technological lock-in and maintain the market for fossil fuel, hence delaying changes required for improving the circularity of plastic waste (Iacovidou et al., 2020). The introduction of the UK Plastic Packaging Tax in April 2022 (aims at taxing plastic packaging that contains less than 30% recycled content) appears to be promising in creating a level playing field for the recycling industry. Nonetheless, its effectiveness in coordinating efforts to sustainably managing post-consumer PET drinks bottle waste remains to be seen. In the absence of national government intervention, consumers (T2–2.I) will have little incentive to reduce consumption and dispose of their PET bottles properly. Meanwhile, the waste management industry (T2–1.I) will have relatively little financial incentive to engage in the mechanical reprocessing of PET bottles arising from the relatively low profit margins, and the lack of financial support by investors due to the inferior quality of rPET compared to its virgin count part (lower product quality can result to implications in their reputation and profitability margins), sustaining a very low demand for recycled plastics (Ebner and Iacovidou, 2021).

Moreover, the UK government lacks sufficient resources to cater for the information needed to support its decision-making processes. What's more, it provides little financial support to local government, hereafter called Local Authorities (LAs) (T2–4.I). Therefore LAs actions towards a sustainable plastic waste management, including that of PET bottles, depends on private business investments that are not always directed towards sustainability (Porter, 1997). Hence, public investment in waste infrastructure assets and innovative technologies is limited, and the management of plastic waste is carried out largely through private companies. Consequentially, this creates a technological lock-in where businesses show a preference to well established technologies such as incineration with energy recovery, and LAs (T2–4.I) are trapped into the long contracts they make with waste management companies, struggling to constitute a legitimate space and rationale for intervention. Financial institutions (2.E) engage in limited risk sharing for new technology investments in a rapidly evolving market, such as that of plastics (Hill, 2016).

To step-up the PET drinks bottles recycling activities LAs (T2–4.I) and national government (1.E) need to revamp their relationship, as well as the relationship they have established with consumers (2.I). In the UK, consumers (2.I) are neither properly incentivised to sort out their waste correctly, nor are they penalised for failing to do so. This, significantly downplays the role of the UK consumers (in the household, and on-the-go) in the recycling of PET drinks bottles. What's more, it hampers the promotion of social responsibility. Whilst, LAs (T2–4.I) attempt to mobilise consumers (2.I) to participate the recycling schemes and DRS, their awareness raising campaigns are often not delivering the desired results. It is thus, imperative for LAs (T2–4.I) to understand the key communication barriers in order to fine-tune their campaigns and strategies towards achieving a behaviour change that supports their recycling efforts (Joseph, 2006). This requires decent planning, supported by substantial financial resources that LAs do not currently have access to.

4.2.3. T1 and T2 stakeholder convoluted dynamics

Policy instruments, such as taxes, and incentives (e.g. via the deposit return schemes) and price-based measures (e.g. imposed via refill stations) can if effectively implemented bring changes in the dynamics between upstream and downstream stakeholders. In this realm is the extended producer responsibility (EPR) schemes, which were introduced to place responsibility for the management of post-consumer PET bottles on producers / brand owners (T1-1.I), and also, handlers, i.e. retailers and wholesalers (T1–5.1) of plastic packaging. EPR schemes aim to cover the cost of the EoL management of post-consumer packaging products (incl. plastics) and incentivise the waste management industry (T2–1.I), whilst demonstrating the commitment of plastic packaging producers / brand owners (T1–1.I) and handlers (T1–5.I) to conform to the regulations and take responsibility in supporting recyclability and waste reduction; a process that is usually carried out via intermediary organisations (PRO: producer responsibility organisation) (6.E) (Hahladakis et al., 2018a; BPF, 2021a). In the UK, the costs ensued for the EoL management of plastic packaging is partially covered through the Producer Responsibility Obligations (Packaging Waste) Regulations 2007, and the use of a market-based EPR scheme for packaging, known as the Packaging Waste Recovery Note (PRN), or Packaging Waste Export Recovery Note (PERN) system, for when packaging waste is recycled overseas (BPF, 2021a). PRNs/ PERNs are certificates that indicate a tonne of plastic packaging has been recycled, recovered or exported, and are traded between waste management industry (T2–1.I) (i.e. UK accredited reprocessors and exporters) who are allowed to issue and sell PRNs/PERNs, and the intermediaries that act on behalf of the producers / brand owners (T1–1.I) and handlers (T1–5.I). These exchanges take place in an open market, and therefore PRN/PERN prices fluctuate depending on supply and demand (Matsueda and Nagase, 2012). The current EPR implementation in the UK, and the way the PRNs system currently operates creates mistrust regarding the sale of evidence notes and the way income therefrom supports the recycling of plastic packaging waste (Iacovidou et al., 2020).

Moreover, the way in which the EPR is currently being practiced in the UK overburdens LAs (T2–4.I) with the cost of collection and management of plastic packaging waste. It offers LAs very little (if any) cost compensation, which, in turn, hampers infrastructure investments due to financial risks. As a result, the UK lacks the capacity to deal with the cumulating and ever-increasing amount of plastic waste generated, including PET drinks bottle waste, and succumbs to the exporting of plastic waste for recycling elsewhere.

Therefore, it comes as no surprise that plastic pollution is largely perceived as "out of sight, out of mind" (Barnes, 2019). This phenomenon of plastic waste exports has led to short-term improvements locally by promoting changes in the collection regimes or awareness raising campaigns, and long-term implications as a result of underestimating plastic waste mismanagement in the exporting countries (Barnes, 2019). In 2017, the Chinese government banned the import of plastic waste, and western governments including the UK, were forced to confront the problem urgently (Noritake, 2019; Vollmer et al., 2020; Wen et al., 2021). By 2019, the plastic waste trade flows from the UK to China had dropped to 37% of the flows in 2018 (Wen et al., 2021), but other East Asian countries (e.g. Malaysia, Vietnam, Indonesia) have since taken the hit. In 2019, the amendment of Basel Convention, a multilateral environmental agreement amongst several countries, including the UK, for controlling the transboundary movements of hazardous waste and their disposal, included the global trading of post-consumer plastics in a legally-binding framework (Basel Convention, 2021). Plastic waste exports including only clean, separated single stream plastic waste materials or clean mixtures of non-halogenated polymers, such as PET from the UK to non-OECD (e.g. Malaysia) are permitted under the Basel Convention (Smith, 2021). NGOs (3.E) are ringing the alarm for political groups to implement measures that in the long-term can support the recycling of a bigger fraction of PET drinks bottles. Investments to increase plastics recycling capacity may appear nonsensical from an economic point of view, but with exporting becoming problematic and the incumbent regulatory reforms mandating an increase in the use of rPET, such investments may become feasible in the near future. To that end, the ability of legislative bodies (1.E) to control and monitor these changes and enforce regulations remains a major issue.

Notwithstanding the efforts of the national government (1.E) to control the plastic packaging sector's activities, its role is constrained by the well-established market of the PET drinks bottles. This is largely a side effect of the UK's liberal market economy, where there is little government intervention, and where corporations/businesses upstream and downstream (i.e., T1&T2–1.I, T1–4.I, T1–5.I) coordinate their activities mainly through competitive market arrangements (Fifka and Drabble, 2012). As Hall and Soskice (2003) point out, the power of British trade unions (5.E) and the bargaining power of employees (3.I) are both below the average of other market economies (Hall and Soskice, 2009). This signifies that the transition to a sustainable circular plastics economy can only stem from the market. Indeed, corporations/ businesses (T1&T2–1.I, T1–4.I, T1–5.I), as well as research institutions (9.E), are ahead of the policy debate and efforts to promote circular economy implementation (Hill, 2016). There is now a strong drive from corporations/businesses (T1&T2–1.I, T1–4.I, T1–5.I) to cater for greater accountability and transparency on taking up circular economy initiatives, largely as a reaction to consumer (2.I) expectations due to the rise of the pro-environmental behaviour and less so, due to policy initiatives (Fifka and Drabble, 2012).

Any political strategy related to product replacement, increase of product cost, or adoption of recycled product needs to be supported by producers and brand owners (T1–1.I) as well as consumers (2.I). Producers, brand owners and consumers are in a particularly strong position to motivate the adoption of bans and/or promote the use of recycled content and introduction of rather expensive alternative materials, but can equally act as barriers by expressing opposing viewpoints, or not supporting, these ideas and practices (Jansson et al., 2017). A characteristic example was the resistance by well-established brand owners (T1–1.I) such as Coca-Cola, 820 Danone, Nestlé, and PepsiCo in adopting the proposal of the EC regarding the mandatory tethered caps in plastic drinks bottles (Nielsen et al., 2020). Moreover, public acceptance prevents the national government (1.E) from applying high pressure on producers and brand owners (T1–1.I) who have a power over multifaceted voters. For example, influential voters include workers in the PET bottles production and drinks manufacturing in-

dustries (T1–3.I) that are worried about their jobs, or consumers (2.I) that are concerned about the environment and human health, but are simultaneously wary of the affordability of consumer goods.

The well-functioning relationship that the UK government (1.E) has established with research institutions (9.E) (through a large research grants portfolio) promotes its scientific-orientated agenda. Research institutions (9.E) make a significant and valuable contribution to knowledge building via: synthesising existing knowledge and new research findings to explain systems or phenomena; creating new understanding of the interconnections between stakeholders, sectors and systems; and managing unknowns to support problem-solving and inform change. And yet, they have very limited control over the practicalities and capabilities needed to internalise this knowledge building capacity into policy- and decision-making processes (Bammer, 2019). Industry associations (6.E) are able to bring together shareholders from both parts of the value chain (T1&T2–1.I) with research groups (9.E), and aid the adoption of policy-relevant research agendas on transitioning PET bottles value chain in circular economy (Barrowclough and Deere Birkbeck, 2020). Science-based stakeholder dialogue can link research with knowledge domains outside academia, and therefore it should be perceived as a representative practice of thinking together rather than as a substitute for scientific thinking (Welp et al., 2006).

Financial institutions (2.E) are a powerful and effective stakeholder to addressing the challenges in the plastic packaging sector, simply because the sector is accountable to its investor base only. Venturelli et al. (2018) investigated the engagement of European banks in sustainability issues, and highlighted that almost three quarters of the studied banks overlooked the consistency between planned targets and achievement, while a more concise communication with industry sectors (T1&T2–1.I, T1–4.I, T1–5.I) and clarification of strategic objectives would strengthen the engagement of the banking sector. With the UK consumers (2.I) and financial institutions (2.E) becoming concerned about social and environmental matters, large asset management companies such as Black Rock and activist hedge funds such as the Children's Investment Management Fund (TCI) might be more willing to adopt an active role in pushing the management of producers / brand owners (T1–1.I) to alter their manufacturing inputs and processes. The current trend towards Environmental, Social and Governance (ESG) investing is an example of how the financial sector (2.E) incentivises producers / brand owners (T1–1.I) to adopt more sustainable practices (ESG, 2021). Financial institutions (2.E) (e.g. central banks) might need to revisit their engagement into the plastic packaging system. This can be achieved by moving from privileging large and long-standing petrochemical industries (T1–4.I) towards creating credit for desired plastics alternatives and substitutes, promoting "*a sustainable transformation away from environmentally and socially degrading economic processes*" (Barrowclough and Deere Birkbeck, 2020).

Previous stakeholder analyses in the waste management sector (T2–1.I) found that the influence and participation of all stakeholders, both internal and external, is a prerequisite for the transition towards a more sustainable economy and their role should be tracked over a time period considering current situation (Joseph, 2006; Heidrich et al., 2009). The current mode of production, as well as the technological, and regulatory lock-ins in the PET drinks bottles value chain are making the system incapable of change by itself due to economic factors (e.g. using primary materials in PET bottles production is cheaper than using rPET), socio-technical arrangements (e.g. PET drinks bottles are able to provide freshness, convenience, safety, and accountability in everyday life (Evans et al., 2020)), lack of incentives for recycling downstream. This situation indicates the need for a close collaboration amongst all stakeholders involved in the PET drinks bottles value chain; external and internal stakeholders. On the one hand, the overemphasis on consumers' (2.I) behaviour and household practices which is currently trending in policy, industry and research fields may lead to an underestimation of the problem, and will be plainly insufficient to address the low plastic recycling rate (Evans et al., 2020). On the other hand, greater attention to the design and technical attributes and performance of PET drinks bottles shifts attention from their EoL fate and the changes needed to improve their recycling rates (Hahladakis and Iacovidou, 2019).

It is thus evident, that gaining an improved understanding of the dynamics upstream and downstream in the value chain of PET drinks bottles, it is a noteworthy and necessary starting point in aiding the transition towards to a more sustainable plastics economy. Regulators and local government need to work together with brand designers, manufacturers, importers, wholesalers, retailers, waste management companies, recyclers, consumers and other organisations (e.g. trade-unions, associations, NGOs). This would help to coordinate their actions, and make it feasible to maintain progress in waste and resource management; to promote technological innovation and investment; to implement transparent environmental policies; and to use information-based instruments to raise the social responsibility of businesses and individuals.

4.3. External stakeholders and their role on making the transition to a circular plastics economy

Black et al. (2019) reported that PET drinks bottles producers and brand owners (T1–1.I) and reprocessors (T2–1.I) are tied-up in the investments they made to improve their processes, such that any change will likely cause financial damage. In this respect, the mission of the external stakeholders involved in the plastic packaging value chain is to provide: i) transparency in the system and access to data for monitoring and investigating trends in PET bottles production, trade, and distribution in the economy across P-C-M; ii) set up easy to achieve, measurable sustainability targets and standards to promote better management; and iii) develop financial and policy levers to support the implementation of i) and ii) (Barrowclough and Deere Birkbeck, 2020).

Transparency can provide clear insights on where, and how PET preforms / bottles / drinks are imported, produced, filled, and placed on the UK market, as well as how many of the PET bottles are recovered for recycling, and how many are exported. At the stages of sorting and reprocessing, a constant and transparent monitoring of PET bottles flows at each stage of value chain is required to account for the losses/rejects in the system, and identify hotspots for intervention. This type of granularity in the system, may require a lot of scrutiny that is time-consuming, but as Hopkinson et al. (2018) suggest it is a necessary step towards the adoption of a circular economy; streamlined via "*investment in information management and tools to manage complex system dynamics and anticipate future scenarios (p.91)*".

To date, there is a long list of external stakeholders in the UK (Table A.1) including mainly: governmental bodies (1.E), trade associations (6.E), and NGOs (3.E) operating at international, national, and regional level in a rather fragmented manner (Nielsen et al., 2020). Trade associations (6.E), that exhibit self-organisation and dynamism, emerge from a multiple supply network that is built upon complex adaptive collaborations usually on short- to medium-term supply risks, which tend to be relatively opportunistic and ad hoc (Azadegan and Dooley, 2021). Their main priority is to align their members with the national and European regulations to support the development of a sustainable system of PET bottles, whilst preserving their financial interests. The main challenge for trade associations (6.E) is to harmonise expectations between their members which may often be opposing. For example, the mem-

bers of British Plastics Federation (BPF), that focus on the entire PET value chain include both manufacturers and recyclers, whose financial interests might be opposed from the perspective that PET bottles production from primary raw materials (e.g. oil) might be a more affordable option than from secondary materials (e.g. rPET preforms) (Ritchie, 2018).

NGOs (3.E) influence consumers (2.I) via organised campaigns and educational activities. For example, Greenredeem (Table 2) has launched a pilot scheme of recycling kiosks in 25 schools in the UK, where schools were awarded a 5p donation per drink bottle collected to encourage increased recycling rates of PET drinks bottles. This pilot scheme led to the collection of 60,000 plastic bottles in the first four months of implementation indicating that incentivising consumers can positively influence recycling (UKCPN, 2019). However, a recent study indicated that NGOs (3.E) symbolically engage plastic production and consumption on a systemic level since they mainly focus on simple plastic items that are easy to regulate and reprocess (easiest objects are usually targeted), while more complex objects remain unaddressed (Nielsen et al., 2020). This situation might be attributed to the fact that NGOs (3.E) may partner up with government (1.E) that is strongly lobbied by shareholders (T1–1.I), and therefore NGOs are steered by government towards a 'specific' direction.

Governmental bodies (1.E) focus on certain areas including practices and strategies related to resource efficiency, EoL management, and waste generation reduction. However, little attention is paid to strategies that encourage the development and change of behaviour (e.g. social awareness), the redesign of current unsustainable processes (e.g. production of complex plastic items) and alternative operational processes in line with the circular economy concept (Klein et al., 2020). The need to focus on these strategies becomes critical when one considers the increasing embedment of PET bottles in the food market practices (e.g. meal deals and packed lunch ideas that are fully convenient for on-the-go consumption always include a soft drink bottle). Concurrently, the multi-dimensional limitations of the use of alternative materials enhance the centrality of food plastic packaging in contemporary economic and social trends (Evans et al., 2020). This situation emerges from commercial, technological, regulatory, and social-culture elements, and the increased promotion of a lifestyle that is based on convenience and overconsumption (Evans et al., 2020). The strong lobbying position of producers and brand owners (T1–1.I) is reflected by the influence they have over consumers (2.I) preferences (via attributes such as freshness, convenience, safety, accountability and affordability).

A list of most prevalent external stakeholders, that have a pivotal role in making the transition of PET bottles in the UK to a circular economy and are grouped according to these influencing factors (type of engagement, level of information, and stage of value chain) and stakeholder category (Fig. 1), is provided in Fig. 4 (raw results are provided in Table A.1). In the following sections, we quantified the presence of external stakeholders (obtained by Fig. 4) grouped by the stakeholder category and level of information, according to the type of engagement in all stages of value chain (P-C, and C-M) as well as in the system as a whole (P-C-M).

4.3.1. Production-Consumption (P-C)

In the (P-C) stages of the PET drinks bottles value chain in the UK the influence of external stakeholders is lesser than in the downstream (C-M) stages (Fig. 5). The stakeholders' engagement is restricted only to *consult* and *involve* type (lying in the middle of the engagement spectrum), and their activities fall into the 1st and 3rd level of information, respectively (Fig. 5). Due to the restricted level of engagement, external stakeholders' activities are solely focused on improving the knowledge-base and knowledge transfer; largely via the activities of research institutions (9.E) (via data provision and facilities / equipment that support data extraction and analysis), and those of the trade associations (6.E), NGOs (3.E), and governmental bodies (1.E). The activities of the latter groups of stakeholders aim to streamline improvements in PET bottles production methods. They also seek to reform policy measures and introduce new regulatory instruments in order to create the financial opportunities for promoting sustainability in the sector and to influence the producers and brand owners (T1–1.I) (I2S, 2021a).

The absence of the *inform* type of engagement, hinders the creation of complex value and the transition to sustainable PET bottles management. Although *inform* is the lowest level of engagement, it constitutes the main pillar to building upon the other types of engagement. Therefore a balanced proportion of all types of engagement in a system is required for developing an effective circular economy strategy (Salvioni and Almici, 2020; Asari, 2019). For instance, research institutions (9.E) suffer from the lack of generating tangible research impact, and fail to establish networks for the dissemination of scientific findings, and research support. This has a direct impact on producers and brand owners (T1–1.I) who miss opportunities for knowledge transfer and information access that could help them reconsider and revamp their business models and improve their decision-making processes. Similarly, the absence of the *collaborate* type of engagement is symptomatic of the inertia of external stakeholders in making improvements to the upstream part of PET bottles value chain. This is reinforced by the regulatory framework and political landscape (3rd level of information), and the way the market operates in the UK (4th level of information), which in turn, has a direct impact on the provisioning services and the environment (1st level of information) and the political landscape (with focus on the regulatory compliance with standards related to PET bottles in contact with food) (3rd level of information).

Henceforth, governmental bodies (1.E) appear to be the prevalent external stakeholders operating in the P-C stages of the system followed by trade associations (6.E) (Fig. 5). These observations are exemplified by the fact that the P-C stages often serve the needs of internal stakeholders, and therefore, interventions aimed at imposing sustainability measures on the PET drinks bottles system are limited (Barrowclough and Deere Birkbeck, 2020).

Fig. 5 indicates the need to further involve of external stakeholders upstream in the system that focus on other levels of information (e.g. 4th and 5th) through a wider variety of engagement.

4.3.2. Consumption-Management (C-M)

In the stage of C-M there is larger and multi-faceted participation of external stakeholders (Fig. 6) compared to P-C stages.

The majority of external stakeholders participate in the C-M stages through the *consult* engagement type, and are mostly composed of trade associations (6.E), and some NGOs (3.E). Trade associations (6.E) role in C-M is more active and broader than that of NGOs' (3.E) due to their main incentive to protect the interests of their members (Table 2); usually, shareholders (T1&T2–1.I) with significant lobbying power. Therefore, trade associations can considerably contribute to increasing the circularity potential of PET drinks bottles in the UK. The *consult* type of engagement that NGOs exercise is crucial to helping shareholders downstream (T2–1.I) gain access to technologies and information on new business opportunities (I2S, 2021a), which can boost value creation in the 2nd and 4th level of information. Consultation activities can also: contribute to improvements in the provisioning services of local government (T2–4.I) (1st level of information); support informed decision-making processes via the generation of new (or better / updated) information / data (3rd level of information) – that helps both national (1.E) and local government (4.I) -, and increase pub-

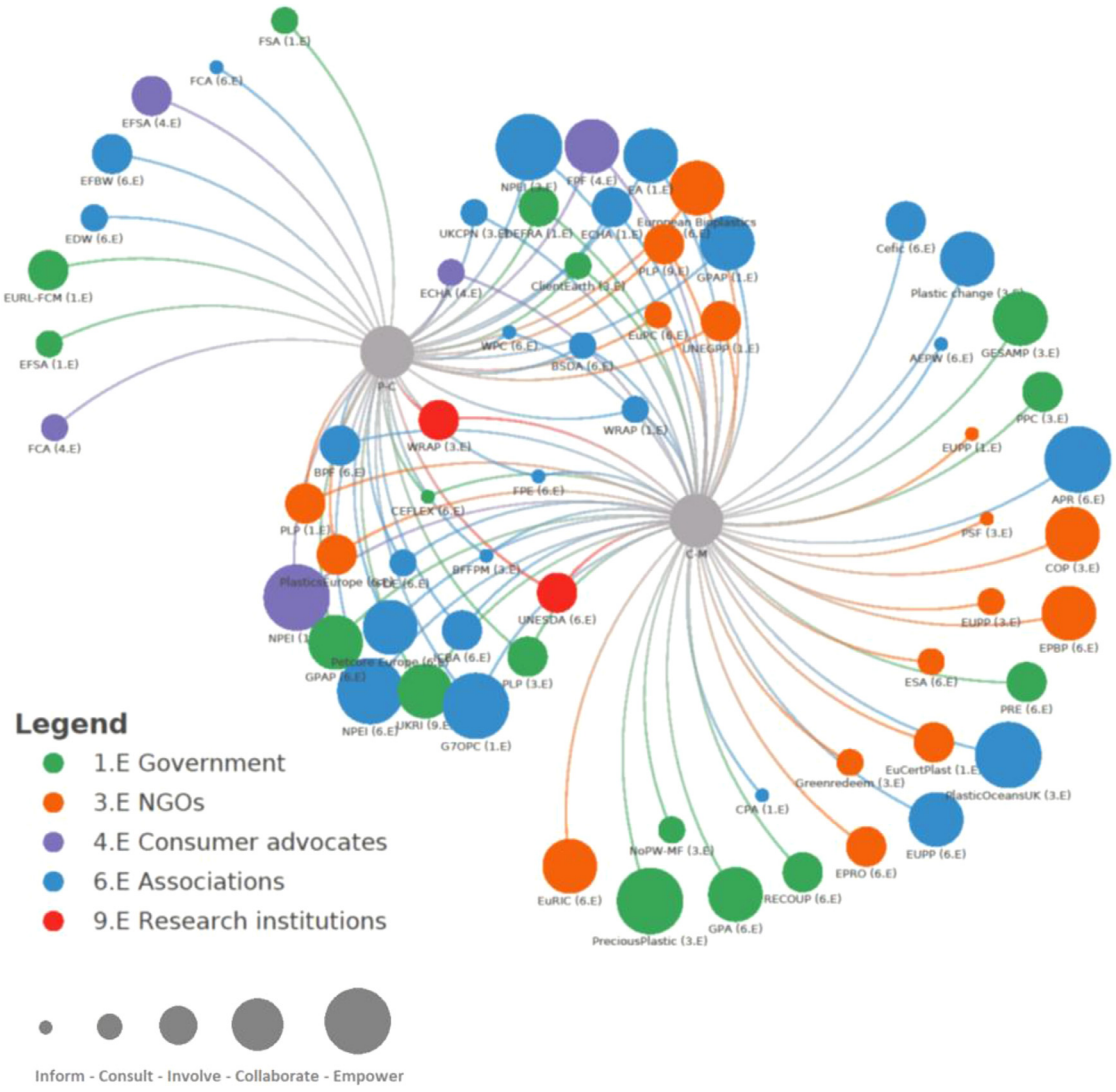

Fig. 4. Map of external stakeholders that participate in the recycling value chain of PET bottles in the UK identified according to the stakeholders category, type of engagement, and stage of value chain (P-C and C-M). Map can be accessed and viewed at: https://embed.kumu.io/3f275ca2eaacf08029479338270d95e1

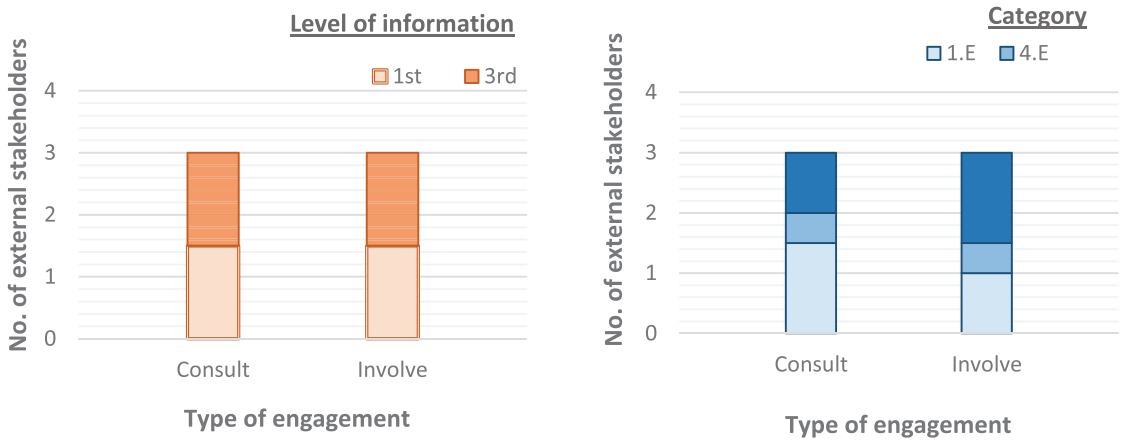

Fig. 5. Quantification of the most active external stakeholders in the stage of P-C (upstream) of the value chain of PET bottles in the UK based on the type of engagement considering: the level of information (A); and the category of external stakeholders (B).

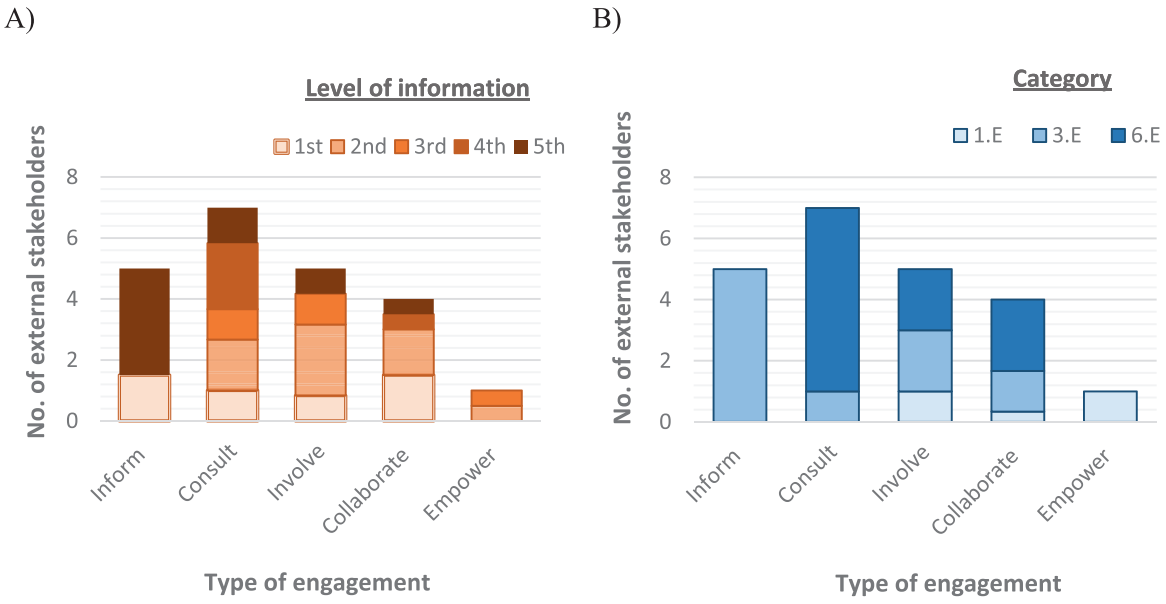

Fig. 6. Quantification of the most active external stakeholder in the stage of C-M (downstream) of the value chain of PET bottles in the UK based on the type of engagement considering: the level of information (A); and the category of external stakeholders (B).

lic awareness by helping consumers (2.I) realise their role in shaping waste management practices and realising their implementation (I2S, 2021a). Besides their particularly pronounced role in the *consult* type of engagement, trade associations (6.E) can influence all, but the 3rd, levels of information (1st, 2nd, 4th, and 5th), via the *collaborate* and *involve* functions. The 3rd level of information is mainly shaped and affected by governmental bodies (1.E), and engagement functions thereof, who are responsible for the regulatory compliance and legal actions related to PET drinks bottles C-M (Section 2.1).

Whilst, governmental bodies (1.E) appear to have gained traction on the *empowerment* type of engagement (Fig. 6), the varying capacities and broad capabilities of shareholders downstream (T2–1.I) cannot guarantee that targets to improve PET bottles recycling rates are going to be met. The reason is two-fold. One it is due to the complex and dynamic factors related to technological innovations and the market volatility induced by the transition (Hopkinson et al., 2018), and two, is the absence of incentives needed to mobilise a more sustainable consumer behaviour. To date, governmental bodies (1.E) attention has been placed to providing guidance on best available techniques and technologies used by the waste management industry (T2–1.I) and strategies for waste prevention and recycling improvement (4.I). Nonetheless, the role of governmental bodies (1.E) is extremely important at the stage of EoL management of PET bottles and therefore a more active and effective intervention is required to improve consumer consumption/ disposal practices, and the waste management infrastructure for promoting PET bottles recycling.

Finally, NGOs (3.E) appear to be particularly active through the *inform function*, even though their role in the *consult* type of engagement is limited (Fig. 5(B)). NGOs activities are placed on informing and educating consumers with the aim to instigate a change in consumers purchasing habits, beliefs, behaviours and attitudes towards plastic waste (5th level of information). This behaviour change is considered to be instrumental in reducing the amount of PET drinks bottles placed on the market, whilst simultaneously preventing environmental impacts associated with their (mis)management (1st level of information) (Fig. 5(A)). In isolation the NGOs activities cannot be far-reaching; collaboration with governmental bodies (1.E) and trade associations (3.E) can be instrumental to creating the enabling conditions required, for promoting the sustainable management of PET drinks bottles across all levels of information.

4.3.3. Production-Consumption-Management (P-C-M)

The participation of external stakeholders has the greatest impact when taking the whole PET bottle value chain (P-C-M) into account (Fig. 7). The *involve* and *collaborate* engagement strategies are employed by trade associations (6.E) and government bodies (1.E) at all levels of information, with a focus on infrastructure and innovation (2nd level) and business practices and market (4th level) (Section 2.2.2). This suggests that the external stakeholders efforts at encourage shareholders (T1&T2–1.I) to transform their practices towards achieving a sustainable circular plastics economy are mid-way through creating tangible impact. To that end, research institutions (9.E) and NGOs (3.E) are critical in nurturing multilateral collaborations needed to increase the circularity potential of PET bottles via the *inform* and *consult* functions that seek to inform, educate, influence perceptions and change behaviours.

In the UK, UKRI (9.E) is the leading research body that develops partnerships of universities (9.E) and research organisations (9.E) with shareholders (1.I), charities (3.E) and government (1.E) providing opportunities for research and innovation. For example, UKRI has launched the Smart Sustainable Plastic Packaging (SSPP) programme aiming to increase the efficiency and sustainability of PET bottles production in the UK (UKRI, 2021).

A coordinated participation of all external stakeholders in the system through *consult* and *inform* engagement is required to access existing knowledge and technologies, and create new knowledge; a prerequisite to move towards *involve, collaborate* and *empower* stages of engagement. To date, as indicated by Fig. 4 and 5, attention has been largely focused on the downstream part of the system. Focusing on one part of the system (in this case, downstream) however, entails the risk of distraction from other problematic social and environmental arrangements in making improvements in PET drinks bottles recycling (Evans et al., 2020).

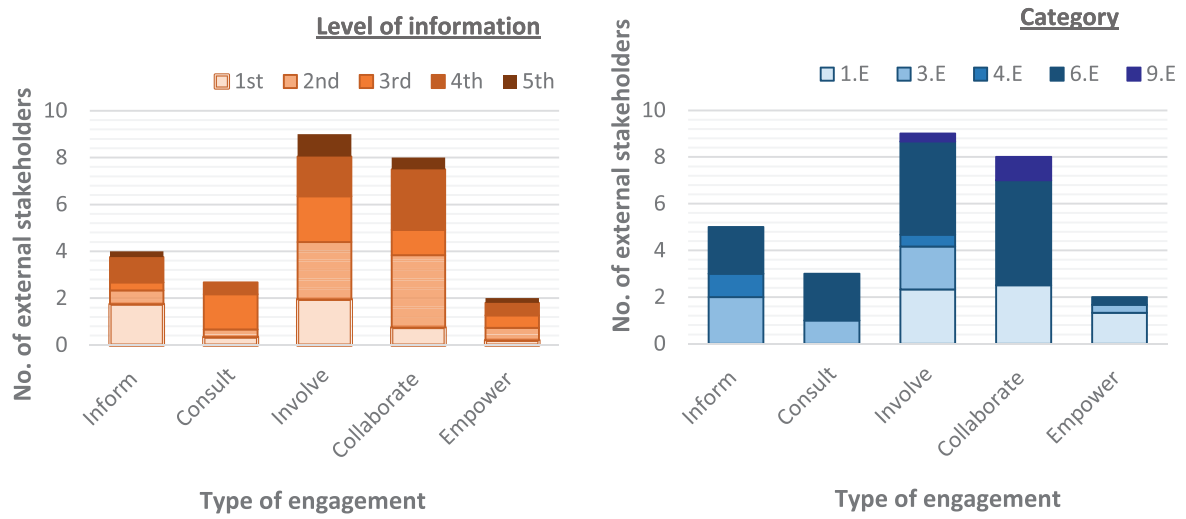

Fig. 7. Quantification of the most active external stakeholder in the entire value chain (P-C-M) of PET bottles in the UK based on the type of engagement considering: the level of information (A) and the category of external stakeholders (Fig. 1) (B).

5. Conclusions

The study revealed that stakeholder theory can go beyond the social sciences boundaries, to provide a lens through which we can understand stakeholders' role and importance in the environmental engineering and policy fields. We showed that the integration of stakeholder theory to a systems-based approach like CVORR can generate critical insights through breaking the disciplinary silos. This not only can extend theory, but it can offer a transdisciplinary approach to assessing resource recovery systems.

In the UK, the PET drink bottles belong to a well-established liberal market where producers and brand owners (internal stakeholders operating upstream of the value chain) have a significant lobbying power over the entire value chain, and are strongly supported by financial institutions and retailers / wholesalers. The main practical implication arising from this dynamic is an ever-increasing attention at the management of PET bottle waste downstream of the value chain, which is further nurtured by external stakeholders that lack the power and incentives to shift attention upstream. A focus on the downstream part of the system, revealed inefficiencies that are allotted to the technological lock-ins, the inability of the waste management sector to comply with the regulations, or the constrained ability of local government to influence (and increase) consumers' participation in the recycling schemes, and make changes in the collection and management infrastructure. These inefficiencies are further promoted by external stakeholders (e.g., trade associations, NGOs and research institutions), that often go for the low hanging fruits and spur activities mid-stream (e.g., focus on changing consumers behaviour), and/or downstream (e.g., focus on improvements in waste management infrastructure) of the value chain.

While producers, brand owners and suppliers reap the benefits of the ever-increasing demand for PET drinks bottles in the market, the local government and waste management industry (internal stakeholders operating downstream of the value chain) are burdened with the costs and accountability to conform and meet the targets set by the UK government. This dynamic presents many challenges to the waste management industry, whose issues are often being ignored. The strife to improve the collection and management of PET drinks bottles by way of promoting circular economy needs to be matched by policies and market-based instruments that support local government and waste management industry, and control the volatility in the prices of virgin and recycled commodities.

The lack of political tenacity and strategic direction and innovation that tackles inefficiencies in the whole system can severely restrict the ability to close the PET drinks bottles loop. Policy-makers need to create a level playing field by giving all stakeholders access to the development of policies. They also need to introduce mechanisms with which they can increase the integrity and transparency of the decision and policy making processes and take all stakeholders' perspectives into account; thereby formulating effective policies. It is at the best interest of the local government, and businesses alike, to rethink of their business models and introduce technological innovation (e.g. advanced collection systems such as DRS and/or refilling market stations). The value proposition offered by these innovations can build trust between consumers and businesses and establish rapport over capturing value from plastics (PET bottles).

Finally, the study highlights the importance of creating a well-coordinated stakeholders' network to achieving a transition to a sustainable circular plastics economy. Henceforth, understanding the dynamics spatial (global, national, local) and temporal (annual, five-year period, etc.) involved in the plastic packaging system, is crucial to identifying ways to seize the multi-dimensional benefits of an increased PET bottle waste recycling rate and making it possible to transition to a sustainable circular plastics economy. Both theoretical and empirical approaches need to be employed to ensure success in finding common ground, uncovering hidden aspects and making real progress on improving the PET drinks bottles recycling in the UK.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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