Drivers and barriers to circular agrifood trade between the UK and EU. A systems thinking approach

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Abstract

The trade relationship between the United Kingdom (UK) and European Union (EU) offers a unique case study for investigating how a transition to more circular trade relationship in the agri-food sector could be fostered. The key dynamics influencing circular trade, both in terms of current circularity, and those that could be leveraged in the future to increase circularity via a circular trade transition, are represented through a systems thinking approach into a causal loop diagram. This study highlights the complexities of introducing circularity into UK-EU agri-food trade. It also proposes key considerations for future circularity between the UK and EU in agri-food trade, highlighting most efficient interventions to facilitate a circular trade transition and decouple economic activity from the extraction of finite resources. Though both parties have voiced commitments to fostering circularity into their respective economic systems, few concrete measures to promote circular trade have been considered. As reflected in this study, doing so in agri-food value chains will require coordination of procedural, policy, technical, and design-based changes. Given the barriers to circular trade, primarily having to do with transitionary costs and uncertainty, a circular transition should not be considered inevitable and cannot expect to occur “organically” via whatever current momentum exists in the circular economy movement.

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Introduction

Given the highly globalised nature of economic activity, including in agri-foods where food is widely imported and exported, integrating circular economy principles into international trade transactions is a further essential consideration for reaping the touted benefits of circular economy practices. Key global stakeholders such as the Organisation for Economic Co-Operation and Development (OECD) and the World Trade Organisation (WTO) have voiced the need to make trade more circular to combat climate change and diversify economic activity worldwide to meet the needs of a growing global population (Steinfatt, 2020). In 2021 the United Nations Economic Commission for Europe also recognised circularity in agri-food trade as essential to the future food security of the continent, hosting a roundtable titled Fostering Circularity in Food Trade, which brought together key government leaders, researchers, and businessowners and highlighted potential avenues for circularity in this sector and the ways in which these measures could offset the environmental and human costs of current linear food systems.

The trade relationship between the United Kingdom (UK) and European Union (EU) offers a unique case study for investigating how a transition to more circular trade relationship in the agri-food sector could be fostered. Investigating potential circularity in UK-EU agri-food trade is especially key at this moment given that the UK's exit from the EU in 2020 has allowed for a drastic re-evaluation of the two entities' trade relations at the highest levels of government, opening the potential to integrate more sustainable trade practices into policy moving forward. Furthermore, the UK and EU are one another's largest trading partners, including in agri-foods. This is an especially important trade relationship for the UK in terms of food security and ensuring a diversity of food product offerings, which imports 46% of the food it consumes, with 60% of these imports coming from the EU (DEFRA, 2021). The agri-food sector, however, is currently a considerable source of emissions for both the UK and EU. Addressing these emissions via circular trade practices could significantly reduce the EU and UK's carbon footprint and bring both parties closer to meeting their respective, as well as shared climate goals, such as the Paris Agreement, of which the EU and UK are both signatories. Investigating the drivers and barriers to circular trade between the UK and EU in the agri-food sector will, therefore, be the focus of this analysis.

Methodology

Key factors influencing circular trade in the UK-EU agri-food case study context could be subdivided broadly into policy factors, market dynamics factors, and research and design factors, which are summarised in Table 1.

Table 1 Examples of Drivers and Barriers to Circular Trade (CT)

Analytical Category	Factor Influencing CT	Drivers	Barriers	Incentive Mechanisms
Policy and Regulation	WTO policy	Trade standard harmonization	Trade standard hereogeneity	Policy requirements and recommendations
	UK trade/agri-food policy	Circular supply chain standards	Linear supply chain paradigm	Benchmarks for environmental health
	EU trade/agri-food policy	Standardised definitions of circualrity	Definitional heterogeneity	Emissions goals
	UK-EU trade/agri-food policy	Multi-stakeholder discussion forums	Lack of communication around circualrity	Preferential trade agreements for circular goods
	IPR accessibility	Frameworks for assessing circularity	Lack of circularity info. gathering	Free trade agreements for circular goods
		Circularity protocol standardisation	Lack of protocol or standardisation	
		Free trade in circular goods	Non-tariff barriers	
Market Dynamics	Comparative advantages	Low food waste	High food waste	Education around circular goods/food waste
	Supply and demand	Evidence for circular best practices	Uncertainty around best practices	Subsidies/funding for circular activities
	Cost of circular agri-food activity	Demand for circular goods	Lack of awareness around circular goods	
Supply/Value Chain Logistics	Raw material procurement	Raw material re-valorisation	Extraction of virgin materials	Establish best practices for agri-food value chains
	Processing practices	Use of secondary raw materials	Lack of re-valorisation efforts	Renewable energy use requirements
	Transport practices	Renewable energy for processing/transport	Use of non-renewable energy	
	Supply chain labour	Circular-trained workforce	Lack of circular economy training	
Research and Design	Research goals	Circularity-focused research and design		Funding for circular research
	Research funding	Funding for circular research		Require circular designs along value chains
	Design goals	Circular design goals		

The goal of this study was to create a causal loop diagram (CLD) modelling drivers and barriers to circular agri-food trade between the EU and UK. *Figure 1* outlines the steps taken to gather information that would support the creation of this CLD and identification of key system changes that could be enacted to bring about a transition to a more circular agri-food trade system overall. Systems thinking is a framework to understanding complex real-world dynamics with numerous different parts and influences. “Systems” are defined as interconnected “elements”, that come together to fulfil a “purpose” and are particularly useful in describing complex real-world issues, such as the negative effects of linear economy.

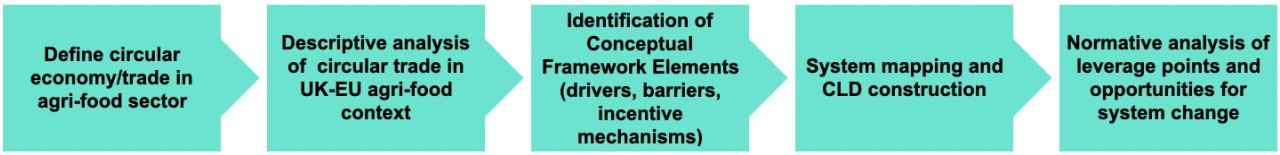

Figure 1 Summary of research approach taken to determine system dynamics within UK-EU agri-food trade in terms of trade circularity (*created using Keynote*).

System elements were selected based on the impact they had on the target variable, circular trade activity in agri-foods. The purpose of a CLD is to map out the dynamics and structure of a system and highlight causalities and feedback loops within the system (Meadows, 2008). CLDs are made up of variables, or “nodes” connected by arrows that indicate one-directional links between variables. Feedback loops represent system dynamics that “reinforce”, represented by an “R”, or “balance”, represented by a “B”, each other in a self-perpetuating, cascading manner. Reinforcing loops mean that the dynamics or nodes involved build upon each other. For balancing loops this is the reverse, where the nodes involved diminish one another. Table 2 briefly summarises examples of different agri-food category activities considered in the building of the CLD.

Table 2 Defining CT in Agri-Foods

CT Category	Examples of Activity or Good
Biological Materials	Regeneratively agriculture
	Trade in secondary materials from food waste
	Revalorization of food processing by-products/waste
Durable Goods	Machinery promoting sustainable agricultural activity
	Production, transport, processing using renewable energy
	Repair, reuse, recycling, and remanufacturing of equipment
CT-Enabling Services	Consulting for circular transition
	Workforce with knowledge of CE principles
	Workforce skilled in circular value chain activities

Next, the identification of leverage points was key for the normative phase of this analysis, or determination of how a circular transition could occur, and which systemic changes should be made to foster circularity. Leverage points in the case study are ways in which the agri-food trade system between the UK and EU can change to be more circular, thus decreasing the influence of barriers and increasing the influence of drivers.

Results

The causal loop diagram represented in Figure 2 highlights key dynamics influencing CT, both in terms of current circularity, and those that could be leveraged in the future to increase circularity via a CT transition. Figure 2 contains 26 nodes, divided up into drivers (blue) (n=11) and barriers (red) (n=5) to CT activity, the target variable. Dashed lines indicate hypothetical connections between nodes. "UK-EU Agri-food CT" is the target variable, meaning the ways in which the various nodes within the model feed into this variable, represented in light green, aid answering the overall research question of how the various drivers and barriers to CT interact to promote or hinder this activity.

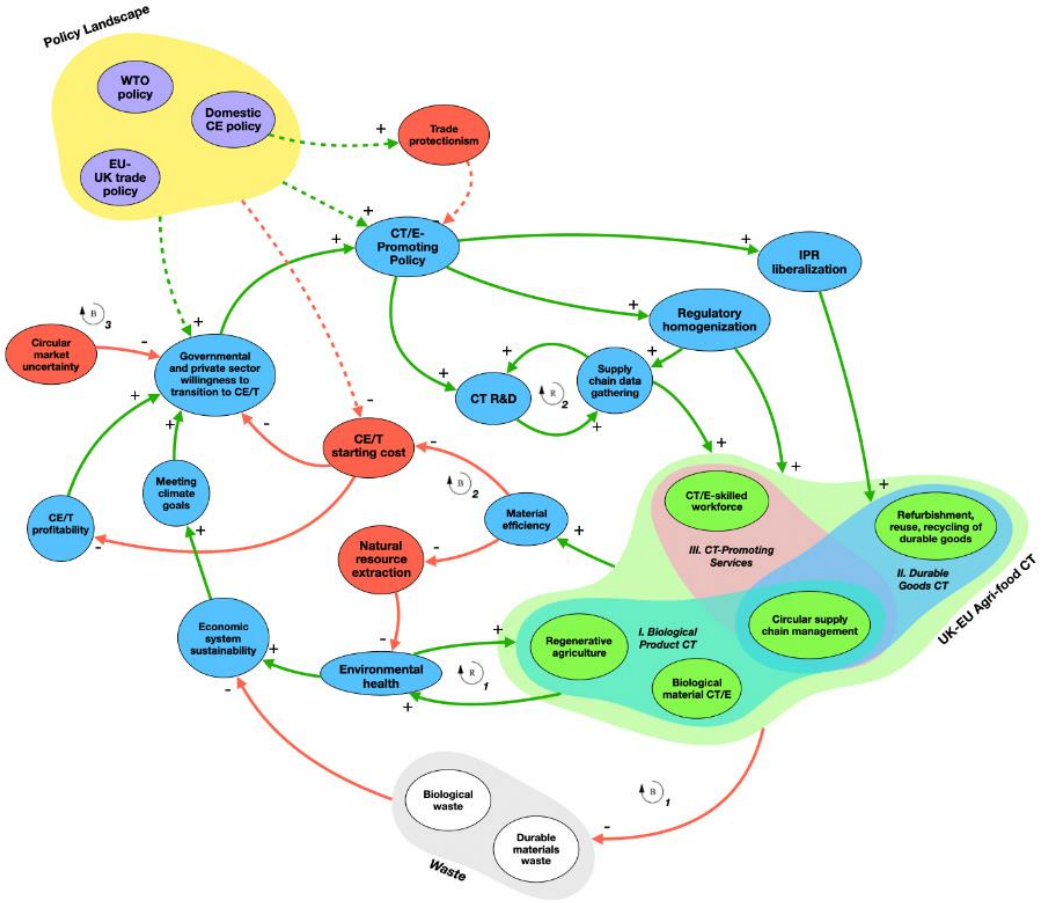

Figure 2 CLD of overall drivers (blue) and barriers (red) to agri-food trade between the UK and EU The target variable is "UK-EU Agri-food CT" which encompasses the three main categories of key agri-food trade activity, Biological Products, Durable Goods, and CT-Promoting Services. Positive (+) arrows increase or decrease variable arrow is pointing to in the same direction. Negative (-) arrows indicate an inverse relationship. Reinforcing and balancing loops are indicated throughout and are explored in further detail in subsequent sub sections.

The Policy Landscape grouping encapsulates levels of policy most relevant to trade circularity in the case study context. The "CT/E-promoting policy node" was selected as a system characteristic since structuring policy to specifically address circularity is more favourable as a driver than general promotion of economic sustainability and green practices as these do not necessarily make trade practices more circular (Barrie et al., 2022). As the key defining qualities of circularity are limiting resource extraction and waste, simply performing linear economic trade using renewable energy, for example, does not meet the goals of CE, which are to systematically decouple resource extraction from economic activity (Ellen MacArthur Foundation 2021; 2022).

The Policy Landscape variables were also grouped to illustrate the interconnections between these three tiers of policy, which were not further represented on Figure 2 to maintain clarity of the diagram. As the UK and EU are subject to WTO regulations, "EU-UK trade policy" and "domestic CE-policy" is influenced by the "WTO policy" node (Steinfatt, 2020). The connections between "Policy Landscape" and "CE/T-promoting policy" and "Governmental and private sector willingness to transition to CE/T" are dashed due to the ever-evolving nature of policy, and the fact that the WTO, UK, and EU have all taken first steps to developing CE policies but have not fully made a circular transition. Therefore, the dashed lines can be interpreted as indicating that the Policy Landscape variables have the potential to adopt CE/T-promoting policy. The WTO can leverage its sustainability-focused working groups to promote trade circularity, for instance, and the UK and EU could add a circularity clause to the UK-EU TCA.

The Policy Landscape also has the potential to promote "Governmental and private sector willingness to transition to CE/T". Since a CT transition is a considerable undertaking that would require extensive investment in the form of research, data gathering, and trial and error, not all stakeholders may be willing to commit to this transition under current system dynamics (Barrie et al., 2022; Ellen MacArthur Foundation, 2021). For instance, in an investigation of barriers to CE in the EU, Kirchherr et al. found that "Lacking awareness and/or willingness to engage with CE" in the private sector made companies hesitant to adopt circular practices. Already "operating in a linear system" was also identified as a barrier. This speaks to the difficulty of facilitating what amounts to an economic paradigm shift away from the status-quo of linearity (2021). Policies such as subsidies for sustainable agricultural production, investment in renewable energy, research into best practices for circular economic and trade activity are all potential facilitators of CT within agri-foods that could increase willingness of governments and businesses to adopt CT activities despite initial barriers (Despoudi et al., 2021; Paltrinieri et al., 2022). This will be further reinforced when discussing the relationship between "CE/T profitability" and "Governmental and private sector willingness [...]".

Another key system dynamic highlighted in Figure 2 is the connection between "domestic CE policy" to "trade protectionism". Trade protectionism can act as a barrier to trade circularity (Barrie et al., 2022; de Lange 2022). This is also why the line between domestic policy and trade protectionism is a dashed and positive line, implying potential increase in protectionism within this system depending on whether decisionmakers decide to facilitate free trade in sustainability or circularity-promoting activities or not.

"CE/T-promoting policies" could be designed by relevant stakeholders with the intent of fostering circularity, potentially via legislative and non-legislative actions, as well as collective benchmarks. CE/T-promoting policy could then in turn foster circular research and design, indicated with a positive connection to "CT R&D", aimed at further understanding how to best implement CT principles, as well as new innovations in increasing circularity, like new uses for food waste products, or new methods of agricultural production that meet UK and EU consumers' need for food with minimal environmental impact (Barrie et al., 2022; Ellen MacArthur Foundation, 2021). The first reinforcing loop identified (R1 in Figure 2) was between "CT R&D" and "supply chain data gathering", the latter of which can be defined as the act of collecting key information on transactions along agri-food supply chains. The aspects of supply chains that have the potential to affect circular economic activity are numerous, but ultimately those that affect the production of waste, either biological (i.e., food waste) or durable (i, e., used machinery), are of most significance to circularity. Detailed information on supply chain dynamics could help identify opportunities for greater circularity (Despoudi et al., 2021; ARUP,

2018; Barrie et al., 2021). This is where the reinforcing dynamic between this "data gathering" and "CE/T R&D" occurs, where research will inform how best to perform circular economic activities. ARUP et al. identified "design tools" and a "material database", for instance, as key "enablers" of circular activity. "Identifying new innovation" was also an enabler, which corresponds to "CE/T R&D" in the overall system map represented by Figure 3 (2018). "New innovations" include "develop[ing] standards and other infrastructural facilities which will assist recycling and reverse logistics", which would also be drivers of CT related to R&D (Despoudi et al., 2021).

"CE/T-promoting policy" could also foster "regulatory homogenization", also indicated with a positive connection, as the latter is a key driver identified in the literature (Barrie et al. 2022, Rizos et al., 2021; Kirchherr et al., 2018). The connection, therefore, between "regulatory homogenization" and "CT in Agri-food" is positive. Regulatory homogenisation would also make supply chain data gathering easier since standardized definitions, codes and data access would make information transfer more efficient and reduce hurdles to drawing equivalences between different processes relevant to circular activity (Barrie et al., Rizos et al, 2021). CE/T-promoting policy could also facilitate IPR liberalisation that strategically allows information sharing along agri-food value chains to promote recycling, repair, and remanufacturing efforts (Ballardini et al., 2020; Eppinger et al., 2021). IPR liberalisation is essential the effective revalorisation of durable goods, hence the positive connection between IPR liberalisation and "II. Durable Goods" (Ballardini et al., 2021; Barrie et al., 2022).

Furthermore, based on definitions of CE and CT, waste reduction is an inherent result of circular activity, hence the positive arrow from "Agri-food CT" to the "Waste", which encapsulates both biological, and durable materials waste (Barrie et al., 2022; Ellen MacArthur Foundation, 2019). Environmental health is promoted by overall circular economic activity, but particularly the "I. Biological Product CT" section of "Agri-food CT activity", which is indicated in Figure 5 through the positive connection between "I. Biological Product CT" and "environmental health". These nodes form a reinforcing dynamic where the healthier the environment is, the more effectively regenerative agricultural practices can occur (Ellen MacArthur, 2021).

CT activity also enhances material efficiency, thus reducing natural resource extraction. "Material efficiency" is also the key driver of eventually reducing "CE/T starting costs" (Ellen MacArthur Foundation, 2021; (Vegter et al., 2020). "Material efficiency" also inherently decreases "natural resource extraction", thus indicated by the negative connection between these two nodes. For example, implementing CE practices can correlate with reduced waste disposal costs, as well as decreased risks involved with disposal of waste, which in turn decrease overall costs (Barrie et al., 2021; Ellen MacArthur Foundation, 2021).

Another key dynamic highlighted by Figure 2 is how waste reduces economic sustainability and CE/T profitability. Waste points to inefficiencies in resource use and corresponds with increased GHG emissions, which will reduce economic system sustainability. Economic system sustainability will also positively impact "meeting climate goals". These can serve as motivators for the private and public sector, thus positively influencing "governmental willingness to transition to CE/T" (Rizos et al., 2021; deLang et al., 2022; Barrie et al., 2022; Kircherr et al., 2018).

CE/T start-up costs, however, negatively impact (-) CE/T profitability, which would otherwise be a key driver of CT activity since profitability of business activity is essential for its adoption (Rizos et al., 2021; Hina et al., 2022). Finally, market uncertainty was also cited as a

reason some stakeholders were hesitant to undertake CE or trade activities (Kirchherr et al., 2018). This encompassed the lack of precedent for CE business models, lack of proven technologies to implement CE principles, and lack of certainty around labour demand if a transition were to occur (European Commission, 2018; Hina et al., 2022; Kirchherr et al., 2018).

Discussion and Conclusion

This study highlights the complexities of introducing circularity into UK-EU agri-food trade. It also proposes key considerations for future circularity between the UK and EU in agri-food trade, highlighting most efficient interventions to facilitate a circular trade transition and decouple economic activity from the extraction of finite resources. Though both parties have voiced commitments to fostering circularity into their respective economic systems, few concrete measures to promote circular trade have been considered. As reflected in this study, doing so in agri-food value chains will require coordination of procedural, policy, technical, and design-based changes. This study also points to the need for intentional, circularity-focused research and policy action for maximum impact. Given the barriers to circular trade, primarily having to do with transitionary costs and uncertainty, a circular transition should not be considered inevitable and cannot expect to occur "organically" via whatever current momentum exists in the circular economy movement.

As further exemplified by the high-leverage power of policy in the CLDs, governments will need to craft legislation, ideally with binding requirements, to foster circular activity amongst key stakeholders. This speaks to the high-leverage power of "system goals", where circularity in trade as a goal set by governments and the private sector will be essential to a circular transition. Conducting research on how to engage with consumers around circularity will also be essential to ensuring the long-term financial success of a circular transition and overcome company hesitance to adopting circular production practices. It follows that expanding research efforts specifically geared towards developing best practices in circular trade in agri-foods will be key to easing uncertainty and incentivising businesses and other key relevant stakeholders to make this transition. Despite the relatively little research in agri-food trade circularity, the WTO and UNECE have stated that greater trade circularity is essential to ensuring the continued food security of Europe, including the UK and EU. Since many foods available in the UK and EU are internationally traded, decisions about what to produce in each respective bloc must also be weighed with climate change considerations. Since circular trade in agri-foods ultimately begins with domestic production, as is demonstrated by the results of this study, local production and maximising its sustainability will have to be calibrated to domestic and then international consumption levels, ideally while minimising as much waste as possible throughout the supply chain.

This study also indicates multiple areas where research efforts should be diverted. Labour implications of a circular transition in agri-foods will be essential considering how important the service sector is to fostering and performing circularity, but the literature review yielded little information on this sector not only in regard to agri-food circularity, but overall circular economy transitions. Traceability and transparency in food systems is another key area with extensive overlap between the policy and technical sides of trade but will also be essential to not only defining what circularity could look like in agri-food value chains but would give greater granularity and detail to the barriers and drivers to a circular trade transition. Indeed, given that little information currently exists on circularity in agri-food trade, these results are highly generalised and do not take into account differences between different EU states that may be relevant in this context. Some research exists in regard to circular trade between "unequal" trade partners, i.e., a developed and less developed nations, but this should extend to the European context, where differences are less stark than, for instance, circular trade between the most highly developed nations in the world, and the least. Furthermore, the trade relationship between the UK and EU will continue to evolve as the UK defines its national,

devolved, and international policies around agri-food value chains. These changes will ideally incorporate circular trade goals, which will continue to be pursued through and researched and ongoing bi-lateral discussions by both parties, alongside local circular economy-promoting measures.

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Appendix

Table I Citations for CLD Figure 5: "Overall EU-UK Circular Trade Drivers and Barriers"

Nodes (A->B)	(+) / (-)	Citation(s)
A: Domestic CE policy B: Trade protectionism	+	Barrie et al., 2022 Barrie & Schröder, 2021
A: EU-UK trade policy B: Trade protectionism	-	Barrie et al., 2022; Burchard et al., 2019
A: Brexit B: Trade protectionism	+	Coe et al., 2019; O'Carroll, 2022; Kren et al., 2022; Jeliffe et al., 2023
A: Policy Landscape B: CT/E-promoting Policy	+	Barrie et al., 2022; Barrie & Schröder, 2021
A: Trade protectionism B: CT/E-promoting Policy	-	Barrie et al., 2022; Burchard et al., 2019
A: Policy Landscape B: Governmental and private sector willingness […]	+	Despoudi et al., 2021; Paltrinieri et al., 2022 Ellen MacArthur Foundation, 2022
A: Policy Landscape B: CE/T starting cost	-	Kirchherr et al., 2018;
A: Governmental and private sector willingness […] B: CE/T-promoting policy	+	Kirchherr et al., 2018; Barrie et al., 2022 UNECE, 2021
A: CE/T-promoting policy B: CT R&D	+	Kirchherr et al., 2018; Barrie et al., 2022 Ellen MacArthur Foundation, 2021
A: CE/T-promoting policy B: Regulatory harmonization	+	Barrie et al. 2022; Rizos, 2021 Kircherr et al., 2018
A: CE/T-promoting policy B: IPR liberalisation	+	Ballardini et al., 2021; Oncel, 2023; Eppinger et al., 2021; Barrie et al., 2022
A: CT R&D B: Supply chain data gathering	+	Barrie et al., 2022; Despoudi et al., 2021;
A: Supply chain data gathering B: CT R&D	+	Barrie et al., 2022; Despoudi et al., 2021;
A: Supply chain data gathering B: CT Activity	+	Barrie et al., 2022; Despoudi et al., 2021; Kircherr et al., 2018
A: Regulatory homogenization B: CT Activity	+	Kirchherr et al., 2018; Barrie et al., 2022
A: Regulatory homogenization B: Supply chain data gathering	+	Barrie et al., 2022; Hina et al., 2023 Rizos et al, 2021
A: IPR liberalization B: II. Durable Goods CT	+	Barrie et al., 2022; Eppinger et al., 2021
A: CT Activity B: Material efficiency	+	Barrie et al., 2022; Kirchherr et al., 2018
A: I. Biological Product CT B: Environmental health	+	Ellen MacArthur Foundation, 2021
A: Environmnetal health B: I. Biological Product CT	+	Ellen MacArthur Foundation, 2021
A: CT Activity B: Waste	-	Barrie & Schröder, 2021; Despoudi et al., 2021
A: Material efficiency B: CE/T starting cost	-	Ellen MacArthur Foundation, 2021; Vegter et al., 2020
A: Material efficiency B: Natural resource extraction	-	Kircherr et al., 2018
A: Natural resource extraction B: Environmental health	-	Barrie et al., 2022
A: CE/T starting cost B: Governmental and private sector willingness […]	-	Kircherr et al., 2018
A: Waste B: Economic system sustainability	-	Barrie et al., 2022 Ellen MacArthur Foundation; 2021
A: CE/T starting cost B: CE/T profitability	-	Kircherr et al., 2018
A: Environmnetal health B: Economic system sustainability	+	Ellen MacArthur Foundation, 2021
A: Economic system sustainability B: Meeting climate goals	+	Steinfatt et al., 2020 Barrie et al., 2022
A: CE/T-profitability B: Governmental and private sector willingness […]	+	Kircherr et al., 2018
A: Circular market uncertainty B: Governmental and private sector willingness […]	-	Kircherr et al., 2018
A: Meeting climate goals B: Governmental and private sector willingness […]	+	Steinfatt et al., 2020