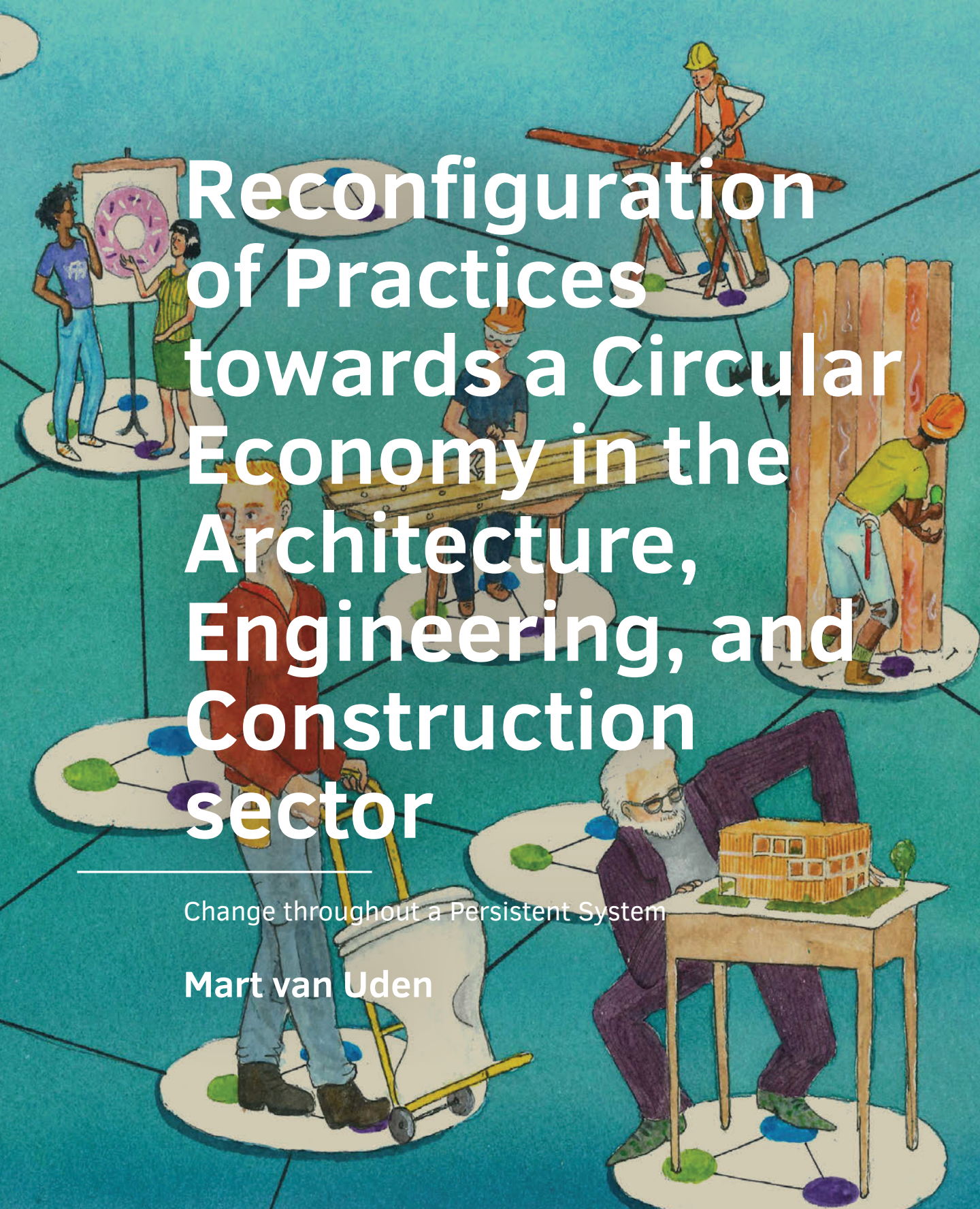

Reconfiguration of Practices towards a Circular Economy in the Architecture, Engineering, and Construction sector

Change throughout a Persistent System

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Reconfiguration of Practices towards a Circular Economy in the Architecture, Engineering, and Construction sector

Dissertation

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by the authority of the Rector Magnificus, prof.dr.ir. T.H.J.J. van der Hagen
chair of the Board for Doctorates
to be defended publicly on
Monday 26 May 2025 at 17:30 o'clock

by

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This dissertation has been approved by the promotors.

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Want het groote geschiedt niet bij impulsie alleen
en is een aaneenschakeling van kleine dingen die tot elkaar gebragt zijn

Great things happen not by impulse alone,
but by a series of small things brought together
[translation: author]

Vincent van Gogh (1882)

Acknowledgements

It has become a cliché that pursuing a PhD is a daunting task. One might start fresh and energetic, smiling and idealistic, but after years of hard work, often around the end of the second year, despair strikes when looking back at the few accomplishments and looking forward to the large pile of work, plans, and goals that somehow still needs attention. Furthermore, idealism often breaks down when confronted with harsh realities and systems that prove to be so path-dependent that they have become extremely difficult to change, despite all the energy and feelings of righteousness that a fresh PhD candidate is able to summon. Also, that whole idealistic goal that was set in the beginning turns out to be flawed in a myriad of ways. Then, when one starts to acknowledge that this whole trajectory is a Sisyphean task, many experience that in the end the PhD research is a task that you have to perform by yourself, and that in the end there is no one to fall back on, because so often no one directly depends on the work of a PhD candidate. And with that daunting task ahead, with that broken idealism, and in the end just alone, every Sisyphean PhD candidate has to walk down the mountain to pick up the dropped boulder and carry it back up again, knowing that that boulder will fall time and time again.

This was not my trajectory. And although I did experience some elements of this Sisyphean PhD trajectory, in the end my journey was a delightful one. I experienced great joy in being allowed to carry my boulder up the mountain on a daily basis and I see both value and pleasurable absurdity in the task of academic work with its large amounts of reading, endless re-writing, and nitty gritty of data analysis. For this reason, I think it is useful and proper to look back at those who have helped me experience my PhD journey as such, and I want to thank them in this chapter, knowing that my journey has been influenced by many and will therefore also forget some, for which I want to already state my apologies.

First of all, I want to thank my supervision team, my promotors Hans Wamelink and Ellen van Bueren, and my co-promotor Erwin Heurkens, who helped me individually, but also helped me greatly as a complimentary team. I have been very lucky with Hans as a first promotor. He taught me to perceive my PhD trajectory not as simply exercising academic work, but also as a project, with goals, sub-goals, planning, and many pragmatic choices that need to be made along the way to accomplish everything. Also Hans' personal touch, guiding me according to my needs at that moment, reflecting on my skills and preferred ways of working, helped enormously.

Ellen on the other hand, mostly guided me on becoming a good academic, focusing on theory and academic storytelling. Working with her kept reminding me of the joy of doing academic work and why I wanted to become an academic in the first place. Erwin has been a huge help in managing myself, helping to keep me focused, improving my writing skills and stimulating rigour in my methodologies, pushing me to take time off and cycle, and helping me deal with sometimes seemingly contradictory advice from my promotors. I owe you three a lot, as you helped me grow as an academic and a person, while keeping the atmosphere light and pleasurable throughout the four years we have been working together.

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Third, I would like to thank the members of the CBE hub. Having so many people working on the circular economy so often together in one place, is an absolute pleasure. For this I would like to thank the steering committee, with Tilmann (to whom the hub owes so much), Olga, Karel, Karlijn, Alexander, Nicolette, and Dirk, who have been organising so many meetings, workshops, video recording sessions, summer schools, etc. And I would also like to thank its many members with whom

I have had the pleasure to join the circularity discussions, to name a few: Felipe, Mohammad, Anna, Tamara, Andi, Anne, Lu, Tanya, Eline, Di, Brian, Piero, Saskia, Casper, David, Sultan, Vincent, Karlijn, Koray, and Mariette.

Fourth, I would like to thank the people of 01.West.700, both the regulars as the spontaneous joining ones, who have made coming to the office such a pleasure. As my PhD trajectory started in lock-down, coming to the office was a relief, especially with such a welcoming group, for which I want to mention: Lucy, Felipe, Nina, Erwin, Karlijn, Saskia, Marietta, Manja, Yawei, Joris, Karel, Vit, Anna, Macarena, Maarten, and Daniel.

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And lastly, but most importantly, I want to thank my partner, Tove. You have experienced most of all the effect of long working days, me being distracted by academic topics, or being numbed by weeks of coding, or anonymising data. And yet,

you have always stood by me, taken care of me when needed, and even enjoyed with me the excitement of academic victories, such as new publications, public events, and meeting my academic heroes. It has been such a pleasure to share this journey with you and I want to thank you for trodding along this path with me.

Without all of you this journey would have been very different and not at all as pleasurable as it has been. Thank you all!

Mart

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Summary

Changing interorganisational behaviour towards a circular economy

The Architecture, Engineering, and Construction (AEC) sector is a major contributor to CO_2 emissions and waste and responsible for a significant consumption of resources. As a response, in the Netherlands, the goal is to make the sector 50% circular by 2030 and fully circular by 2050, replacing the traditional linear, 'make-use-dispose' economy. The goal of a circular economy is to allow development that meets the needs of the present without limiting the needs of future generations.

Transitioning the AEC sector to circular practices is challenging due to factors like the long lifespan of buildings and extensive supply chains that impact the complexity of construction projects. Further, the transition faces significant barriers—technical, regulatory, and organisational—despite the demonstrated feasibility of sustainable construction. Recent academic research has tried to overcome this by focusing on defining circular economy principles, managing construction waste, and developing strategies to measure circularity and guide architectural design.

Despite these efforts, systemic change is limited. Focusing on behavioural change is seen as key to accelerating the transition. This research is part of the larger "Transitions and Behaviour" research program funded by NWO, focusing on how behavioural interventions in collaborative construction practices can support the shift to a circular economy. This dissertation addresses the gap in understanding how interorganisational behaviour and routinised practices within and outside construction projects influence setting and realising circular ambitions. From there it aims to find stepping stones for intervention that stimulate speeding up this transition.

The research in this dissertation initially seeks to understand how interorganisational behaviour within construction projects impacts the transition to a circular economy, but later expands its focus to examine how routinised practices within and around construction projects can accelerate the adoption of circular principles. By doing so, it aims to provide stepping stones for interventions and contribute to the academic debate on transitions and practices in general and the transition towards a circular economy in the architecture, engineering, and construction sector specifically.

Findings

Chapter 2 delves into the dynamics of interorganisational collaboration within the construction sector that help set and realise circular ambitions. Eight different circular construction projects have been researched through group interviews, which resulted in the following findings. There are dynamics that are prerequisites for setting and realising circular ambitions. These are top-down support from management, the establishment of equal partnerships within construction projects, setting shared circular goals among all stakeholders, and involve intrinsically motivated individuals in these projects, as delivering circular construction projects demands more effort and innovation than conventional construction. The chapter further explores the temporal dynamics of these projects, emphasizing the need for trust and transparency, flexibility, and reciprocal relationships among stakeholders. Further, a project team identity helps align team members towards the common goal of circularity. Additionally, circular construction projects often involve a redefinition of traditional roles, with some stakeholders taking on new responsibilities that challenge established norms in the industry. This can include pioneering leadership, a role that can be taken on by any project member. Lastly, continuity in staffing proves essential to go beyond the trodden path. Contextual factors, such as sector and organisational culture, knowledge flows, and power and tensions, are also identified as significant influences on the success of realising circular ambitions. The AEC sector is traditionally risk-averse and focused on short-term cost reductions, which can impede the adoption of innovative circular practices. The study notes that organisations must overcome these cultural barriers by fostering open communication and continuous learning.

Chapter 3 examines how two theoretical approaches—Sustainability Transitions Research (STR) and Social Practice Theory (SPT)—can be combined into crossover frameworks to better understand and guide sustainability transitions. The approaches are complementary: STR focuses on large-scale systemic changes, particularly in technology and institutions, while SPT emphasizes everyday practices and how they evolve over time. A systematic literature review has been conducted to analyse existing research, focusing on how these two approaches can complement each other. The results show six different crossover frameworks that integrate elements from both approaches. These frameworks provide various ways to conceptualize and analyse transitions, focusing on different aspects such as the interaction between niche-practices and regimes, the role of shared elements like infrastructure and social norms in shaping practices, and focus points for intervention that affect regimes and practices. Some frameworks are better suited for analysing complex systems, while others focus more on local practices or specific moments in a transition. Surprisingly, incorporation of an element of time misses in most frameworks, as most current frameworks focus on a static moment

in a transition. The study concludes that combining STR and SPT provides a more comprehensive understanding of sustainability transitions, allowing researchers to capture both the systemic and practice dynamics that drive change.

Chapter 4 investigates the challenges and pathways for transitioning the Architecture, Engineering, and Construction sector toward a circular economy. It presents a study that explores two case studies in the Netherlands, one applying the dynamics for circularity as found in chapter 2, and one not. The study focuses on the alignment and misalignment of practices related to seven circular design strategies. For this, it applies a crossover framework from chapter 3, using Social Practice Theory and elements from the multilevel perspective. The research analyses how different interorganisational practices, support or hinder each other in setting and realising circular ambitions. Key findings highlight the significant misalignments that impede the transition, especially relating to design with secondary resources. Some significant misalignments stem from different notions on quality, aesthetics, and safety. Others relate for instance to rapid municipal decision-making that does not align with the extra time needed in construction projects to research and realise circular solutions. The study further emphasises the need for better coordination between urban planning and project planning, and reconsideration of value priorities and assessment (e.g. should safety be interpreted differently or should less priority be put on function optimisation, thus leaving room for design with existing buildings). The study concludes that for the AEC sector to successfully transition to a circular economy, systemic changes are necessary that include improved collaboration and clearer policies, allowing practices to reconfigure so as to better align with circular ambitions.

Chapter 5 explores the role of Circular Building Hubs (CBH's) in driving the transition toward a circular economy within the construction industry. It focuses on how CBH's contribute to reusing construction components, analysing their potential and limitations in fostering systemic changes. A series of interviews, observations, workshops, and focus groups was conducted with employees of eight circular building hubs, architects, suppliers, sales platform employees, and non-academic experts. Past and potential future reconfigurations in practices surrounding CBH's. It was found that around CBH's practices have reconfigured, such as deconstruction (in contrast to traditional demolition). However, challenges in selling components and integrating reused materials into construction projects persist. This mostly relates to procurement processes and design skills related to reuse. Practitioners expect CBH's to professionalise and grow in the near future, but to shrink or disappear in the far future, when a digital built environment makes hubs irrelevant. The study concludes that CBH's are valuable as temporary drivers in the transition to a circular economy, helping to reconfigure industry practices in the short term, but in the long practitioners do not see them as structural implementation for a circular economy, only as an intermediate step.

Conclusion

This dissertation focuses on accelerating the transition to a circular economy in the AEC sector by reconfiguring practices, which all relate to interorganisational collaboration. The success of this reconfiguration relies on aligning practices throughout the AEC sector and beyond regarding circularity. By analysing construction projects, circular building hubs, and their broader environments through the lenses of Social Practice Theory and Sustainability Transitions Research, and incorporating elements from organisational studies, the dissertation provides valuable insights into this transition towards a circular economy. It emphasizes that while global environmental pressures drive the need for circular practices, the fragmented nature of the AEC sector and the complexity that stems therefrom hinders progress, reinforcing traditional methods. The research highlights that improved collaboration within interorganisational projects, using the previously described dynamics for circularity (e.g. flexibility), can foster decision-making for circularity, though these efforts often diminish further along the supply chain. The use of crossover frameworks that combine Social Practice Theory and Sustainability Transitions Research offers a way to capture both systemic changes and the barriers to them. By offering the logic regarding the ontological compatibility between these two approaches and presenting six applicable frameworks that can be used to analyse and steer systemic change through practices by researchers and policymakers, this dissertation contributes to the academic debate on transitions and behaviour and offers tools that can be applied beyond the AEC sector.

This is highly needed, as this research highlights that there are still many steps that need to be taken to transition towards a circular economy in the AEC sector. The outcome of this research is therefore not a single focus point that needs attention, but a myriad of changes in practices that need to consistently re-align with each other. This research also emphasizes the various roles that practitioners play in advancing the transition to a circular construction economy. Practitioners are encouraged to engage in learning and experimentation with circular construction projects. Practitioners setting up construction projects are advised to prioritize collaboration and redefine roles and responsibilities to further speed up the transition. One of the key recommendations is recognizing the importance of flexibility in managing circular projects, given their inherent uncertainties. Further, practitioners should appoint individuals within project teams to maintain a focus on circular goals. Additionally, of the myriad changes that are needed, this research highlights specific categories: public clients are advised to show greater ambition in procurement, particularly regarding the reuse of building materials, by engaging

with Circular Building Hubs and exploring market opportunities for secondary building components. Practitioners are encouraged to adopt a systemic perspective, understanding the broader impacts of their decisions and fostering accountability across all stakeholders. This requires open discussions about underlying values, such as safety, function, and beauty, which are crucial for aligning circular ambitions.

Samenvatting

De dissertatie gebruikt verschillende kernconcepten die lastig te vertalen zijn naar het Nederlands, zoals ‘practices’, ‘(mis)alignment’, en ‘reconfiguration’. Om dicht bij de terminologie van het onderzoek te blijven, zijn deze concepten grotendeels letterlijk vertaald in deze samenvatting.

Interorganisationele gedragsverandering voor een circulaire economie

De bouwsector levert een grote bijdrage aan de uitstoot van CO_2 en afvalproductie, en is verantwoordelijk voor een aanzienlijk verbruik van grondstoffen. In Nederland is daarom het doel gesteld om de sector vanaf 2030 voor 50% circulair te maken en vanaf 2050 volledig circulair. Daarmee vervangt deze circulaire economie de traditionele lineaire 'maak-gebruik-gooi weg'-economie. Het doel van een circulaire economie is om ontwikkeling mogelijk te maken die voldoet aan de behoeften van het heden zonder daarmee de behoeften van toekomstige generaties te beperken.

De transitie van de bouwsector naar een circulaire economie is desalniettemin uitdagend. Dit komt door factoren zoals de lange levensduur van gebouwen en lange toeleveringsketens, die de complexiteit van bouwprojecten vergroten. Daarnaast ervaren actoren technische, regelgevende, en organisatorische barrières, ondanks de aangetoonde haalbaarheid van duurzame bouw. Academici hebben in recente wetenschappelijke studies geprobeerd deze obstakels te overkomen door te focussen op het definiëren van de grondbeginselen van een circulaire economie, het managen van bouwafval, en het ontwikkelen van strategieën om circulariteit te meten en architectonisch ontwerp aan te sturen op circulariteit.

Ondanks deze inspanningen blijft systeemverandering vooralsnog beperkt. Onderzoekers en beleidsmakers zien, gegeven deze context, gedragsverandering als een mogelijkheid om de transitie te versnellen. Dit onderzoek maakt deel uit van het grotere "Transitions and Behaviour"-onderzoeksprogramma, gefinancierd door NWO, met als doel te onderzoeken hoe gedragsinterventies in samenwerkingen binnen de bouwsector de transitie naar een circulaire economie kunnen ondersteunen. Dit proefschrift richt zich op de kennislacune in het begrip van hoe interorganisationeel gedrag en geroutineerde praktijken binnen en buiten bouwprojecten de vaststelling

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en realisatie van circulaire ambities beïnvloeden. Vanuit dit uitgangspunt is vervolgens geprobeerd om interventies te vinden die de versnelling van deze transitie kunnen stimuleren.

Het onderzoek in dit proefschrift begint met het begrijpen van hoe interorganisationeel gedrag binnen bouwprojecten de transitie naar een circulaire economie beïnvloedt, maar breidt zich later uit naar hoe geroutineerde praktijken binnen en rondom bouwprojecten de adoptie van circulaire principes kunnen versnellen. Door dit te doen, beoogt het proefschrift handvatten voor interventies te bieden. Daarnaast draagt het bij aan het academische debat over transities en praktijken in het algemeen, en specifiek de transitie naar een circulaire economie in de bouwsector.

Bevindingen

Hoofdstuk 2 behandelt de dynamieken van interorganisationele samenwerking binnen de bouwsector die helpen bij het vaststellen en realiseren van circulaire ambities. Acht verschillende circulaire bouwprojecten zijn onderzocht via groepsinterviews, wat resulteerde in de volgende bevindingen. Er zijn dynamieken die als randvoorwaarde dienen voor het vaststellen en realiseren van circulaire ambities. Dit zijn top-down steun van het management, het opzetten van gelijkwaardige samenwerkingsverbanden binnen bouwprojecten, het stellen van gedeelde circulaire doelen onder alle belanghebbenden en het betrekken van intrinsiek gemotiveerde mensen in deze projecten, aangezien het uitvoeren van circulaire bouwprojecten meer inspanning en innovatie vereist dan conventionele bouw. Het hoofdstuk gaat ook dieper in op de ‘temporele’ dynamieken van deze projecten, met nadruk op de noodzaak van vertrouwen en transparantie, flexibiliteit en wederkerige relaties tussen de betrokkenen. Daarnaast helpt een projectteamidentiteit om de teamleden op één lijn te brengen richting het gemeenschappelijke doel van circulariteit. Verder vereisen circulaire bouwprojecten vaak een herdefiniëring van traditionele rollen. Hierbij worden sommige actoren gestimuleerd om nieuwe verantwoordelijkheden op zich te nemen die de gevestigde normen in de sector ter discussie stellen. Dit kan zich bijvoorbeeld uiten in pionierend leiderschap, een rol die door elk teamlid kan worden vervuld, niet enkel door de formele projectleider. Ten slotte blijkt continuïteit in het personeelsbestand essentieel om gebaande paden te verlaten. Contextuele factoren, zoals de cultuur binnen de sector en organisaties, kennisstromen, en machtsverhoudingen, hebben ook grote invloed op het succes van het realiseren van circulaire ambities. De bouwsector is van oudsher risicomijdend en gericht op kostenbesparingen op korte termijn, wat het aannemen van innovatieve circulaire praktijken vaak belemmert. Dit onderzoek stelt dat organisaties deze culturele barrières moeten overkomen door open communicatie en het voortdurend bevorderen van leerprocessen.

Hoofdstuk 3 onderzoekt hoe twee theoretische benaderingen—Sustainability Transitions Research (STR) en Social Practice Theory (SPT)—kunnen worden gecombineerd in crossover-frameworks om duurzaamheidstransities beter te begrijpen en te beïnvloeden. Deze benaderingen vullen elkaar aan: STR richt zich op grootschalige systeemveranderingen, met name in technologie en instituties, terwijl SPT zich richt op alledaagse praktijken en hoe deze in de loop van de tijd evolueren. Een systematische literatuurstudie is uitgevoerd om bestaand onderzoek te analyseren, met de focus op hoe deze twee benaderingen elkaar kunnen aanvullen. De resultaten tonen zes verschillende crossover-frameworks die elementen van beide benaderingen integreren. Deze frameworks bieden verschillende manieren om transities te conceptualiseren en analyseren. Ze richten zich bijvoorbeeld op aspecten zoals de interactie tussen niche-praktijken en regime-praktijken, de rol van gedeelde elementen zoals infrastructuur en sociale normen in het vormgeven van praktijken, en interventiepunten die zowel regimes als praktijken beïnvloeden. Sommige frameworks zijn beter geschikt voor het analyseren van complexe systemen, terwijl andere zich meer richten op lokale praktijken of specifieke momenten in een transitie. Verrassend genoeg ontbreekt in de meeste frameworks een element van tijd, omdat de meeste huidige frameworks zich richten op een statisch moment in een transitie. De studie concludeert dat de combinatie van STR en SPT een meer omvattend begrip van duurzaamheidstransities biedt dan de afzonderlijke benaderingen. Hierdoor kunnen onderzoekers zowel de systeem- als praktijkdynamieken vastleggen die veranderingen teweegbrengen.

In hoofdstuk 4 worden de uitdagingen en richtingen voor de transitie van de bouwsector naar een circulaire economie onderzocht. De studie bevat twee cases in Nederland, waarvan één de dynamieken voor circulariteit toepast zoals gevonden in hoofdstuk 2, en één niet. De studie richt zich op de afstemming en misafstemming van praktijken met betrekking tot zeven circulaire ontwerpstrategieën. Hiervoor wordt een crossover-framework uit hoofdstuk 3 toegepast, met gebruik van Social Practice Theory en elementen uit het multilevel perspective. Het onderzoek analyseert hoe praktijken in een verscheidenheid van organisaties elkaar ondersteunen of belemmeren bij het vaststellen en realiseren van circulaire ambities. Er zijn veel misafstemmingen gevonden die de transitie belemmeren, vooral met betrekking tot ontwerpen met secundaire grondstoffen. Sommige significante misafstemmingen komen voort uit verschillende opvattingen over functionaliteit, esthetiek, en veiligheid. Andere hebben bijvoorbeeld betrekking op snelle gemeentelijke besluitvorming die niet in lijn is met de extra tijd die nodig is in bouwprojecten om circulaire oplossingen te onderzoeken en te realiseren. De studie benadrukt verder de noodzaak van betere coördinatie tussen stadsplanning en projectplanning, en het heroverwegen van kernwaardes en hun prioriteiten (bijvoorbeeld of veiligheid anders moet worden geïnterpreteerd of dat minder

prioriteit moet worden gegeven aan functieoptimalisatie, zodat er ruimte ontstaat voor ontwerpen met bestaande gebouwen). De studie concludeert dat er voor de bouwsector systeemveranderingen nodig zijn om succesvol over te gaan naar een circulaire economie. Voorbeelden hiervan zijn verbeterde samenwerking tussen afdelingen en organisaties en helderder nationaal beleid, wat de mogelijkheid geeft om praktijken te herconfigureren zodat ze beter in lijn zijn met circulaire ambities.

Hoofdstuk 5 onderzoekt de rol van Circulaire Bouwhubs (CBH's) in het aandrijven van de transitie naar een circulaire economie binnen de bouwsector. Het beschrijft hoe CBH's bijdragen aan het hergebruiken van bouwcomponenten, en analyseert de potentie en de beperkingen van de hubs voor systeemverandering. Er zijn interviews, observaties, workshops en focusgroepen uitgevoerd met medewerkers van acht circulaire bouwhubs, architecten, leveranciers, medewerkers van verkoopplatformen, en niet-academische experts. Zowel herconfiguraties in praktijken rondom CBH's in het verleden als in de toekomst zijn onderzocht. Het onderzoek laat zien dat verschillende praktijken rondom CBH's zijn hergeconfigureerd, zoals deconstructie (in tegenstelling tot traditionele sloop). Echter, er blijven uitdagingen bestaan rondom de verkoop van componenten en het integreren van hergebruikte materialen in bouwprojecten. Dit heeft voornamelijk te maken met inkoopprocessen en ontwerpvaardigheden met betrekking tot hergebruik. Geïnterviewden verwachten dat CBH's in de nabije toekomst zullen professionaliseren en groeien, maar dat ze op de lange termijn zullen krimpen of verdwijnen op het moment dat een digitale gebouwde omgeving hubs overbodig maakt. De studie concludeert dat CBH's waardevol zijn als tijdelijke stimulator in de transitie naar een circulaire economie, omdat ze helpen bij de herconfiguratie van praktijken in de industrie op korte termijn, maar dat ze op de lange termijn niet als structurele oplossing worden gezien, enkel als behulpzame tussenstap.

Conclusie

Dit proefschrift richt zich op het leveren van een bijdrage op het versnellen van de transitie naar een circulaire economie in de bouwsector, door middel van het herconfigureren van praktijken door de gehele sector heen met betrekking op interorganisationele samenwerking. Succesvolle herconfiguratie hangt af van de afstemming van deze praktijken in relatie tot circulariteit. Door bouwprojecten, circulaire bouwhubs en hun bredere omgevingen te analyseren door de lenzen van Social Practice Theory en Sustainability Transitions Research, en elementen van organisatieonderzoek te integreren, biedt dit proefschrift waardevolle inzichten in de transitie naar een circulaire economie. Het benadrukt dat er weliswaar mondiale druk is die het gevoel voor de noodzaak van circulaire praktijken aanjaagt, maar dat tegelijkertijd de gefragmenteerde aard van de bouwsector – en de complexiteit

die dit veroorzaakt – de transitie vertraagt en traditionele werkwijzen versterkt. Het onderzoek wijst erop dat verbeterde samenwerking binnen interorganisationele projecten, met behulp van de hiervoor beschreven dynamieken voor circulariteit (e.g. flexibiliteit), besluitvorming voor circulariteit kan bevorderen, hoewel de invloed hiervan vaak afneemt in de verdere toeleveringsketens. Het gebruik van crossover-frameworks die Social Practice Theory en Sustainability Transitions Research combineren, biedt een manier om zowel systeemveranderingen als de barrières daarvoor vast te leggen. Door de ontologische compatibiliteit tussen deze twee benaderingen uit te diepen en zes toepasbare frameworks te presenteren die onderzoekers en beleidsmakers kunnen gebruiken om transities middels praktijken te bestuderen en te sturen, draagt dit proefschrift bij aan het academische debat en biedt het hulpmiddelen die mogelijk ook buiten de bouwsector kunnen worden toegepast.

Dit is hoog nodig, want dit onderzoek toont aan dat er nog veel stappen gezet dienen te worden voor de transitie naar een circulaire economie in de bouwsector. Dit onderzoek benadrukt dat er niet een enkel focuspunt is waar aandacht aan gegeven zou moeten worden, maar dat er een veelvoud van kleine veranderingen nodig is in praktijken die vervolgens consistent in afstemming met elkaar moeten worden gebracht. Dit onderzoek benadrukt verder de verschillende rollen die stakeholders spelen in het bevorderen van de transitie naar een circulaire bouweconomie. Stakeholders worden aangemoedigd om te leren van en te experimenteren in circulaire bouwprojecten. Aan degenen die bouwprojecten opzetten, wordt geadviseerd prioriteit te geven aan samenwerking en rollen en verantwoordelijkheden opnieuw te definiëren om de transitie verder te versnellen. Een van de belangrijkste aanbevelingen is het belang van flexibiliteit te erkennen bij het managen van circulaire projecten, gezien de onzekerheden die spelen bij dit soort ambities. Verder, van de vele veranderingen die er nodig zijn, is het goed om nadrukkelijker in te zoomen op de volgende onderwerpen. Stakeholders zouden individuen moeten aanstellen binnen projectteams die de focus op circulaire doelen behouden. Daarnaast wordt openbare opdrachtgevers geadviseerd meer ambitie te tonen bij inkoop, met name wat betreft het hergebruik van bouwmaterialen. Dit kan mogelijk gemaakt worden door samen te werken met Circulaire Bouwhubs en beter de marktkansen voor secundaire bouwcomponenten te verkennen. Stakeholders worden aangemoedigd om een systemisch perspectief aan te nemen, de bredere impact van hun beslissingen te begrijpen, en verantwoording te stimuleren bij alle betrokken partijen. Dit vereist open discussies over onderliggende waarden, zoals veiligheid, functie, en esthetiek, die cruciaal zijn voor het afstemmen van circulaire ambities.

1 Introduction

1.1 Transition to a Circular Economy in the Architecture, Engineering, and Construction system

Anne, a real estate developer, had a tough time. She had written the company policy on circularity, but faced with reality, it was hard, if not impossible, to realise many of the grand ambitions she had set for herself in the tower she was developing. The plan was to use residual flows from the local tiles factory, but this did not suffice for the complete building. It would just be enough, if she was lucky, for the entrance way. In theory it was possible to make the building adaptable for future changes – walls could change position - but she was sceptical if that was likely to happen in practice. There were plans for technical innovations for energy use and generation, but there was so little time to properly dive into possible solutions. The municipality also did not help. They demanded a sculpture, an expensive, energy inefficient shape, due to the many square meters of façades. They did not set any ambitious demands regarding circularity. Doing more than the minimum made the building so expensive that her company would not make any profit from it anymore. Anne had an intrinsic motivation to do more but felt hindered by a myriad of systemic barriers.

This anecdote, based on one of the conducted interviews for this research, shows some of the barriers practitioners face when developing circular buildings. There is a pressing need to overcome these though. The Architecture, Engineering, and Construction (AEC) sector is one of the largest producers of CO_2, and one of the largest consumers of energy and resources in the world (UNEP, 2020). As a response, similar to other countries in the EU, in the Netherlands, covenants and policy documents state that in 2030 50% of the AEC sector should be circular and 100% in 2050 (NL, 2016). The intention is that this circular economy should replace the linear economy that relies on the principle of 'make-use-dispose' (Kirchherr, Reike, & Hekkert, 2017; Leising, Quist, & Bocken, 2018). Nobre and Tavares (2013; 2021, p. 18) define a circular economy as follows:

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"an economic system that targets zero waste and pollution throughout materials lifecycles, from environment extraction to industrial transformation, and to final consumers, applying to all involved ecosystems. Upon its lifetime end, materials return to either an industrial process or, in case of a treated organic residual, safely back to the environment as in a natural regenerating cycle. It operates creating value at the macro, meso and micro levels and exploits to the fullest the sustainability nested concept. Used energy sources are clean and renewable. Resources use and consumption are efficient. Government agencies and responsible consumers play an active role ensuring correct system long-term operation."

The goal of a circular economy is therefore similar to many sustainable models; allow development that meets the needs of the present without limiting the needs of future generations (Munaro, Tavares, & Bragança, 2020). The limitation stems from the boundaries of planet earth and its resources. However, the practical concepts used in a circular economy demand even more radical change than many other sustainable visions insinuate, because circular economy explicates strategies to continuously sustain the circulation of resources and energy within a quasi-closed system (Nasir, Genovese, Acquaye, Koh, & Yamoah, 2017), throughout the sector and beyond (Heurkens & Dąbrowski, 2020). Yet, despite this radical demanded change, because of the combination of environmental quality and economic growth, it became a popular alternative as a framework for change (Sauvé, Bernard, & Sloan, 2016).

Changing the sector to build more circular is not a simple task, as it not only involves a technical change, but also changes regarding user practices, regulations, industrial networks, infrastructure, and symbolic meanings (Geels, 2002; Kirchherr et al., 2018). Further, unlike many other sectors, buildings have a particular long lifespan that affects the way in which they generate waste and make environmental impacts (Ossio, Salinas, & Hernández, 2023). Lastly, buildings are usually one-off projects with extensive supply chains that impact their complexity (Benachio, Freitas, & Tavares, 2020). Since this change affects actors throughout the sector, on different levels, with different aspects and dimensions, we can speak of a transition (Köhler et al., 2019). Moving the transition forward has been proven difficult, since there are several institutional, organisational, and psychological barriers which slow down the mainstreaming of these processes (Brown & Vergragt, 2008; Van Bueren & Broekhans, 2013a). This hinders the transition, even though many construction projects have shown that sustainable construction can live up to conventional construction methods in terms of costs and quality (Van Bueren & Broekhans, 2013a).

In the last decade, and especially during the trajectory of this research (2020-2024), the state of the circular economy has changed in the AEC sector, regarding both practice and (academic) research (Hossain, Ng, Antwi-Afari, & Amor, 2020; Ossio et al., 2023). In the Netherlands, several national initiatives have started that developed a common understanding of what a circular economy means in the sector. This resulted in a variety of products, such as a common lexicon (CB'23, 2024), guidelines for circular construction (CB'23, 2023), ways to measure circularity (CB'23, 2020), norms, and learning platforms (Cirkelstad, n.d.). Also, many public and private organisations have developed circular policies (Bucci Ancapi, 2023). All of this fits the first stage of the transition path, experiment, laid out by CB'23 (2020), as shown in figure 1.1.

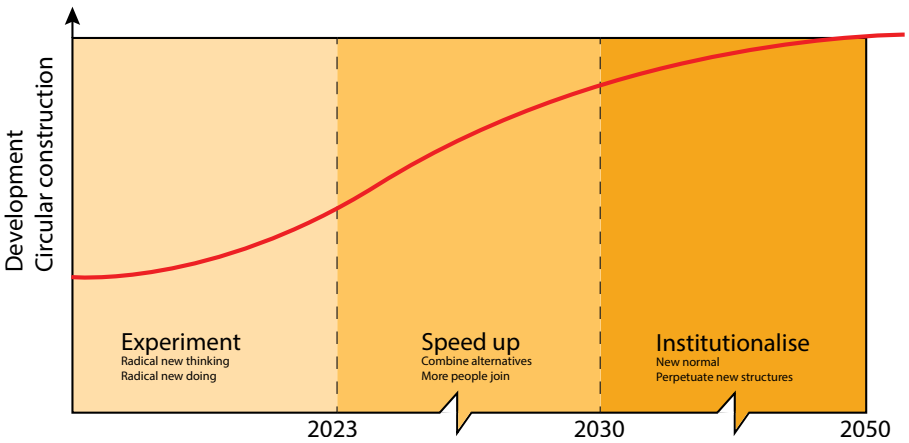

FIG. 1.1 Trajectory transition circular economy in AEC sector (based on CB'23 (2020))

In the last decade, academically, much emphasis has been put on defining a circular economy (Kirchherr et al., 2017; Ossio et al., 2023), construction and demolition waste management (Zhang et al., 2022), making it quantifiable, using Life Cycle Analysis and Material Flow Analysis (Hossain et al., 2020), and developing design strategies (Cambier, Galle, & De Temmerman, 2020) and business models (Leising et al., 2018). This is mostly related to the levels of individual materials and cities (Hossain et al., 2020; Pomponi & Moncaster, 2017).

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1.2 Transitions and Behaviour

1.2.1 Transitions...

In this dissertation transitions are understood as a structural changes of a societal system (e.g. a technological system) that itself resides in a system of systems (e.g. political, legislative, economical) that affects formal structures (e.g. physics, legislation, economics), informal structures (e.g. culture, ideologies, discourse), and practices (e.g. routines, habits, procedures) (de Haan & Rotmans, 2011). Transitions encompass many different actors (Geels, 2005), concern multiple aspects (Heurkens & Dąbrowski, 2020), are path-dependent, and progress non-linearly (Wittmayer & Loorbach, 2016).

Taking such a transition lens is an increasingly common way to look at change, because it recognises that many environmental problems (e.g. climate change) comprise large societal challenges that cannot be overcome by incremental change (Köhler et al., 2019). The transition lens has also been increasingly applied in the AEC sector (e.g. Gibbs & O'Neill, 2015; Van Bueren & Broekhans, 2013a), although this is not yet common and still considered in its early stages (Cândido, Lazaro, Freitas e Silva, & Barros Neto, 2023).

1.2.2 ... and behaviour

Despite the emergence of so-called 'transition managers' (Shiroyama & Kajiki, 2016), it is often stated that due to the complexity of societal systems, transitions cannot be managed in terms of command and control (e.g. Rotmans & Loorbach, 2009). Scholars therefore often turn to behaviour, as the daily practices of actors can be governed (Shove & Walker, 2010), because they provide loci for interventions (van Marrewijk, 2022). This does not mean the scale is downplayed, as a societal transition is in the end a transition of many interrelated behaviours (Watson, 2012).

This research is funded by NWO and part of the larger programme Transitions and Behaviour. This programme started in 2019 and funded a total of 12 projects. The aim is to research how behaviour and behavioural change can make transitions possible and accelerate these (Dutch Research Council (NWO), n.d.). Projects

concern a variety of sectors, such as food, mobility, energy, and, such as this project, the architecture, engineering, and construction sector. It is unsurprising that NWO started this programme, as many scholars see potential in further steering transitions through behavioural change in general (Köhler et al., 2019; Shove & Walker, 2010) and in the transition of the AEC sector towards a circular economy in particular (Pomponi & Moncaster, 2017).

The TranCiBo project, of which this research is part, is one of the 12 funded projects of the NWO programme. The aim of TranCiBo is to explore, reflect, and learn from behavioural interventions in collaborative practices in the design phase of circular construction projects to support the transition to a circular and low-carbon construction economy (van Marrewijk, 2022). To further support and add to that, this PhD research specifically was designed to take a more systemic perspective and not merely focus on the design phase of construction projects. There is a consortium associated with the research project, which consists of architects, contractors, public clients, branch organisations, and the knowledge platform Cirkelstad.

1.3 Problem Statement

This section discusses the problem statement. It starts off with problems in practice. This will provide context and highlights the *raison d'être* for academic research. After this, the section dives deeper into the academic reasoning behind this research, as it discusses the research gap, aim, and questions.

1.3.1 Problems in practice

The AEC sector is one of the largest producers of CO_2 and waste and one of the largest consumers of energy and resources (UNEP, 2022). This is not only caused by the nature of construction products, which are large and heavy, but also due to the relatively low efficiency of resources (Migliore, Talamo, & Paganin, 2020). To tackle this, several top-down policy initiatives from the EU have been brought forth, but they do not always generate circular outcomes due to a variety of reasons, e.g. lack of economic initiatives, lack of data, and vague legislation (Migliore et al., 2020). The specific reasons vary extensively per country. In order to get a grasp on the specific reasons in

their national contexts, research is needed that explains current practices in and around the AEC sector that enable or inhibit the setting and realisation of circular ambitions. The problem addressed in this research is that of the lack of understanding of these practices and how these influence the transition as a whole. This is highly needed, as research shows that the transition is not developing fast enough(Hanemaaijer et al., 2023), and that many actors are not changing their practices, even when they state they want to (Eikelenboom & van Marrewijk, 2023; Hanemaaijer et al., 2025).

1.3.2 Research gap

Whereas early CE research largely focused solely on a systemic scale (Pomponi & Moncaster, 2017), or on development and application of evaluation criteria (Hossain et al., 2020), scholars state that real-life actors' practices are understudied but very important to understand what enables and what inhibits the setting and realisation of circular ambitions in construction projects (Hossain et al., 2020; Leising et al., 2018; Pomponi & Moncaster, 2017), as well as to better understand (how to speed up) transitions (Köhler et al., 2019; Shove & Walker, 2010) and interventions to make that happen (van Marrewijk, 2022). The gap particularly concerns the level of buildings, as recent systemic literature reviews show that individual materials and cities (though often conceptualised as eco-cities) have had more academic attention (e.g. Hossain et al., 2020; Pomponi & Moncaster, 2017). These construction projects are difficult to manage in general, but even more when they regard innovation, as they are interorganisational projects (Wamelink & Heintz, 2015). Much is still unknown about how interorganisational behaviour can influence transitions (Eikelenboom & van Marrewijk, 2023).

Scholars further acknowledge that behaviour is not only important but understudied within projects, but also outside projects, since behaviour outside construction projects also influence practices within these projects that enable or inhibit realising circular ambitions in construction projects (e.g. Badi & Murtagh, 2019; Dokter, Thuvander, & Rahe, 2021; Leising et al., 2018; Superti, Houmani, & Binder, 2021). Little is known about how behaviour in various new (more circular) supply chains affects behaviour of other actors in the supply chain (Badi & Murtagh, 2019). Further, (behaviour concerning) the creation of laws and policy (Migliore et al., 2020), and economic market mechanics (Aagaard, 2019) are important elements for the realisation of circular ambitions in construction projects, even though they are not part of construction projects themselves. Also behaviour within client organisations are important for the realisation of circular ambitions (Gann & Salter, 2000; Wamelink & Heintz, 2015), even though they are not a part of the AEC

sector, how it is traditionally defined (Underwood & Isikdag, 2009). Scholars often state the necessity of taking on a holistic perspective when dealing with behaviours (e.g. Badi & Murtagh, 2019), underlining the importance of not tackling these knowledge gaps one by one, but as a whole.

In transitions in general, there has been some effort to bridge these knowledge gaps, e.g. through studies on power relations (e.g. Avelino & Wittmayer, 2016), through studies that focus on user behaviour (e.g. Schot, Kanger, & Verbong, 2016), and through studies that focus on how daily practices influence transitions (Hargreaves, Longhurst, & Seyfang, 2013; Watson, 2012). However, proper understanding of how daily behaviour in the context of construction projects influence transitions is still lacking (Geels, 2018; Köhler et al., 2019; Leising et al., 2018; Pesch, Vernay, van Bueren, & Pandis Iverot, 2017; Pomponi & Moncaster, 2017).

This research therefore has a substantive and a formal research gap (Bowen, 2006; Glaser & Strauss, 2017). The substantive research gap, concerning empirical questions, regards the transition towards a circular economy in the architecture, engineering, and construction industry. The formal research gap, concerning conceptual questions, regards the conceptualisation of behaviour in transitions.

1.3.3 Research aim

The first part (chapter 2) of this research addresses this knowledge gap with the aim to create an understanding of interorganisational behaviour in and around construction projects with circular ambitions, focusing on the dynamics that help speed up the transition towards a circular economy. As a result from the first findings, presented in chapter 2, it became clear that a more fundamental understanding of behaviour was needed, as well as a wider scope than just construction projects. The aim therefore shifted towards creating an understanding of practices that help or hinder the transition towards a circular economy in the architecture, engineering, and construction sector. Practices are defined as ways of doing and saying in different moments, at different places, by different bodies and minds (Reckwitz, 2002). They are routinized forms of behaviour consisting of various interconnected elements: meanings (e.g. motivation), materials, and skills (e.g. know-how). This shift from interorganisational behaviour in projects to practices in transition is further explained in 1.4 Research Approach. Both of these should be regarded as specific conceptualisations of the larger term ‘behaviour’, as it has been presented in the NWO proposal and how it is often used in earlier literature on this specific transition (e.g. Pomponi & Moncaster, 2017).

In the second part (chapter 3-5), this research focuses on understanding practices that enable and inhibit the realisation of circular ambitions in construction projects and its relation to the transition towards a circular economy as a whole. Practices in projects are chosen as focus points, because innovation in the construction sector is often brought about through projects (Reindl & Palm, 2020; Winch, 1998) and projects can be portals for transitions (Van Bueren & Broekhans, 2013a). More specifically, practices around the design phase of projects are chosen as focus points, since here the most influential decisions are made concerning sustainability (Bragança, Vieira, & Andrade, 2014; Reindl & Palm, 2020). However, following from first results, this research will not be limited to the scope of construction projects, but also incorporates practices from outside projects that influence practices in projects, such as practices concerning the creation of policies, and practices concerning financers. This is needed, because practices within the project cannot properly be understood without understanding influencing practices from outside the project (Dokter et al., 2021; Leising et al., 2018; Superti et al., 2021).

Concludingly, this research starts out with the aim to create an understanding of how interorganisational behaviour in construction projects influences the transition towards a circular economy in the architecture, engineering, and construction sector. After chapter 2 this shifts to creating an understanding of how practices in the architecture, engineering, and construction sector and its environment influence the setting and realisation of circular ambitions in construction projects, and how these (changing) practices can aid to a circular transition in the architecture, engineering, and construction sector. By doing this, this research also aims to create knowledge upon which interventions can be based, and to add to the larger academic debate that focuses on both transitions and practices.

1.3.4 Research questions

This section explains the research questions behind this research and provides concepts and context needed to understand these questions.

Based on the debates of existing literature and the research gap, the main research question is defined as:

— How do practices within the AEC-sector and its environment influence the setting and realisation of circular ambitions in construction projects and the transition towards a CE in the AEC-sector?

To research this main question, four questions and four corresponding studies are used to capture different elements of the overall research question. Knowledge from earlier studies/chapters have influenced later studies/chapters and also the research questions have therefore follow from earlier findingsbeen constructed based on earlier findings, as will be discussed in more detail in 1.4.4.

The first question concerns dynamics in construction projects that help realise circular ambitions. These dynamics are defined as "the processes of relating activities across boundaries to maintain patterns of change and continuity through time, and to the forces that produce these patterns" (Cropper & Palmer, 2008, p. 636). In context of the main research question, we therefore understand these dynamics as processes that can help reconfigure practices in construction processes. This results into research question 1:

— **RQ1.** *Which dynamics in the execution of interorganisational construction projects are relevant to realise their circular ambitions, and how do these projects contribute to the transition towards a circular economy?*

The second question is not a substantive (i.e. relating to empirical questions), but a formal (i.e. relating to concepts) question. It concerns the combination of practices and transitions. Many scholars see potential in crossovers between Social Practice Theory and Sustainability Transitions Research (e.g. Geels, 2010). Crossovers are defined as interplay of concepts between two different approaches. They therefore do not aim to synthesise approaches, but use insights from both, while still staying true to the foundations of both (Geels, 2010; Moore, King, Dale, & Newell, 2018). By answering this question, the results offer frameworks that can be used to study the transition towards a circular economy in the architecture, engineering, and construction sector. The results of this study therefore explicitly informed research questions 3 and 4. Further, this research aims to add to the debate how practices and transitions can be used together and therefore improve our understanding of how actions of actors can stimulate or hinder systemic changes. This results into research question 2:

— **RQ2.** *How have Social Practice Theory and Sustainability Transitions Research been used together so far and what are the strengths and limitations of the different crossover frameworks?*

The third question regards practices and transitions within construction projects and their environments. The study that answers this question aims to research how practices align and misalign regarding different circular design strategies. Circular design strategies describe which circular design choices can be made and with which tools. Alignment is here conceptualized as practices that stimulate other practices on setting or realizing circular ambitions and misalignment on practices that hinder this.

This study makes use of a crossover framework from study 2. The combination of this results into research question 3:

— **RQ3.** *How do practices (mis)align with each other regarding circular design strategies and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?*

The fourth question follows from the results on the third question (chapter 4). Of all circular design strategies, it turned out that design with secondary resources had the most misalignments. An often mentioned solution to this regards the use of circular building hubs. Circular building hubs are defined as physical locations where construction and demolition waste in the form of building components from disassembling sites are transported to, sorted, inspected, prepared, repaired, refurbished, remanufactured, and temporarily stored, so they can be reused or repurposed later as secondary building components in construction projects. This study again focuses on practices and transitions and therefore also makes use of a crossover framework from study 2. The combination of this results into research question 4:

— **RQ4.** *Which reconfigurations have taken place in the system-of-practices in which circular building hubs reside regarding reuse of secondary building components and how is it deemed likely to transition in the future?*

By answering these four questions in separate studies and synthesising results, this dissertation will answer the overall research question.

1.4 Research Approach

This section explains the research approach for this research. It explains the context, methodology, and research traditions that pertain to this research.

1.4.1 Research context

As mentioned in section 1.2, this research is part of the TranCiBo project. Although the whole TranCiBo project has this interventionist approach, this research itself should not be considered interventionist, but exploratory and explanatory. As such, it partly informed interventions and eventually helped in the creation of an intervention toolbox (TranCiBo, 2024). This role was taken, as much is still unknown about the transition towards a circular economy in the architecture, engineering, and construction sector, especially from a behavioural perspective (Munaro et al., 2020; Pomponi & Moncaster, 2017). However, during this project, twice a year meetings with the consortium have taken place in the form of presentations and workshops. These functioned as method of validation, but also as feedback to practitioners to make a societal impact. Based on the input for interventions and this direct feedback to practitioners, this research can still be understood as action research (Hennink, Hutter, & Bailey, 2020), even though this is not reflected as such in any of the individual studies.

1.4.2 Methods

The research of this dissertation is qualitative in every of its studies. A qualitative approach is chosen as it provides a contextualised understanding of behaviour and practices (Hennink, Hutter, & Bailey, 2020) that help or hinder the transition towards a circular economy in the architecture, engineering, and construction sector. The approach is especially useful because of the complexity of the system and the transitions under study.

The exact methods differ per study and can be found in figure 1.2.

Research question	Chapter	Methods	Purpose
1) Which dynamics in the execution of interorganisational construction projects are relevant to realise their circular ambitions, and how do these projects contribute to the transition towards a circular economy?	Chapter 2	Case studies: Group interviews. Workshop	To understand how practices can change in construction projects to stimulate setting and realising circular ambitions
2) How have Social Practice Theory and Sustainability Transitions Research been used together so far and what are the strengths and limitations of the different crossover frameworks?	Chapter 3	Systemic literature review	To understand how SPT and STR can be used together
3) How do practices (mis)align with each other regarding circular design strategies and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?	Chapter 4	Case studies: interviews, observations, document analysis. Workshops	To understand what helps and hinders the transition towards a CE for different circular design strategies
4) Which reconfigurations have taken place in the system-of-practices in which circular building hubs reside regarding reuse of secondary building components and how is it deemed likely to transition in the future?	Chapter 5	Interviews, observations, focus group, workshops	To understand recent and future changes regarding CBH's and their role in the transition

FIG. 1.2 Overview of research questions, chapters, methods, and research aims

Although this dissertation used a variety of qualitative methods, overall it can be considered as a large in-depth case study of The Netherlands. The Netherlands is chosen as case, as it provided access to necessary resources. Further, many consider The Netherlands a frontrunner in this transition (e.g. Leising et al., 2018) and frontrunners are especially useful in studying transitions (Geels et al., 2016). The individual methods described in figure 1.2 will be discussed in depth in the corresponding chapters and will therefore not be discussed in this introduction.

1.4.3 Constructivist grounded research

This research overall can be considered constructivist grounded theory. A constructivist approach focuses on how and why actions and meanings are shaped in specific contexts (Charmaz, 2006; Glaser & Strauss, 2017). It acknowledges that the researcher becomes part of that context and therefore changes the outcomes of the research. Constructivism is part of the wider interpretivist tradition (Charmaz, 2006), which acknowledges that what researchers see is an interpretation of reality and not an objective outside world. The result is therefore not an undisputed truth, but an understanding of reality.

Grounded theory methods allow for systematic, though flexible guidelines for collecting and analysing qualitative data with the aim to construct theory that is 'grounded' in data (Charmaz, 2006). It is therefore the data that forms the foundation of theorizing, not previously developed theories. However, that said, this study made use of sensitising concepts, guiding concepts for interview questions and analysis (Bowen, 2006; Charmaz, 2006). This started implicitly (chapter 2), as is common in grounded theory (Bowen, 2006), and in later chapters became explicit, using concepts from Social Practice Theory and Sustainability Transitions Research. These sensitising concepts offered a direction for questioning, but did not themselves not offer hypotheses for research outcomes. Further analysis was founded on emerging themes.

Grounded theory allowed to recurringly come back to the data and ask new questions based on earlier findings. Earlier findings therefore redirects subsequent data gathering and redefines analytic issues. This made the research exploratory.

1.4.4 Exploratory research

As much is still unknown about the transition, especially regarding behaviour (Munaro et al., 2020; Pomponi & Moncaster, 2017), this research should be regarded as exploratory. There are different takes on the exact meaning of exploratory research (e.g. Creswell, 2003; Swedberg, 2020), but here it means that although a general research approach was written beforehand, during the process of research, results from earlier studies influenced later studies, as is shown in figure 1.3. This concretely means that study 1 (chapter 2) showed that a wider scope, a more systemic perspective, was needed, as many practices around projects were influencing project results regarding circularity. To properly study this, it was decided that transitions research and Social Practice Theory were applied. These can still be used to study the interorganisational character of the transitions, as was the focus of study 1 (chapter 2). The theoretical implications of using Social Practice Theory and transitions research have been researched in study 2 (chapter 3). This led to conceptual frameworks that have been applied in study 3 (chapter 4) and study 4 (chapter 5). Based on study 1 (chapter 2), study 3 (chapter 4) did not solely focus on projects, but explicitly took practices in the wider environment of projects into account. Whereas study 1 focused on a broad definition of circular economy, from study 3 (chapter 4) it became clear that most barriers were part of design with secondary resources, so study 4 (chapter 5) focused on circular building hubs, an increasingly popular phenomenon that should make design with secondary resources easier achievable.

As this is exploratory constructivist grounded research, the individual studies are linked through emerging concepts. Although this allows for extra creativity(Svensson & Nikoleris, 2018) and following concepts that were previously unknown (i.e. unknown unknowns) (Svensson & Nikoleris, 2018), an important limitation of this methodological approach is that it does not aim to fill in a previously defined framework to tie all individual studies perfectly together without loose ends. This fits the context of the transition towards a circular economy, as it, just like our understanding of it, is only just emerging.

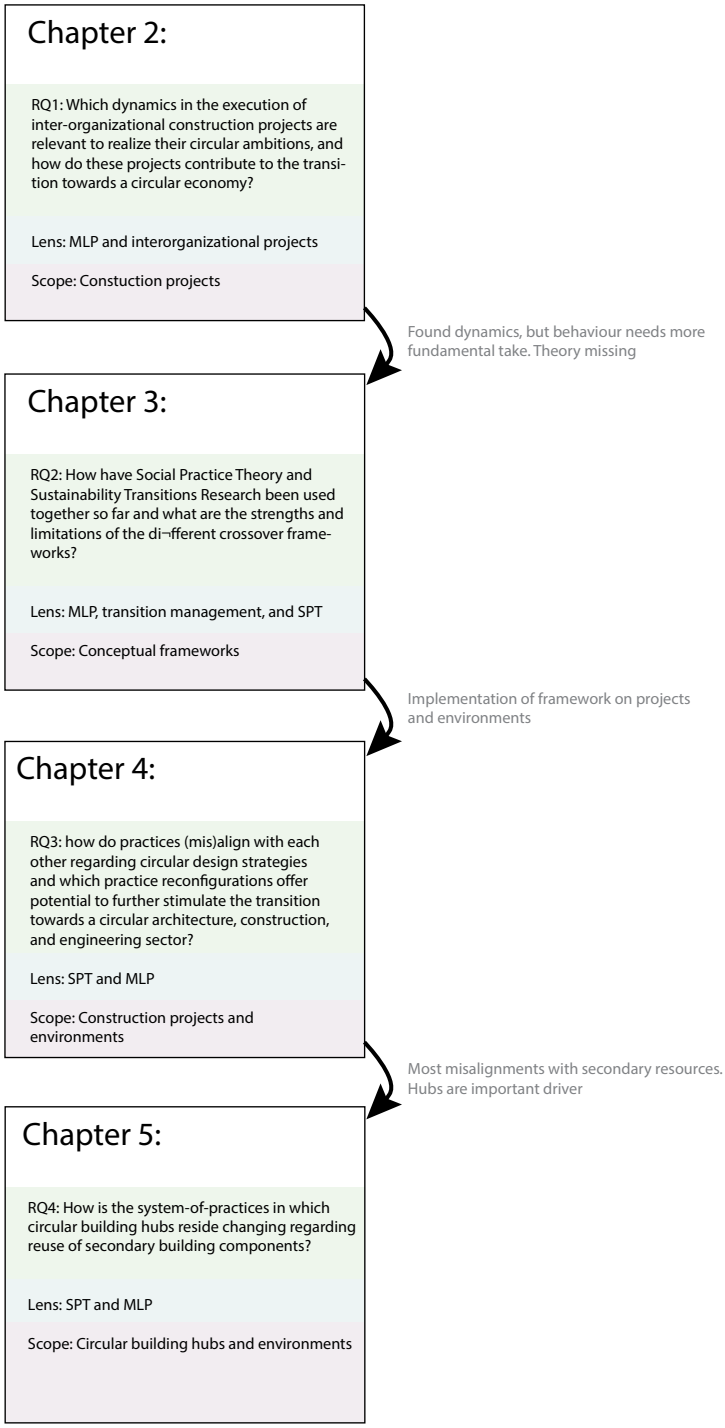

FIG. 1.3 Relation between chapters

TOC

1.5 Relevance of the Dissertation

This section explains the relevance of the dissertation academia and practice.

1.5.1 Academic relevance

Radical change is needed to meet the sustainability challenges of today (Markard, Raven, & Truffer, 2012), especially in the AEC sector (Nasir et al., 2017). Sustainable Transitions Research offers concepts to understand this change and considers it to be multi-dimensional, multi-aspectual, and multi-actor (Köhler et al., 2019). So far, within transitions research, daily behaviour and practices of actors are understudied, but considered of vital importance for the realisation of transitions (Köhler et al., 2019; Pesch et al., 2017).

First, this dissertation offers insights on the complexes of practices that lead to the realisation of circular construction, the way parts of these practices are institutionalised, and how they change to aid the transition as a whole. Second, this contribution concerns an exposition of the ontological and theoretical implications of studying transitions and practices and offers a set of frameworks that can be applied to study practices in transitions.

Although all results from the studies in this dissertation offer insights on the overall academic debate around circular construction, the individual chapters also engage with specific debates. Chapter 2 relates to organisational sciences, and specifically interorganisational collaborations in connection to transition research. It shows how interorganisational projects can be vehicles for transitions, but also what the limitations are, as supply chains highly influence the transition as well. Chapter 3 relates to the wider discussion on sustainability transitions and social practices. It shows frameworks through which the two approaches can be used together and in which context these frameworks are most useful. Chapter 4 applies one of these frameworks in construction projects and their contexts. It therefore also relates to project management for circular construction. It shows that circular construction often conflicts with other values in project management. And lastly, chapter 5 also applies one of these frameworks and concerns the debate around circular hubs and relates this phenomenon to logistical hubs and supply chain management. It shows that circular hubs and logistical hubs have very different functions and origins and should not be confused, although they might be somewhat similar in the future.

1.5.2 Societal relevance

Apart from filling the gaps in these bodies of literature, the research is contributing to the transition towards circular construction by explaining how complexes of practices inhibit or enable the realisation of circular ambitions and analysing where the barriers and enablers are for the transition towards a circular economy. Since the AEC sector is one of the largest producers of CO_2 and waste, and one of the largest consumers of energy and resources in the world (UNEP, 2020), there is a great need for this transition. Since the sector is known for its slow take on change (Wamelink & Heintz, 2015; Winch, 1998), there is a great need for more research, especially studies that take a wide system perspective into account in order to deal with the fragmentation of the sector.

This research offers practitioners stepping stones for intervention to use in construction projects to stimulate setting and realising circular ambitions. Further, it offers insights in the different stages the transition is in and the barriers facing practitioners. This is useful knowledge for policymakers. Lastly, this research has offered input for the TranCiBo research project as a whole, which offers an intervention toolbox that might aid actors throughout the system, working in different levels (e.g. projects, changing organisations), in changing their practices in such a way that it speeds up the transition towards a circular economy in the AEC sector.

1.6 Outline of the Thesis

This section outlines for each chapter what the reader can expect, in line with figure 1.2. Chapter 2 answers research question 1 and aims to understand how practices in construction projects can change to stimulate the transition towards a circular economy in the AEC sector. Eight case studies have been conducted with group interviews for each of them and triangulated using a workshop. This results in 14 dynamics that can aid setting and realising circular ambitions. The chapter concludes that these dynamics mostly influence the projects themselves. The influence fades further down the supply chain.

Chapter 3 answers research question 2 and aims to understand how Social Practice Theory and Sustainability Transitions research can be used together. A systematic literature review has been conducted. It results in 6 crossover frameworks that all make use of concepts from both Social Practice Theory and Sustainability Transitions Research. The chapter concludes that different frameworks are useful for different contexts, such as high or low complexity.

Chapter 4 answers research question 3 and aims to understand how practices help or hinder the transitions towards a circular economy for different circular design strategies. Two case studies have been conducted using interviews, observations, and document analysis. Three workshops have been conducted for triangulation. The results offer alignments and misalignments for seven circular design strategies. The paper concludes with highlighting misalignments that require focus as they regard many circular design strategies or highly impact one.

Chapter 5 answers research question 4 and aims to understand recent and future changes regarding circular building hubs and their role in the transition towards a circular economy. Interviews and observations have been conducted and a focus group and two workshops have been used for triangulation. The results highlight changes that have created the system in which circular building hubs reside, and changes that are expected in the future. We conclude that circular building hubs should be regarded a driver for the transition towards a circular economy in the architecture, engineering, and construction sector, but not the final solution for a circular economy.

Chapter 6 synthesises the preceding chapters and argumentation. The chapter offers a reflection on the answers to the main research question. It further offers implications for scholars and practitioners. Lastly, this chapter discusses the limitations of this research and offers recommendations for future research.

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Research question	Chapter	Methods	Purpose
1) Which dynamics in the execution of interorganisational construction projects are relevant to realise their circular ambitions, and how do these projects contribute to the transition towards a circular economy?	Chapter 2	Case studies: Group interviews. Workshop	To understand how practices can change in construction projects to stimulate setting and realising circular ambitions
2) How have Social Practice Theory and Sustainability Transitions Research been used together so far and what are the strengths and limitations of the different crossover frameworks?	Chapter 3	Systemic literature review	To understand how SPT and STR can be used together
3) How do practices (mis)align with each other regarding circular design strategies and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?	Chapter 4	Case studies: interviews, observations, document analysis. Workshops	To understand what helps and hinders the transition towards a CE for different circular design strategies
4) How is the system-of-practices in which circular building hubs reside changing regarding reuse of secondary building components?	Chapter 5	Interviews, observations, focus group, workshops	To understand recent and future changes regarding CBH's and their role in the transition

FIG. 2.1 Overview chapters

2 Sustainability Transition through Dynamics of Circular Construction Projects

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ABSTRACT The aim of this paper is to better understand the dynamics of circular construction projects and how these interorganizational projects contribute to the transition towards a circular economy. It is essential that the construction sector develops and adopts interorganizational initiatives to support the transition to a circular and low-carbon construction economy. A benefit of being involved in such initiatives is that organizations reflect on the emergence and acceptance of new practices related to changing organizational roles and responsibilities. In this paper, we study eight circular construction projects within the context of an interorganizational initiative to stimulate the transition towards a circular economy by exploring insights from evaluations thereof. We build upon literature from Sustainability Transitions Research (STR), circular construction research, and interorganizational project studies. Our findings show three clusters of dynamics that are relevant in the realization of circular ambitions in interorganizational construction projects: (1) prerequisites, (2) temporal dynamics in interorganizational projects, and (3) contextual influences.

These insights highlight factors that enable the realization of circular ambitions in construction projects and contribute to our understanding of the dynamics of interorganizational construction projects and their role in the context of STR.

KEYWORDS circular transition; construction projects; interorganizational collaboration

2.1 Introduction

To contribute to the transition towards a circular economy in the construction industry [1,2], public and private partners collaborate in interorganizational initiatives, in which they learn from the successes and failures of interorganizational construction projects with strong circular ambitions [3]. An interorganizational project is here understood as a group of organizations that interact reciprocally to coordinate their efforts for a complex service or product during a finite period of time [4]. The transition to a circular economy requires continuous monitoring and reflection on interorganizational circular projects for learning on goals, network activities, behavior, and management [5]. Collaboration in construction processes is power-ridden and not easy to change, as partners collectively appear to stick to well-known traditional routines and social practices [6]. To withdraw from these familiar and fixed social practices, it is of crucial importance that the construction sector develops and adopts interventions influencing both people and organizational behavior [7]. Interorganizational projects, therefore, are interesting settings for innovation, as members of diverse organizations with different work practices and cultures work together over a limited period of time [8]. Innovative solutions learned in these projects can stimulate change in participating permanent organizations [9] and larger sociotechnical systems [10]. By doing so, they create tensions in terms of the institutional context of the construction sector. We study these tensions through the lens of the Multi-Level Perspective (MLP), a dominant perspective in Sustainability Transitions Research (STR) that explains the uptake of innovations (niche) by incumbent players (regime), often due to influences from a wider context (landscape) [11,12]. The perspective of actors in construction projects is used to understand the dynamics of these institutional tensions, which is a missing perspective in STR [13].

The central aim in this paper is to better understand the dynamics of interorganizational circular construction projects. Dynamics of interorganizational projects refer here to the process of relating activities across boundaries to maintain

patterns of change and continuity through time, and to the forces that produce these patterns [14] (p. 636). For example, Levering et al. [15] identified in the shipbuilding sector the continuity of some interorganizational project practices and change of others, both influenced by combinations of self-reinforcing mechanisms. Ebers [16] understands dynamics of interorganizational projects to be related to partners' motives, preconditions, institutional forms, and outcomes produced. Scholars [14,15,17] argue these dynamics are not well understood. For example, Geraldi and Söderlund [17] have criticized research on interorganizational projects for understanding these as homogeneous static entities, while Sydow and Braun [18] missed a multi-level understanding of interorganizational forms of organizing. In addition, power relations between organizations are often not acknowledged in interorganizational project studies, though there are exceptions (e.g., [18–20]). Rather than perceiving interorganizational projects as episodic, fixed, and with limited issues of power [21], we understand these as relational, uncertain, and transpiring at different levels [22]. Tensions over power relations will arise in the interface of these levels as the reconfiguration of the construction sector transcends the sector boundaries, offering a redefinition of the rules by which the sector is operated [7].

Based on the discussion above, the central research question in this paper is: "Which dynamics in the execution of interorganizational construction projects are relevant to realize their circular ambitions, and how do these projects contribute to the transition towards a circular economy?"[1] To answer this question, we studied the delivery of eight interorganizational circular construction projects within an interorganizational initiative, named "Accelerating Together", a consortium of public clients and private contractors in the Netherlands trying to reduce the emission of greenhouse gases and waste. To collect data, we used an engaged scholarship approach [23], in which the authors and project members jointly executed a qualitative evaluation of the projects. Our findings show three clusters of dynamics that are relevant to project members in the realization of circular ambitions in construction projects: (1) prerequisites, (2) temporal dynamics in interorganizational projects, and (3) contextual influences. These findings contribute to the literature on interorganizational projects [14,18] with a better understanding of their dynamics over time. Furthermore, the findings contribute to further development of the field of STR, as called for by scholars (e.g., [24,25]), by providing an in-depth understanding of the interaction between niche and regime and the role of interorganizational projects in this.

1 This research question is written in American English, in line with the rest of the paper, whereas the research question in the introduction of the dissertation has been written in British English, in line with the dissertation as a whole. The language in this article has not been modified to fit the dissertation, but has been inserted as it was written.

The structure of this paper is as follows. First, we discuss the theoretical foundations of STR, the MLP specifically, and the role of interorganizational projects in this perspective. In the Methods section, we introduce the Accelerating Together initiative, and we explain how the qualitative study of eight interorganizational circular construction projects has been executed and how the findings have been analyzed. Then, the findings from the evaluations on the interorganizational circular construction projects are presented in three clusters of dynamics. Finally, we discuss the relevance of these findings for the academic debate on interorganizational circular projects and sustainability transitions and highlight the most important conclusions and suggestions for future research.

2.2 Sustainability Transitions and Interorganizational Projects

The literature on sustainability transitions has received increasing attention over the past decades [13,24,26]. Sustainability transitions are "long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" [24] (p. 956). Transition is here understood as a structural change—the outcome of developments that influence and strengthen each other in the areas of economy, culture, technology, institutions, nature and the environment [27]. Therefore, transition is a co-evolutionary process, involving change across a range of different dimensions (e.g., technologies, markets, infrastructures, behavior) and enacted by multiple actors, each with their own agency. Transitions are characterized by uncertainty and open-endedness, taking place on different levels and entailing multiple, interdependent developments [13].

We use the MLP, as it offers a framework to understand the transition as a whole, allowing us to look at the interaction between different levels with their respective rules [11]. We build on existing literature on the role of construction projects [28] and the role of individual actors in the interaction between niche and regime [12]. From this perspective, we can define conventional construction as a socio-technical regime, which we understand as a "continuous evolving hegemonic configuration of artefacts, actors, and institutions" [28]. It refers to dominant practices, activities, methods, and preferences that are bound by both formal and informal rules [22].

The regime is known to create lock-ins and path dependencies that make it hard to change [29]. The iron triangle of projects (time, scope, and budget) [30] is the main guiding principle in conventional construction projects [31]. Contrasting conventional construction, we can perceive circular construction as a niche innovation, distinguishing itself by a strong focus on minimizing the ecological footprint of construction. This is performed by limiting the amount of resources used and by closing material loops [28] and/or by slowing material loops through designing reusable products that have a longer life cycle [3].

Furthermore, recent literature reviews show diverse factors influencing the transition towards a circular economy (e.g., [1,2,32–35]). For example, Manuro et al. [34] suggest the lack of clarity on circular business models and government support, e.g., laws, tax, and subsidies. In another example, Mhatre et al. [36] focus on tools to enable circular construction, such as the use of a BIM platform, the creation of an urban mine, or using a materials passport for material stocks. Furthermore, Charef et al. [35] found knowledge, stakeholder engagement, asset lifecycle, procurement, policies, incentive schemes, and technologies to be important factors. In addition, Adams et al. [2] provide three sets of challenges to the transition. The first set is related to the economics of circular construction projects, such as the lack of incentives to design for end-of-life, the low economic end-of-life value of products, and an unclear financial business case. The second set of challenges is related to the construction industry's structure, such as the fragmented supply chain caused by the multitude of actors, and a perceived general lack of interest, awareness, and knowledge on circularity. The third set is related to design, e.g., the end-of-life of a building and the uniqueness of designing buildings. Finally, Leising et al. [3] suggest four general requirements for circular construction: (a) a new process design where a variety of disciplines in the supply chain is integrated upfront; (b) the co-creation of an ambitious vision; (c) the extension of responsibilities to actors along the entire construction supply chain; and (d) new business and ownership models.

Although the construction sector has gained experience in circular construction through a number of (pilot) projects, upscaling to large-scale use in this sector is challenging [28]. Upscaling requires radical rethinking of the roles and responsibilities of clients, contractors, architects, and other firms and has serious institutional and legal challenges in the supply chain [37]. However, innovations diffuse rather slowly in the construction sector, while organizations collectively appear to stick to well-known traditional roles, responsibilities, and social practices [6]. Particularly, collaboration between organizations in the construction sector is laborious and issues around collaboration are pertinent to this sector [32]. Therefore, changing the socio-technical regime of conventional construction by upscaling circular projects is challenging.

Scholars in the field of STR (e.g., [24,25]) suggest linkages with well-established (project) management and organizations studies can aid in maturing the field of STR. Especially, literature on interorganizational projects is interesting as a circular construction project can be understood as a temporary space where interactions between niche and regime take place, which can therefore be a potential portal for mainstreaming niche innovations [28]. From this literature, we learn that interorganizational projects are constituted by multiple practices, embodied in and accomplished by various actors, from different organizations and allow for the creation of innovations and change (e.g., [8,9,14,38]). Furthermore, in such projects, actors from different organizations bring along different work practices, narratives, norms, and values that shape changes [15]. Especially, "outsiders" who operate according to entirely different norms and values can bring disruptive innovation in construction projects [39]. This concept of outsiders can take shape as new organizations that play roles in construction projects, but can also be manifested by incorporation of new employees within companies dominated by regime institutions.

In the context of the construction industry, we understand the transition towards a circular economy as a multi-level and multi-actor process of continuous meaning-making, negotiating, and organizing in interorganizational projects [40], producing everyday changes [41], and simultaneously serving to (re)shape organizational processes, fields, and contexts. At the same time, it is important to acknowledge that the relation between these different levels of analysis is co-constitutive and recursive, as contexts, fields, and processes also shape practices and actors [42]. Therefore, change through interorganizational projects is an open-ended and continuous process of adaptation to changing conditions and circumstances across organizational and sectoral boundaries [43]. Circular ambitions, which require the entry of new players from "outside" the regime and a reconfiguration of existing relationships, make the dynamics in projects completely different from the "business as usual" dynamics [13]. In search of new roles and power, organizations might not rely on their known innovation mechanisms and practices, but may have to develop new ones [20], which might also challenge the role and boundaries of their organization, the way they relate and communicate with other organizations, and the way they perceive their objectives.

In sum, we understand interorganizational circular construction projects as co-constitutive, continuously changing, and deeply entwined interrelations between members of different organizations, where managers and employees have implications beyond their own organizational boundaries. However, these micro processes take place within a regime context that influences the possibilities for actions taken by actors in projects. This is why the temporal dynamics in interorganizational projects, where actors operate in the interface between niche and regime, are interesting to research and why actors' evaluation of these dynamics are the object of study for this paper.

2.3 Methodology

The study focuses on a specific interorganizational initiative, Acceleration Together, which is a consortium of public clients and firms with expertise on construction engineering, technology and construction process. The partners have ambitious goals of learning from their circular construction projects and agreed on sharing information, expertise, and evaluations. The consortium is organized in collaboration with an innovation platform for developing knowledge on the circular economy. We applied an engaged scholarship approach [23] in which researchers and participants of the Accelerating Together program jointly formulated evaluation questions, executed the evaluation, and discussed its results. To this end, circular projects involved in the Accelerating Together program and researchers agreed on the joint evaluation of the roles, practices, processes, and outcomes of eight circular projects, including three new building projects, two renovation building projects, one demolishing and (re)building project, one urban development project, and one new infrastructure project. Although experienced in construction in general, for employees of six projects, this was the first time they worked in a project with high circular ambitions. The group interviews were held from December 2020 to March 2021, each centered around one of the eight projects. In total, 22 different construction professionals were interviewed, with the smallest group of just one person and the largest including four construction professionals (see Table 2.1).

TABLE 2.1 List of interviewees.

Interview No.	Interviewee No.	Project	Role
1	1	New building 1	Client
	2		Contractor
	3		Consultant
2	4	New building 2	Client
	5	New building 2	Client
	6		Client
	7		Consultant
3	8	Renovation building 1	Contractor
	9	Renovation building 1	Contractor
	10	Renovation building 1	Contractor
	11		Consultant
	12		Client
4	13	New building 3	Real estate developer
	3		Consultant
5	14	Demolishing and (re)building 1	Client
	15		Client
	16		Contractor
	11		Consultant
6	17	New infrastructure 1	Client
	18	New infrastructure 1	Client
	19	New infrastructure 1	Contractor
	6		Client
	11		Consultant
7	20	Urban development 1	Real estate developer
	21	Urban development 1	Real estate developer
	13		Real estate developer
	3		Consultant
8	22	Renovation building 2	Contractor
	3		Consultant

Data were collected through semi-structured group interviews, an interview method which uses a list of topics to guide the questioning [44]. Interviewees were asked to prepare for the interviews by describing their circular construction projects in terms of materials, energy, water, social, and management. This six-page document included questions such as “What is the level of demountability of the building in your current design?” and “What actions are you taking to get energy from renewable sources?” This document served as the basis for the semi-structured interviews, during which additional questions were asked about why a particular

answer was given, and what contributed and what hindered them in their actions. For questions on management, a topic guide was used, and depending on the course of the interview, relevant questions were posed, such as “What do you consider constraining factors in the current form of collaboration?” or “Who has the power to lift the circular ambitions in this project to a higher level?” The interviews lasted on average 134 min, with a minimum of 107 min and a maximum of 188 min, and were all conducted through video calls due to the COVID-19 pandemic. The interviews were conducted by two of the authors, alternating leading roles, and one circular construction consultant of one of the three involved consultancy firms. Such a researcher triangulation is helpful in assuring the quality of interview data [45]. This allowed for an efficient task division, documenting of the interviews, and cross-examination of the retrieved data. In six out of eight interviews there was also another participant of the Accelerating Together program present in order to pose critical questions and to stimulate learning between the involved partner organizations. In turn, they were also asked questions in order to unfold key differences or comparisons in the way they handle circular construction projects. These professionals are included in Table 2.1, but not listed under a project name. Group interviews offer richer data than one-on-one interviews, as groups allow for snowballing, where one reaction triggers the next, and offer a clearer understanding when there is or is not consensus on a topic, similar to focus groups [46]. The disadvantage of group interviews is that individuals might be reluctant to share personal information [47], although this is contested, fitting our results. A second disadvantage is that some people might be outvoiced by others [47].

The results were analyzed in a multi-step approach [45]. First, all interviews were analyzed by the researchers and the three consultants, offering a common vocabulary to talk about these projects, and allowing for preliminary conclusions that could be tested with other projects. Secondly, barriers and enablers were distilled from the interviews. These were then compared with those from the literature [2,3] and the quick analysis of the previous (explorative) round of the Acceleration Together program and summarized in a report for the program. This was first checked and commented on by our interdisciplinary team of researchers, then by the involved consultants, and finally by the participants of the Acceleration Together program. Third, with this information at hand, the transcripts were analytically generalized [48] on emerging first-order topics that gave explanations of the produced results or the lack thereof, which, following Cropper and Palmer [14], were named the dynamics of interorganizational projects. Then, using researcher triangulation, these were grouped in 22 dynamics under the headings of prerequisites, temporal dynamics in interorganizational projects, and contextual influences. This categorization emerged from interviews, where interviewees mentioned conditions that are necessary before the start of construction projects,

factors within construction projects that influenced the realization of circular ambitions, and factors from outside the project influencing this. Based on these findings, our research team named the categories and grouped all dynamics accordingly. Note the difference between dynamics of interorganizational projects and dynamics in interorganizational projects. The former, as elaborated in the previous section, includes prerequisites, temporal dynamics in interorganizational projects, and contextual influences. The latter refers to the dynamics within construction projects and solely to the temporality of these projects themselves. These temporal dynamics have often been ignored by researchers [19], but offer possibilities to function as portals for the transition towards a circular economy [28]. Fourth, with our research team, we decided on combining certain dynamics, and letting go of less relevant ones. This resulted in the fourteen dynamics as described in Figure 2.1. Fifth and lastly, an overview of these fourteen dynamics including the categorization was presented to practitioners as a member check [45], offering possibilities for feedback and used for the final categorization of the dynamics. Writing was distributed among three writers, peer reviewed by the writers, and then by the whole research team.

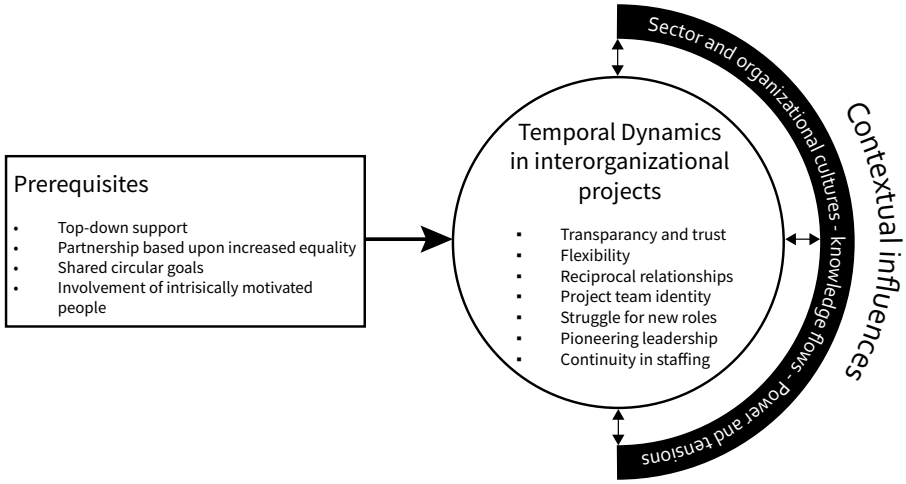

FIG. 2.2 The interplay between the dynamics of interorganizational projects that are relevant in the realization of circular ambitions in construction projects.

2.4 Findings

The fourteen identified dynamics related to the realization of circular ambitions in construction projects can be divided into three clusters. The first cluster includes prerequisites that are needed for setting and realizing circular ambitions in construction projects. The second cluster contains the temporal dynamics that play a supportive role during the realization of circular ambitions in construction projects. The third cluster is related to contextual factors that influence temporal dynamics in interorganizational construction projects, which are in turn influenced by these. The interplay between the dynamics of interorganizational projects is visualized in Figure 2.1; it shows the relationships between prerequisites, temporal dynamics in interorganizational projects, and contextual influences.

2.4.1 Prerequisites for Circular Construction Projects

The first cluster of findings we discuss here are the prerequisites that, according to interviewees, are needed for setting and realizing circular ambitions in construction projects. Four prerequisites are mentioned: (a) top-down support; (b) partnership based on increased equality; (c) shared circular goals; and (d) involvement of intrinsically motivated people. These four dynamics are discussed below.

Top-Down Support

Support from higher levels of the organization seems to be one of the prerequisites for setting and realizing circular ambitions within construction projects, as was found in the organizations of all interviewees. Two interviewed clients agreed that "[...] if your management team, or director, or board of trustees don't believe in it [circularity], you won't get anywhere"(Interviewee 14). Three aspects are particularly notable. Firstly, an important aspect of support from the management team is being open to the possibility of change, a key element in transitions. Secondly, the higher management of organizations can support circular ambitions both formally, using policy documents, and informally, by encouraging or discouraging behavior on the work floor that stimulates circular construction. In projects where support is lacking, higher managers can still be persuaded by intrinsically motivated employees to support or even promote circular construction, if they are still approachable. Thirdly, it matters to what extent support of higher managers is entrenched in the

whole organization; management support is not a guarantee for success. If the management team supports circular construction, but the ideas or policies have not been implemented on lower levels, the effects of support remain minimal. This is exacerbated by strong project cultures; project leaders tend to do execute tasks their own way, and are often given freedom in this regard. To stimulate support throughout the whole organization, higher management could choose to hire people with a suitable profile, allowing support for circularity to materialize in daily practices.

Partnership Based on Increased Equality

Public clients traditionally set up tenders minimizing their own risks. However, since circular ambitions must take hold in all organizations involved, clients must work more dialectically with their contractors. This necessitates a more equal relationship, as explained by one public client: "traditionally we take on projects in a clear client-contractor role division, but we are convinced that we can only make the transition towards a circular economy together with our supply chain partners, […] which is why we took on this project as equal partners" (Interviewee 17). Such a partnership based on equality is becoming more popular in the construction sector [49]. One contractor explicitly asked for a new approach: "you don't get most out of it for both parties like this [traditional tendering]. If you take on projects differently from both sides, identify the risks, come up with a process, a model for the risks present, you can properly tackle those. With [traditional tendering] organizations will either cover themselves, or not participate at all" (Interviewee 2). We found two reasons why more equal partnership is needed: (1) throughout the chain, contractors need to step into the project earlier than traditionally, as clients are in need of their knowledge; and (2) mutual dependency is higher, as circular projects are more uncertain and ask for adaption, e.g., because the availability of specific non-virgin materials cannot be guaranteed at the start of the project. We found a partnership can successfully be expressed, e.g., financially, by using a common budget to pay for unexpected risks, or an alliance contract with open bookkeeping.

Shared Circular Goals

Because circularity is easily overlooked due to many additional ambitions of construction projects, an explicit shared goal or vision on circularity is a prerequisite to realize circular ambitions (e.g., [3]). Often, visions are stated in the beginning of projects, but if no concrete goals are formulated and it does not become an explicit returning topic of conversation, they tend to lose value. One interviewee stated clearly that in the phases of a concept design and definitive design, 80%

of the choices are made, implying that at this point, this shared vision needs to be clear for all project members. Coming to a common goal through conversation between the different partners involved seemed to be a preferred way of working, opposing projects where goals are formulated by one partner, with the belief that communication will result in better plans. However, for municipalities, this can be difficult; since tenders follow a strict judicial protocol, conversation is considered illegal and would allow for unfair advantages. This is why some interviewed real estate developers considered working solely on projects on their own initiative, allowing for conversation with the municipality (e.g., Interviewee 13). Partner selection based on a common goal seemed to allow for supportive temporal dynamics, such as trust and transparency, later on in the project. Interviewed real estate developers described the importance of partnering: "At first we selected partners based on a [shared vision] and only then looked at the financial consequences of that partnering. But [now we say] first 'what is our drive?', 'would we want to work together?', that was the first criterion" (Interviewee 20).

Involvement of Intrinsically Motivated People

Delivering construction projects within a priorly set time and budget is challenging, but delivering circular goals in construction projects within a linear system takes even more effort. Therefore, when circular construction is not the norm yet, one of the prerequisites for setting and realizing circular ambitions is involving people that are intrinsically motivated, as illustrated by one client: "all projects that included sustainable or circular procurement, do so due to the project managers that adhered to those principles" (Interviewee 12). Intrinsic motivation seems important for three reasons. Firstly, project members may need to go the extra mile by continuously questioning actions, discussing alternatives to linear solutions, and challenging others to think outside the box. One interviewee explained: "It is in my DNA, but that is not the point, it is about starting a conversation to make sure it also gets into the DNA of the other. This is only possible through continuously expressing, promoting, and questioning it" (Interviewee 14). Secondly, to innovate, it is necessary that project members go beyond the beaten track. As one client explained: "It does ask something of your employees, they need to dare to do it differently than the five colleagues that went before him or her" (Interviewee 6). This closely relates to the support of higher management that can decide to hire people with a suitable profile, but also to partner selection. Thirdly, our analysis shows that like-minded people in a project can aid circularity. It is motivating for project members to work with others who are also intrinsically motivated and it may enhance transparency and trust, because no project member tries to slack off. A real estate developer expressed this: "we don't want to tick boxes, we want to spark" (Interviewee 20).

2.4.2 Temporal Dynamics in Interorganizational Projects

The second cluster of findings we discuss are the dynamics that, according to interviewees, play an important role in the realization of circular ambitions in construction projects, which we understand as temporal dynamics in interorganizational projects. Seven dynamics are mentioned: (a) transparency and trust, (b) flexibility, (c) reciprocal relationships, (d) project team identity, (e) struggle for new roles, (f) pioneering leadership, and (g) continuity in staffing. These are discussed below.

Transparency and Trust

One of the main supportive characteristics of the dynamics found in circular construction projects is the creation of transparency and trust, which is needed to create flexibility, achieve higher quality, and to stop greenwashing. However, we found, as is also often mentioned in the literature, that the dominant culture in the construction sector is based on distrust and avoidance of risks [49]. In contrast, transparency can only be created if project members dare to be open and vulnerable and create relationships based on trust, and this requires action. One of the clients explained that they did not feel the need to monitor or control the actions of the demolisher, as the demolishing process was very transparent (Demolishing and (re) building 1). When partners are honest and open about their actions, they can rely on each other, and the need to control one another diminishes.

In line with this, trust is essential for effective collaboration [50]. In a trusting relationship, a party expects that another party will perform particular actions, irrespective of the ability to monitor or control those actions [51]. This also means daring to be vulnerable, and, e.g., can imply accepting that nobody is a circular expert at the start of the project, as circular construction is still in the innovation phase (Urban development 1). Transparency and positive experience can in turn reinforce trust between partners [52]. Being open and vulnerable may include sharing risks and feelings about the progress and the completion of a project within time and budget. Through the creation of transparency and trust, collaboration in projects can grow and generate opportunities to support each other, which are essential in relation to flexibility in circular construction processes.

Flexibility

In circular construction projects, flexibility is needed because of the uncertainty created by circular ambitions and the continuous lack of practical knowledge. Circularity exists out of many different elements and is as a whole unmeasurable. In addition, innovations come with risks and potential failures, often creating the necessity to adapt or fully change concrete solutions. Therefore, clients cannot uphold their traditional role as knowledgeable planners and controllers, which is often desired to avoid insecurity and risks. One contractor explained: “if you are asked to step out of your comfort zone, because you do not know beforehand how to realize [the circular ambitions] exactly, then by definition you have to move away from all that is familiar” (Interviewee 10).

In order to innovate and employ circular possibilities, flexibility, both in terms of planning and budget, seems necessary. In practice, the preparation phase of circular construction and demolishing may take more time, due to additional practices, e.g., investigating potential measures, finding recycled materials or off-set possibilities for harvested materials. A compensating advantage might be that the construction phase is often shorter than in traditional construction processes; therefore, the whole project is not necessarily prolonged. Similarly, the project budget would benefit from flexibility, without necessarily increasing total expenses. A contractor argued: “sometimes, it is in the benefit of the project, if the installation engineer receives a little bit more budget, and we a little bit less. It is a tension field because everyone has to stay within their own budget, even though you could manage it more efficiently” (Interviewee 8). Other projects illustrate that when clients create room for maneuver in terms of budget and/or planning, and are therefore willing to take risks, possibilities arise for higher levels of circularity than previously perceived possible.

Finally, flexibility seems to be better achievable with transparent relations, due to the awareness about the stakes of other project members. Moreover, knowing about potential risks for other team members might minimize surprises and the need for flexibility in the first place.

Reciprocal Relationships

Traditionally, relations in construction projects are formal, based on a contract. When adaptations in the plan are made, often one party bears the risks and consequences. In a circular project, actors are interdependent and need to take a shared responsibility to realize circular ambitions, without blaming each other [49]. Interviewees recognized the need for a reciprocal atmosphere. In reciprocal relationships, partners keep a close eye on the exchange of resources in which all parties contribute to circularity or benefit according to their needs. Additionally, scholars acknowledge trust and reciprocal dependency as important dynamics for effective collaboration in projects (e.g., [49]).

One project developer explained that "one of the success factors [of circular construction] is involvement of a particular type of person. […] In a project with an integral approach it makes sense to select people that are tempted to make a connection with others. Do not take this the wrong way, I am not saying we are chilling and sitting around the campfire together, but it is decisive for your success" (Interviewee 20). Reciprocity then implies that partners acknowledge the efforts others make in realizing circularity measures and help each other find solutions when problems arise. For example, in one of the projects, the client, a Dutch municipality, gave suggestions to the contractor for alternative circular measures when the original plans did not work out (Interviewee 4). Another contractor explained that it works well if trade-offs are not only based on money, but when other stakes of the involved partners are taken into account, as well (Interviewee 10).

Project Team Identity

An important change dynamic mentioned by the interviewees is the creation of a project identity. Identity is here understood as the identification of project members with project's goals, values, and norms [53]. Project members frequently experience a double identity—being a member of a circular project and at the same time a member of their own organization. Tensions between project members can emerge because of this double identity. The creation of a shared identity can be helpful in focusing on project goals; for example, in one project, members were aware of their different identities and decided to organize "Circular Tuesdays" every week to be on the same page. One interviewee elaborated: "in those meetings we took decisions, we discussed the progress of the project, and we held each other accountable in terms of planning and budget. This was extremely motivating; I looked forward to it every week, and I thought it was amazing" (Interviewee 19). A shared identity can be created by developing trust and by explicating a shared vision and mission

on circularity. Furthermore, this process is strengthened by the development of a reciprocal relationship, in which partners exchange knowledge, solutions, and small successes. According to the interviewees, reciprocity is an equalizing and binding force in circular projects as it is beneficial for all partners.

Circularity, in turn, can aid in creating a project team identity, as explained by one interviewee: "I believe circularity definitely encourages good relationships within the team, even if just small measures are taken, it does influence the general atmosphere, which is nice" (Interviewee 8). Creating a project identity requires time-consuming effort and budgets. Yet, the interviewees mentioned that a strong project identity increases their motivation.

Struggle for New Roles

Circular construction processes differ in several aspects from traditional construction processes. Often, a more explicit vision is needed, new demands have to be taken into account, certain areas of expertise become more important in different phases, new types of materials come into play, guarantees on building products of which little is known are needed, and deconstruction becomes an integral part of the process. Actors take on new roles to fulfil these functions, but these roles need to be renegotiated in every project, where the comfort of traditional roles remains attractive.

First, circular construction urges clients to include new tender criteria, such as circular visions that are difficult to judge and compare. They are no longer simply controllers, but become part of a dialectic visioning process. However, now, many lessons are embedded in tendering procedures, so the tendency rises to return to previous roles and judge projects quantitatively. Second, by focusing on closing loops, the end-of-life of buildings becomes more important, giving more responsibility to deconstruction firms. One interviewee argued that this makes them interesting parties to replace contractors and become builders themselves (Interviewee 14). Third, contractors (and in some cases, installation engineers), due to their technical knowledge, become useful advisors during the earlier design stages, both on construction and on harvesting non-virgin materials. However, as this means taking part of the role of architects, contractors are often not tempted to take on this role. Fourth, real estate developers mentioned they took on less directive roles, due to the flexible nature of circular construction projects. This means partnering more out of trust and stimulating actors (at least temporarily) to take over each other's roles. They also mentioned the need to take up a more proactive role by focusing on larger areas in order to reach circular goals, and no longer participate in (small) tenders.

Taking on new roles seems difficult, takes some parties more time, and does not immediately translate to new business models. One contractor added that current contracting forms are based on traditional roles, and that taking on new roles also demands new contracting forms, such as Rapid Circular Contracting (Interviewee 10).

Pioneering Leadership

As there are many other project goals besides circular ambition, the latter is easily lost. To realize circular ambitions, it can be beneficial to appoint a project member to take responsibility to put circularity on the agenda. Especially when experience with circular construction is lacking, this can increase awareness among project members about the need for a circular construction process and the non-traditional elements used therein. This applies especially to projects with high circular ambitions, since these often demand non-traditional solutions and more flexibility. In one project with high circular ambitions, the project leader argued that if they (the real estate developer) would not have set the bar, the project would still be circular, but end up in the midranges concerning the level of circularity. With a drive for circularity, they inspired other project members to take up a similar circular mindset and sustain the ambitions throughout the project (Interviewee 20).

Pioneering leadership is related to power and money, as it is often only possible to realize circular ambitions if sufficient budget is available. In most cases, the client exercises power by deciding on budgets for circular ambitions, and thus has a decisive role. Although leadership can also be taken up by other project members, this is within the limits set by the client. Furthermore, the level of autonomy of a project vis-à-vis its mother organization influences the possibilities of project members to take up a leadership role. A certain level of integration of projects with mother organizations is required [49] to prevent projects from drifting off, creating potential difficulties in the realization of circular ambitions.

Continuity in Staffing

Although continuity in staffing is essential in all construction projects, this applies even more to projects with circular ambitions that deviate from business as usual. Projects with circular ambitions can highly benefit from continuity in staffing in different forms: within projects, in between projects, and between different organizations.

When project members diverge from standards, more in line with circularity, replacing them is an even greater loss than in traditional construction. Construction projects are already strictly divided in the design and construction phases, where first architects and then contractors usually take on a leading role (Winch, 1998). Municipalities also use this distinction in phases to appoint project leaders, which risks the loss of information and hinders innovation. Furthermore, continuity in staffing is important to reach a high-quality level and to stimulate trust. However, sometimes changing project leaders is necessary when personalities, behavior, or stances towards circularity do not match project goals.

Continuity in staffing also has advantages within an organization, between projects, because knowledge remains within a team. One public client mentioned that a preferred team is when one-third of the team has experience in circular construction and two-thirds are without experience, to both take advantage of the knowledge available and open a platform for learning within the organization (Interviewee 18).

Our findings show that continuity can also come about between organizations, e.g., when a project management firm takes on all construction projects within a certain area, so knowledge, a good relationship, and a shared vision between this organization and the municipality can develop over a longer period of time.

2.4.3 Contextual Influences on Circular Construction Projects

The third cluster of findings is related to contextual issues that influence the realization of circular ambitions in construction projects. Three dynamics are discussed here: (a) sector and organization cultures, (b) knowledge flows, and (c) power and tensions.

Sector and Organization Cultures

It is widely recognized that cultures at national, organizational, and project levels have influence in the realization of construction projects [20]. Culture is here understood as the sum of values, norms, rituals, and practices shared by a group of people [54]. We found two dominant cultural issues influencing the dynamics in projects with circular ambitions: (1) the traditional construction sector culture and (2) differences in circular mindsets within organizations. Firstly, this sector culture is perceived to be oriented towards technology instead of strategy, avoiding risks, and having a strong focus on short term cost reduction. Interviewees blame the sector culture for slow innovation in circular construction. The failure to innovate and learn from other sectors has been acknowledged by scholars [55]. Furthermore, the

sector culture is characterized by deep distrust between public clients and private contractors. According to interviewees, contractors are perceived as “criminals” with no conscience and a strong focus on profit. In return, contractors perceive clients as untrustworthy, frequently changing their policies, and leaving project risks to the contractors. This mutual distrust results in notorious controlling and checking of agreements and contracts, frequently seen in construction projects [49]. Furthermore, with such attitudes, short-term goals prevail over long-term goals of constructing circular buildings.

Secondly, differences in organization culture, and especially differences in circular mindset, were mentioned to influence circular projects. As construction projects are interorganizational projects, diverse organizations with different values, norms, and practices must work together to realize a project. For example, one client used the norm that the reuse of material was allowed, but without being visible, which only became clear after reused materials were visibly applied (Interviewee 22). These different circular mindsets are based on an organization’s culture and influence how circular ambitions are translated to project goals. Interviewees mentioned that the best ways to stimulate circular mindsets are to set appealing examples, to have direct colleagues with circular mindsets, to repeat the circular message (over and over again), and to add a more personal component in the message. Some stated that especially younger employees picked up circularity more easily, as they are not trapped in routines and ask more questions. Older generations then hook up on the enthusiasm of these “ambassadors”.

Knowledge Flows

Since circular construction is a relatively new concept, practical knowledge is often lacking. In practice, this new knowledge is also accompanied by a new way of speaking, or a new vocabulary, which tends to need a lot of repetition before it is taken over. Different actors have different issues regarding knowledge. Here, clients, contractors, and real estate developers are discussed.

First, clients say they learned a lot over the last five years, starting with tenders on vision, and now focusing on universal indicators. However, very few employees have the technical knowledge to interpret plans on these indicators; often, only one person within a major municipality has such knowledge. The unique skill lies in the combination of know-how on both tendering and the circular economy. Sometimes circular networks are used to fill gaps of knowledge, or external advisors are counseled. Contractors mention that despite these solutions, clients are still behind on the newest options, since they do not work on circular construction on a daily basis. Second, when contractors take on the role of advisors, ready knowledge is

needed to be useful in discussions during the design phase. However, knowledge is often project-specific, calculations on the environmental impact of the project might take a long time, and sharing project knowledge with the rest of the organization easily leads to a dumping platform, where information is irretrievable. This is also true within a project itself, where BIM models can have hundreds of sub-models, impeding finding the right information. Third, real estate developers mention the necessity for ready information on circular construction to be able to make deals with partners. Comparable with other actors, knowledge sessions are used to gain information, but knowledge on the practicalities of circular construction measures are often still lacking, partly because proper evaluation of projects is uncommon. Thoroughly calculated reference projects have been found useful for ready knowledge, but since projects are so different, these have limited value.

Although seldom used, different ways to monitor lessons from projects with circular ambitions have been found; real estate developers used qualitative scoring lists, a municipality set up a committee for circular tender improvements, and an architecture firm used a wiki to capture the lessons from projects. A difficulty in monitoring, however, is that construction does not always strictly follow the design, and the actual outcomes of a project are seldom known. Monitoring can lead to ready knowledge about circularity among project members, but it is also important that they integrate this knowledge in their existing frame of reference to be able to apply it to daily practice. A way to achieve this is by continuously repeating the message and offering knowledge in diverse ways. One client explained this strategy: “Sometimes, when you hear a song for the first time, you don’t like it, but if you hear it several times, you do. […] and that is what we also do with [circularity]; if you come in contact with it enough, it becomes fun after a while” (Interviewee 14).

Power and Tensions

We analyzed the two most important power issues influencing the dynamics in our studied circular projects: (1) the dominance of clients and (2) the tensions between permanent and temporary organizations. Firstly, the dominance of clients was frequently mentioned during interviews and evaluations. Clients have a leading role in the ambitions and budget of a circular project, the demarcation of roles, and the embedding of circular projects in permanent organizations. Circular construction demands different types of collaboration with partners in the construction chain. For example, the presence of reused materials is of importance; this must be agreed upon at the start of a project. However, during the realization of circular projects, clients often change their ambitions, leaving partners with other circular ambitions with no choice but to follow. Especially, when projects become more expensive,

as they frequently tend to do, circular ambitions are adjusted downwards, to the frustration of partners. The short-term goals of clients, such as budgets, prevail over long-term goals, such as total costs of the construction and the development of partnerships with chain partners. However, clients also lack power—the circular goals which are agreed upon with contractors are difficult to control and maintain in a fragmented construction chain.

Secondly, related to the dominance of clients, there are tensions between permanent organizations and temporary organizations when executing circular construction projects. Support from top management is needed to start a circular project and to select and implement innovative ways of collaboration with partners. Furthermore, permanent organizations try to standardize work processes, tools, and decision-making procedures for circular projects. However, projects often strive for autonomy. Certain autonomy is needed for innovative projects, but too much autonomy results in project isolation with no translation of innovation from temporary to permanent organization [9]. Therefore, a recursive connection with top management and the permanent organization is crucial for successful circular construction projects, which might mean that employees with a different profile, more oriented toward maintaining relations between temporary and permanent organizations, are needed [9]. Lastly, project management offices have been used to commission projects, not only based on the traditional triangle of scope, budget, and time, but also on the value of circularity. This value-based management is becoming increasingly more important [56].

2.5 Discussion

In this paper, we explored the dynamics of eight interorganizational circular construction projects in the Accelerating Together initiative and how these projects can contribute to the transition towards a circular economy. By taking an actor perspective, as called for by others [3], our findings showed three clusters of dynamics that are relevant in the realization of circular ambitions in interorganizational construction projects: (a) prerequisites, (b) temporal dynamics in interorganizational projects, and (c) contextual influences. Furthermore, the joint reflection on these dynamics by clients and contractors helped to develop a shared understanding of how to better realize future circular ambitions, thus supporting the large-scale transition called for in the construction sector [28]. These findings contribute to the debates on interorganizational circular construction projects and on STR.

Firstly, the findings are relevant to the debate on interorganizational circular construction projects [3], with a more in-depth understanding of the dynamics of interorganizational projects, as others have called for (e.g., [14]). By zooming in on project actors, we provide insights into how actors deal with challenges in practice. The findings show that interorganizational projects are not homogeneous static entities [17,18] but dynamic interactions between project actors, in which, among others, trust, reciprocity, and flexibility are important for the successful realization of circular ambitions. The challenges stemming from these dynamic interactions reveal the barriers and enablers for implementing interorganizational circular projects. Most of the barriers and enablers found in our study were identified in earlier studies (e.g., [1,2,32–34]). In addition to these studies, we found four prerequisites and seven temporal dynamics needed for successfully realizing circular ambitions in construction projects as well as three contextual influences. With our focus on actors, we offer a more holistic and power-sensitive overview of how different dynamic elements influence each other, which is frequently missing in the interorganizational project debate [18].

Secondly, our findings contribute to the STR debate (e.g., [11,12]) with a better understanding of how actors in interorganizational circular projects can contribute to the transition towards a circular construction economy [13,24,26]. By focusing on the experiences of actors involved in these projects, we provide an understanding of the interaction between different levels (niche, regime, and landscape), which, up until now, have mainly been discussed from a systemic perspective in transition literature [24]. Based on our findings, we distinguish three ways in which actors in interorganizational projects say they can contribute to the transition: (a) actors from diverse organizations influence each other in interorganizational circular projects; (b) actors bring their experience with and knowledge on circularity to their mother organizations; and (c) experiences and lessons learned are, according to interviewees, transformed to new circular projects in network platforms and other collaborations with future partners. These three ways are discussed below.

First, some actors act from a regime-oriented mindset, implying that they act in line with existing conventional practices and routines, backed up by formal and informal rules. Other actors have a niche-oriented mindset, and try to apply circular principles in their work practices. These orientations are situational, as actors can shift between different mindsets, depending on what they deem suitable in a specific situation. In line with earlier findings [9,38], our study shows that interorganizational projects have the potential to shift project actors' mindsets. Actors from different organizations bring in different work practices, narratives, norms, and values [15], which creates an opportunity for exchange. Most project members had no previous experience with circular construction, and some started off with a skeptical stance

towards this niche innovation. However, most of them reported a much more niche-oriented mindset by the end of the project and can be considered intrinsically motivated people, as discussed in our findings. Actors involved in interorganizational projects, despite having different stakes, can remind each other of the common circular goals that have been set. We noticed that if different actors take up this niche-oriented mindset, they can positively contribute by making sure everybody sticks to the ambitions and takes action to realize them.

Second, according to the interviewees, it is of crucial importance that actors bring their experience with and knowledge on circularity to their mother organizations. Successful but also unsuccessful projects can function as drivers for change within mother organizations by pressuring shifting, frequently informal rules within the dominant regime [37]. Project actors bringing in their newly learned practices can spread circular ambitions within their own organizations and thus contribute to this niche–regime interaction. In this interaction, intrinsically motivated actors, the larger part of the project actors, interact with actors with different mindsets. For example, some project actors said they became ambassadors within their own organizations and successfully challenged other employees to reflect on their regime-oriented mindsets. This can result in top-down support and chances for change in, for instance, organizational policy or tender procedures. If shifts in mindset are not adopted or translated into different practices, rules, and/or policies, effects may fade out and actors can lose intrinsic motivation or become burned out.

Third, actors can contribute to the transition through transforming their experiences and lessons learned to new circular projects. Interorganizational initiatives, such as Accelerating Together, create possibilities for exchange and learning across projects. For example, this program contributes to niche–regime interaction through the development and implementation of a list of both minimal and ambitious goals on various circular project themes. This document, which is openly accessible for consultation while setting up new projects, must inspire actors throughout the supply chain. In this way, niche innovations of circular construction can be strengthened, as learning between actors is fostered, while developed knowledge is brought to the often regime-oriented mother organizations. Moreover, the opportunity of learning between project actors is created over time; new projects create new spaces for niche–regime interaction. For example, when actors with a niche-oriented mindset collaborate with actors with a regime-oriented mindset in new projects, an opportunity for niche–regime interaction, and thus for learning and change, is created. Finally, learning can be strengthened by continuity in staffing, as discussed in our findings, to avoid knowledge loss, and to contribute to a relationship of trust.

2.6 Conclusions

In this study, we answered the question of "Which dynamics in the execution of interorganizational construction projects are relevant to realize their circular ambitions and how do these projects contribute to the transition towards a circular economy?" We identified fourteen dynamics of interorganizational projects, consisting of prerequisites, temporal dynamics in interorganizational projects, and contextual influences. The seven temporal dynamics found to support the realization of circular ambitions in construction projects are (a) transparency and trust, (b) flexibility, (c) reciprocal relationships, (d) project team identity, (e) struggle for new roles, (f) pioneering leadership, and (g) continuity in staffing. In addition, we identified four prerequisites that are needed for setting and realizing circular ambition in construction projects: (a) top-down support, (b) partnership based on increased equality, (c) shared circular goals, and (d) involvement of intrinsically motivated people. Moreover, we found three contextual factors that influence temporal dynamics, which in turn are influenced by them: (a) sectoral cultures, (b) knowledge flows, and (c) power and tensions.

Additionally, through this lens on projects, we give an insight into the potential contribution of these projects in the transition towards a circular construction economy as a whole. It is widely recognized that the existing construction regime is under increasing pressure stemming from global environmental concerns, as is recognized in international, European, and national sustainability agendas [13]. These goals are translated into regulations on environmental performance and transition platforms, which are established to bring about regime change. At the same time, however, the fragmentedness of the sector minimizes opportunities for niche–regime interaction, thereby perpetuating the existing construction regime [28]. Whereas direct collaboration offers space for actors to stimulate each other for circular decision making, and therefore allows niche influences on the project, this influence fades when it affects decision making further down the chain. Here, it becomes clear that not all elements of circular construction, e.g., the creation of circular supply chains, have had the protected space common to niches. Furthermore, due to the locked-in structures and processes [29], the regime inhibits flexibility, which is needed to redistribute time and money and to alter plans, and the option for actors to take on new roles. If actors in the construction chain continue organizing construction projects according to these locked-in practices, possibilities to realize circular ambitions are very limited. However, interorganizational projects can be opportunities for niche–regime interaction, with actors from diverse organizations influencing each other, and also bringing back their experiences with

and knowledge on circularity to their mother organizations. Finally, we have seen that learned lessons and actor experiences can be transformed into new circular projects in interorganizational initiatives and to future partners.

Limitations of our study can be found in the online collection of data due to the pandemic. Face-to-face evaluations were not possible, thus limiting the interaction and observing of interviewees, normally an important source of rich data [20]. Furthermore, all of our evaluated projects were situated in the Netherlands, which makes it difficult to generalize beyond the national scope. However, recent studies (e.g., [32]) share several of our found supporting temporal dynamics in an international context. Nevertheless, it should be noted that circular construction takes on many forms that might all influence temporal dynamics in interorganizational projects. We recommend future research to deepen knowledge on the dynamics found in this paper and to make the relation between them more clear by looking at a wider variety of case studies. Moreover, we recommend researchers to further investigate the interaction of circular construction niches with the regime, both on an organizational and a sectoral level. Our study shows that projects can aid the regime in taking up the niche of circular construction. Yet, at the same time, the limitations of them become clear, since the whole sector, and even parts beyond it, need to change to mainstream circular construction processes [57]. Therefore, more research should be conducted that focuses on actors outside the scope of construction projects and their influence on these projects.

This research's societal relevance is the transition towards the construction and renovation of buildings according to circular principles and thus, significantly reducing CO_2 emissions, resource use, and waste production. Learning from and experimenting with circular construction projects are both important in the transition towards circular construction economy for national and local governments and other organizations in the construction sector. This will support the needed change in collaboration in the construction chain related to organizational roles and responsibilities [7]. Through the program "Accelerating Together", integral thinking was stimulated as people from different types of organizations exchanged their perspective on the process of circular construction. Based on our results and the feedback given during the Accelerating Together program, we endorse the continuation of these types of programs to serve as a platform for shared learning and reflection in an interorganizational setting. Furthermore, we recommend practitioners to take heed of the temporal dynamics in interorganizational projects discussed in the findings, such as making someone explicitly responsible for putting circular ambitions on the agenda during project meetings, and create some flexibility in terms of planning and budget, in order to have room for potential setbacks and innovation during the project. Lastly, we recommend public clients to create a shared vision with architects and contractors before tender procedures, in order to make optimal use of the expertise of each actor and work towards integral solutions.

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Research question	Chapter	Methods	Purpose
1) Which dynamics in the execution of interorganisational construction projects are relevant to realise their circular ambitions, and how do these projects contribute to the transition towards a circular economy?	Chapter 2	Case studies: Group interviews. Workshop	To understand how practices can change in construction projects to stimulate setting and realising circular ambitions
2) How have Social Practice Theory and Sustainability Transitions Research been used together so far and what are the strengths and limitations of the different crossover frameworks?	Chapter 3	Systemic literature review	To understand how SPT and STR can be used together
3) How do practices (mis)align with each other regarding circular design strategies and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?	Chapter 4	Case studies: interviews, observations, document analysis. Workshops	To understand what helps and hinders the transition towards a CE for different circular design strategies
4) Which reconfigurations have taken place in the system-of-practices in which circular building hubs reside regarding reuse of secondary building components and how is it deemed likely to transition in the future?	Chapter 5	Interviews, observations, focus group, workshops	To understand recent and future changes regarding CBH's and their role in the transition

FIG. 3.1 Overview chapters

3 Crossovers between Sustainability Transitions Research and Social Practice Theory

A Systematic Literature Review

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Chapter 2 illustrated that dynamics for circularity are meaningful elements to stimulate setting and realising circular ambitions in construction projects. However, it also showed that the influence of these dynamics diminishes further down the supply chain. Therefore, to study the transition towards a circular economy in the architecture, engineering, and construction sector, a wider scope than just construction projects was needed. Instead, behaviour had to be studied on a more systemic scale, to understand how interorganisational behaviour influenced the transition beyond the scope of these projects. With this change of scope, also a new theoretical interpretation of behaviour was needed that was

suitable to study behaviour on this new scale. The answer was eventually found in Social Practice Theory, as this is an often used approach to study sustainability transitions (Sovacool & Hess, 2017). Social Practice Theory takes practices as unit of analysis (Schatzki, Knorr-Cetina, & Von Savigny, 2001), of which it is often said that that they go beyond mere behaviour (e.g. Spurling & McMeekin, 2014). Practices can refer to consuming, but it the approach has also been used to study practices of professionals and can therefore be applied to study interorganisational behaviour. An advantage of Social Practice Theory is also that previously conducted research link the approach with Sustainability Transitions Research (e.g. Hargreaves et al., 2013; Watson, 2012) that researches systemic change (Köhler et al., 2019). However, other scholars state that Social Practice Theory and Sustainability Transitions Research are ontologically incompatible (e.g. Geels, 2010; Schatzki, 2002). This lead to chapter 3, which shows the results of a systemic literature review on the options for ontological (in)compatibility between the two approaches and possible conceptual frameworks that can be used to study practices and transitions in many sectors and also specifically practice and system change that can be applied for the transition towards a circular economy in the architecture, engineering, and construction sector.

ABSTRACT

Researchers employ many different approaches to study transitions towards more sustainable futures, of which Sustainability Transitions Research and Social Practice Theory are often used. These approaches offer complementary concepts that are helpful to analyse, explain, forecast, and drive sustainability transitions, e.g. heuristics on changing institutions (Sustainability Transitions Research) or dynamics to change behaviour through practice development (Social Practice Theory). However, despite first attempts, it remains unclear how the approaches can be used together. Therefore, the aim of this paper is to expose crossover frameworks in which these approaches are used together, elaborating on conditions that make this possible, and the strengths and weaknesses of specific crossover frameworks. A systematic literature review has been conducted, investigating the potentials and the limitations for crossovers between Social Practice Theory and Sustainability Transitions Research by analysing the approaches according to the different ontologies and theories and then analysing frameworks that have been created so far. This research elaborates on six crossover frameworks that have been created that all have diverse strengths, such as the ability to conceptualise early transitional changes or finding points of resistance in transitions. All the found crossover frameworks made use of either the multilevel perspective or transition management. Other frameworks of transition research have not been found. This research shows that there has been surprisingly little research to crossover frameworks

that incorporate an element of time. The exposition following from this study is interesting for researchers and policymakers working on sustainability transitions and sets an agenda for further framework development.

KEYWORDS Crossovers, Framework, Sustainability Transition Research, Social Practice Theory, Transitions

3.1 Introduction

Sustainability transitions require radical changes in the way products and services are produced and consumed in many systems and societies (Laakso, Aro, Heiskanen, & Kaljonen, 2021). A change on systemic level is needed that goes beyond incremental improvements (Geels, 2020; Hargreaves et al., 2013; Keller, Sahakian, & Hirt, 2022). As these transitions are complex (Mickwitz, Neij, Johansson, Benner, & Sandin, 2021), many different approaches have been developed to study them (Sovacool & Hess, 2017). This development is relevant, as no approach is neutral in itself, because every approach already comprises visions regarding governance, offering both insights and 'black-boxing' of complexities (Jørgensen, 2012). Two often used approaches are Sustainability Transitions Research (STR) and Social Practice Theory (SPT) (Sovacool & Hess, 2017). These have been developed largely in separate academic communities, and provide their own research traditions and answers (Geels, McMeekin, Mylan, & Southerton, 2015). However, these communities have a lot to learn from each other to better understand the complexities of transitions. This understanding is one of many potential specific answers to a larger mission in transition research: to combine insights from both the system level as the level of the actor, which is sometimes conceptualised as behaviour or agency, and sometimes, such as here, as practices (e.g. Dutch Research Council (NWO), n.d.; Köhler et al., 2019; Watson, 2012).

Based on a diverse set of theoretical origins, such as Science and Technology Studies, Complexity Theory, and Sociology of Innovation (Köhler et al., 2019), Sustainability Transitions Research is a set of five codeveloped heuristic frameworks

that considers transitions as complex phenomena[2] (Geels, 2002; Öztekin & Gaziulusoy, 2020), perceiving change as happening at different scales (Obersteg et al., 2019), with multiple actors (Geels, 2002), concerning multiple aspects (Heurkens & Dąbrowski, 2020), in a path-dependent, non-linear way (Wittmayer & Loorbach, 2016). The five frameworks are Strategic Niche Management (SNM) (Rip & Kemp, 1998; Schot & Geels, 2008), Technological Innovation Systems (TIS) (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008), Mission-oriented Innovation Systems (MIS) (Hekkert, Janssen, Wesseling, & Negro, 2020), Transition Management (TM) (Loorbach, 2010), and the Multi-Level Perspective (MLP) (Geels, 2005; Köhler et al., 2019). In the last decade, there has been a huge increase in papers that use STR as an approach for sustainability transitions (Köhler et al., 2019), both in past and future transitions (Köhler et al., 2019; Vähäkari et al., 2020). Several systems have been researched with the approach, e.g. energy, food, water, housing, and transport (Geels, 2005; Hargreaves et al., 2013; Köhler et al., 2019). Yet, despite its usefulness and popularity, researchers found several limitations to the approach. First, so far this approach has mainly been applied to case studies in the Global North, especially The Netherlands and The UK (El Bilali, 2020). Further, it offers useful concepts for change, but not for normality (Hargreaves et al., 2013). And lastly, transitions research is critiqued to tend to focus too much on technology (McMeekin & Southerton, 2012; O'Neill, Clear, Friday, & Hazas, 2019) at the cost of considering agency of individuals and their collaborative actions (Grin, Rotmans, & Schot, 2011; O'Neill et al., 2019). Scholars have argued that with these shortcomings transitions research is not developed (enough) to deal with all relevant transition questions (e.g. Geels, 2011, 2020), even though researchers are actively working on overcoming this (e.g. Van Welie, Cherunya, Truffer, & Murphy, 2018, on the Global South).

To deal with some of these shortcomings, some authors have suggested that more attention should be given to SPT (e.g. Koretsky & van Lente, 2020; Shove & Walker, 2010), a combination of theories that use practices as their focus (Schatzki et al., 2001). Guided by sociologists Pierre Bourdieu and Anthony Giddens among others, SPT originated in the 1970s in response to the agency versus structure debate in the social sciences (Plummer & Van Poeck, 2020). This debate concerns whether individual actors or large-scale social phenomena are the primary determinants of human behaviour, and thus the appropriate focus for social analysis (Schatzki et al., 2001). SPT proposes an alternative view, i.e. that actors and social

2 'STR' is also often used for the wider field, wherein sometimes concepts from these heuristic frameworks are used, but these frameworks themselves not explicitly. In this paper we use the narrow term when these frameworks are explicitly used.

structures are dialectically shaped at the level of social practices (Giddens, 1984). Social practices can be understood as being composed of individuals carrying out both bodily activities and routinized ways or understanding things and situations (Reckwitz, 2002). As such, the approach offers theory about the normality of practices and actor agency in the individual performance of every practice (Hargreaves et al., 2013) and can therefore help overcome many of these gaps of STR. However, the gap regarding the geographical focus of STR (i.e. focus on the Global North, specifically the UK and the Netherlands) will not be overcome by just applying SPT. This requires more empirical work.

As STR is not a theory, but a set of heuristic frameworks (Geels, 2011; Köhler et al., 2019), and SPT is not a single, but a multitude of similar theories (Schatzki et al., 2001), here the term approach is used. This allows to elaborate on these two semi-coherent bodies of literature. When looking at transitions, scholars state the importance of perceiving these through multiple approaches, as multiple perspectives can compensate each other's weaknesses, while acknowledging each other's strengths (e.g. Geels, 2010; Huttunen et al., 2021; Seyfang & Gilbert-Squires, 2019). Nevertheless, for a long time, SPT and STR have been developed in mutual exclusion (Hargreaves et al., 2013), and only recently use of both approaches in an article has increased (Keller, Noorkõiv, & Vihalemm, 2022). Many scholars also state that a full synthesis between the two approaches is impossible, as their ontological basis is fundamentally different (e.g. Geels, 2010; Hargreaves et al., 2013; Laakso, Aro, et al., 2021). Further, they focus on different units of analysis, i.e. SPT focuses on practices and STR focuses on systems/regimes (Seyfang & Gilbert-Squires, 2019). However, in this paper Geels' (2010) more nuanced statement is followed: the approaches can be usefully linked with crossovers.

Following Geels (2010), crossovers are here defined as interplay of concepts between two different approaches. Crossovers therefore do not aim to synthesise approaches (Geels, 2010; Moore et al., 2018), but use insights from both, while still staying true to the foundations of both. Several researchers (e.g. Hargreaves et al., 2013; Van Welie et al., 2018; Watson, 2012) used crossovers into specific conceptual frameworks, which are referred here to as crossover frameworks, which are defined as conceptual frameworks that bring together concepts from different approaches, resulting in a newly defined ontology based on the approaches it stems from. Further, in this case a crossover is never between the whole of STR and SPT, but always between one heuristic framework of STR and one of the interpretations of SPT. Both approaches perceive sustainability challenges as too complex to be solved by incremental tinkering (Hargreaves et al., 2013; Shove & Walker, 2010). Instead these challenges demand fundamental systemic change (Geels, 2005; Hargreaves et al., 2013). As this research shows, crossovers so far focused on connections

between MLP/TM and SPT. The other heuristic frameworks from STR have not been developed into crossovers, so they will not be the focus of the rest of this paper. So far, crossovers have proven fruitful (Keller, Sahakian, et al., 2022), as researchers can make use of system transition explanatory or steering concepts from MLP/TM (Geels, 2011, 2020), but also from concepts of dynamics to change behaviour through practice development, as is common in SPT (Hargreaves et al., 2013; Van Welie et al., 2018). Keller et al. (2022) distinguished seven insights for usage of both SPT and the MLP: 1) one can zoom in on practices and zoom out on regimes/systems, 2) practices and regimes influence each other, and the intersection points between them are interesting points for analysis, 3) the regime is not a completely formal, there are degrees of formality, 4) multiple regimes influence a practice and researching both practices and regimes allows insights in how regimes interact, 5) both producers and consumers play important roles in the transition, 6) 'sticky', persistent practices are useful to study as they can hinder transitional change, and 7) some practices can play a role on the landscape level. This research partly builds on this earlier research and discusses diverse ways in which crossovers can be made, forming crossover frameworks. Crossovers frameworks can be used to answer questions about topics on systematic change, such as the practices that form regimes, or system changing in different locales. Both approaches offer a piece of the complex puzzle of how to analyse transitions. Using crossovers, more of the puzzle becomes visible. Different crossover frameworks have been developed that focus on fundamentally different aspects of the approaches, but as a clear overview of the current research is missing (Geels et al., 2015; Keller, Sahakian, et al., 2022), academics focussing on transitions would benefit from an exposition of the different crossovers to make better informed decisions on which frameworks to use.

This paper primarily aims to expose how these two approaches have been used together so far, elaborating on what the strengths and limitations of the different crossover frameworks are and so offer tools for researchers and policymakers, both private and public, to study and steer sustainability transitions. By distinguishing between different crossover frameworks, it becomes possible to be more precise about their ontological and theoretical contributions. By exposing this, this paper secondarily aims to set a research agenda for future researchers interested in researching transitions and practices. A systematic literature review has been conducted, resulting in 76 papers that have been included that all mention both approaches. First, these papers have been analysed on statements regarding ontology and theory resulting from making crossovers, to understand under which conditions crossover frameworks can(not) be made. For this first part therefore also papers that have not made use of crossover frameworks have been included, as they sometimes explain the conditions that hinder making crossovers. Then, analysis regarded crossover frameworks specifically, and these have been analysed on strengths and

limitations. This analysis involved describing contexts they are useful for, regarding complexity of systems and size (contextual or system), and which aspects of either approach were most commonly used. Findings show that there are fundamentally different ways in which crossovers between the approaches have been found and designed into frameworks, highlighting different elements of either approach. Some are more fundamentally rooted in SPT literature, whereas others have a more equal division between elements from SPT and MLP/TM, therefore also creating new ontologies. Different crossovers can therefore be used to answer different types of research questions (e.g. why certain practices are likely to be reproduced, or which practices influence policy making) and focus on different units of analysis (e.g. set of contextual practices or system (of practices)). With this exposition researchers will be better equipped to use and create crossover frameworks to study transitions, focusing on everyday practices, as is asked for in literature (e.g. Garduño García & Gaziulusoy, 2021; Köhler et al., 2019; Vähäkari et al., 2020).

The article is built up as follows. Section two offers a brief overview of the two approaches. Section three sets out the methodology and elaborates on how data was analysed for this systematic literature review, followed by the results in section four in which combining the approaches is discussed on the level of ontology and theory. Section five sets out the different crossover frameworks that have resulted from the combination and discusses the value and limitations of them. This is followed by a discussion and conclusion with a research agenda in section six.

3.2 The Two Approaches

This section introduces the Multi-Level Perspective (MLP), Transition Management (TM), and Social Practice Theory (SPT), including different forms in which these approaches have been used. Both approaches are considered middle-range 'theories' that give dominance to neither agency nor structure (Geels, 2011; Hargreaves et al., 2013).

3.2.1 Sustainability Transitions Research

3.2.1.1 Core notions on MLP and TM

Since this research showed only TM and MLP have explicitly been used in combination with SPT, these are the focus in this article. TM is based on complexity science and governance studies and focuses on policies that can shape transitions through strategic, tactical, operational, and reflexive activities (Loorbach, 2010). Its primary focus is on prescription and less on description, involving processes of learning, searching, and experimenting. An often used method is backcasting, identifying short-term goals based upon long-term goals and reflections of future developments with the use of scenario building (Loorbach, Wittmayer, Shiroyama, Fujino, & Mizuguchi, 2016; Quist, 2007). TM is a pragmatic framework without a clear ontology or predefined units of analysis (Köhler et al., 2019); the focus can for instance be on activities, experiments, learnings, or (sub-)systems. TM uses several concepts to explain, and help guide transitions, for example, transition arenas, "a small network of frontrunners with different backgrounds, within which various perceptions of a specific persistent problem and possible directions for solutions can be deliberately confronted with each other and subsequently integrated" (Loorbach, 2010, p. 173). These frontrunners, protected by regime actors and structures, help guide the transition on a strategic level. It requires actors with a high level of abstraction. The vision created from this transition arena is then translated to transition agendas on a tactical level, where structural barriers on the regime level form the focus. Overcoming these is explored through developing transition scenarios. On an operational level, experiments and other actions are used to broaden, deepen, and scale up planned initiatives (Van den Bosch & Rotmans, 2008). All levels are continuously monitored reflexively (Van Mierlo & Beers, 2020), both regarding the transition as its management (Loorbach, 2010).

More often used, also in relation with SPT, is the MLP. The MLP consists of three levels, as is shown in figure 3.2 (Geels, 2002):

- The micro level, which is formed by protected niches which create radical innovations (Geels, 2002, 2020).
- The meso level or socio-technical regime, which is "the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems - all of them embedded in institutions and infrastructures" (Rip & Kemp, 1998, p. 338).

— The macro level, which is formed by the socio-technical landscape, a force beyond the direct influence of niche and regime actors, which influences both niches and regime (e.g. macro-economics, deeply embedded cultural patterns, macro-political developments) (Geels, 2002, 2020).

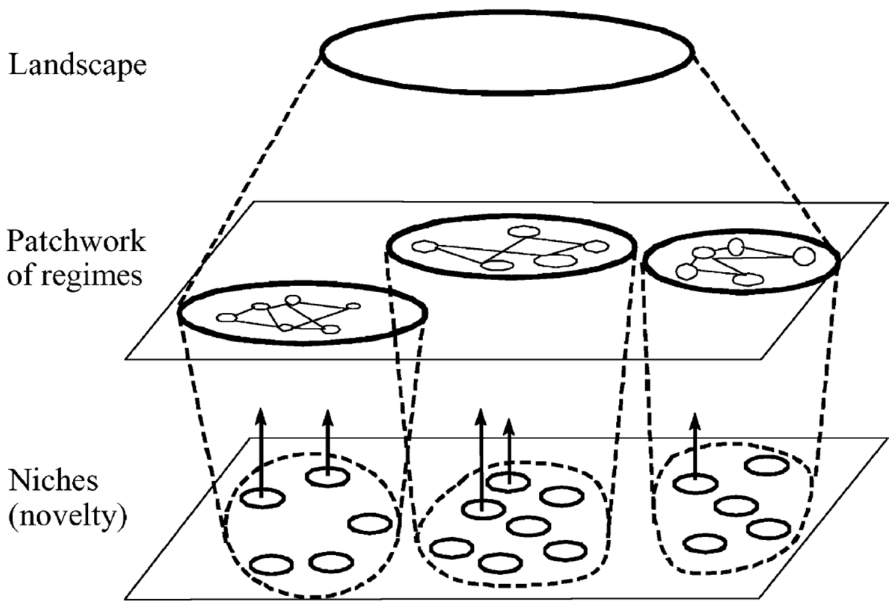

FIG. 3.2 Multi-level perspective (from Geels, 2002)

According to Geels (2011), based on these definitions the perspective is conceptualised as sets of rules. Depending on which level of the MLP they are part of, these rules can be highly flexible (niche) or consistent for long periods of time (landscape). However, in empirical studies the unit of analysis often tends to differ, ranging from actors to complete systems or even transitions. The MLP is often characterised as a flexible ontology based on evolution theory and interpretivism that allows growth through interaction with other, but not all ontological traditions (Geels, 2010).

MLP and TM can be interpreted as intertwined research traditions (Paredis, 2013). Concepts of the MLP (e.g. niche or regime) are therefore also often used in TM research (Loorbach, 2010), though its unclear ontology does not require usage of these concepts. Whereas theoretical papers sometimes make quite clear distinctions between the two perspectives (e.g. Köhler et al., 2019), in empirical

studies notions from both traditions are often implicitly used together or TM is interpreted as a practical implementation of MLP (e.g. Lode, Te Boveldt, Macharis, & Coosemans, 2021).

3.2.1.2 Ontological inconsistencies

In this part the ontological inconsistencies of MLP are discussed. TM is left out from this discussion as it does not have a clear ontology to start with (Köhler et al., 2019). The definition of what constitutes a regime has changed over time. Whereas Rip and Kemp (1998) speak of a set of rules, later the concept often also includes specific actors (e.g. Köhler et al., 2019), or within empirical studies it is often used as 'system', contrasting the theoretical papers that remain closer to the original definitions (Geels, 2011). This ambiguity of the concept regime therefore sometimes has the result that the different levels start to represent 'real world' levels (e.g. administrative or geographical levels including their actors, artefacts, and institutions) instead of levels of structuration, something Grin et al. (2011) explicitly warn against for sake of ontological consistency and the ability to translate theory from one context to the next. This paper sticks to the interpretation of levels as rules, because it is closer to the theoretical foundations of the MLP and makes crossover more likely .

Also, the way in which the levels relate to each other has changed over time. Rip and Kemp (1998) distinguish between the levels by different levels of structuration. The regime is the rule set that sets the norm. This is influenced by a more stable set of rules, the landscape, and a quickly changing set of rules, the niche. Later articles on MLP (e.g. Geels & Schot, 2007; Laakso, Aro, et al., 2021) explicitly mention the nested hierarchies of the levels, assuming that the quickly changing rules of a niche are embedded in the stable rules of the regime and the landscape. However, Geels (2011) later mentioned that the concept of nested hierarchies might better be abandoned, as niches can emerge without direct influence from the regime. This notion would make crossovers with SPT more likely, as this hierarchical aspect misaligns with the flat ontology of SPT (Hargreaves et al., 2013; Laakso, Aro, et al., 2021).

3.2.1.3 Change in the MLP and TM

The core notion of MLP is that change comes about when 1) niches build up momentum, 2) the landscape pressures the regime, so 3) the destabilised regime is pushed to create windows of opportunity for niche innovations (Schot & Geels, 2008). In both MLP and TM change is also often conceptualised through transition paths (e.g. Geels & Schot, 2007; Hoekstra, Steinbuch, & Verbong, 2017; Rotmans et al., 2003). Geels and Schot (2007) recognise that there are different transition paths that can emerge (partly) based on the timing of landscape pressure, which are: 1) transformation, 2) substitution, 3) reconfiguration, 4) de-alignment and re-alignment. Further, disruption is sometimes used as a transition path (e.g. Kivimaa, Laakso, Lonkila, & Kaljonen, 2021), but in the parlance of Geels and Schot (2007) disruptive change is merely a part of any one or a combination of these transition paths. Then, Grin et al. (2011) refer to reproduction, a stable state of the regime that has to be reproduced. Lastly, phase-out can be perceived as a transition path in which no new regime takes over the old (Koretsky & van Lente, 2020).

TM is used to analyse change, but maybe more often as heuristic framework to steer change (Loorbach, 2010). Next to the conceptualisation of transition paths, change in TM is conceptualised as coming about on strategic, tactical, and operational levels that all influence each other. This then results in an X-curve (Hebinck et al., 2022): on the one hand, new regimes emerge through experimentation, which turns to acceleration, emergence, institutionalisation, and stabilisation. On the other hand, old regimes are broken down, from optimalisation, to destabilisation, chaos, breakdown, and phase out. TM is used on systemic scales (Köhler et al., 2019), but maybe more often on local scales, for instance regarding transformation of cities or local regions (e.g. Heurkens & Dąbrowski, 2020; Loorbach et al., 2016).

3.2.1.4 Critiques on the MLP and TM

Over time, MLP has had several critiques. Some of the critiques can be solved by development of MLP itself, while other critiques simply require or are better solved with a different approach (Geels, 2010) or in combination with another approach, such as SPT. MLP is critiqued on its inability to focus on small scales (Banos, Deuffic, & Brahic, 2022; Geels, 2011, 2020) and lack of concepts to explain dynamics on that level (Geels, 2011; Hargreaves et al., 2013; Shove & Walker, 2010; Vasileiadou & Safarzyńska, 2010), such as interaction between humans and technology (Davies & Doyle, 2015; El Bilali, 2020). On a more fundamental level MLP is critiqued as it does not offer a clear ontology, but merely a heuristic framework (El Bilali, 2020;

Geels, 2011; Genus & Coles, 2008). Further, the landscape level can be the source of an infinite type of contextual influences, making it a residual analytical category (Geels, 2011; Shove & Walker, 2010). Also, it remains unclear why the landscape creates pressure in the first place (Labanca et al., 2020). Further, despite proposals to focus more on power relations (e.g. Avelino & Wittmayer, 2016; Geels, 2014), some claim that the difficulty stems from the ontological foundations of the MLP, given its focus on levels of structures at the cost of considering how actors relate to these structures (El Bilali, 2020; Svensson & Nikoleris, 2018). These critiques have led to 1) promoting SPT as better alternative (e.g. Shove & Walker, 2010) or 2) for promoting the coexistence of approaches (e.g. Geels, 2011). In line with the latter, some (e.g. Geels, 2011) claim that the approaches have different foci – MLP focuses on recurring patterns and mechanisms that guide transitions (see also: Papachristos, 2018), while SPT has a more descriptive focus, allowing for heterogeneity, fluidity and specifics of every single transition. Although this is how the approaches have mostly been used, one can question if the difference stems from the theory driven assumptions of the approaches or the empirical studies that have mostly been conducted with them (e.g. as exception Hoolohan and Browne (2020) use designing practices). Lastly, 3) apart from the possibilities to use SPT and both approaches next to one another, following this article the theoretical developments of the last decade are followed (e.g. Crivits & Paredis, 2013; Hargreaves et al., 2013): crossovers could also offer an answer to some of these critiques.

TM has had several other critiques. As the ontology of TM remains vague, the concepts (e.g. chaos and destabilisation) are often interpreted differently (Hebinck et al., 2022). Further, the concepts used in TM also explicitly hide others, simplifying the framework at the cost of understanding complex transitions (Voß & Bornemann, 2011). Also, there is often an implicit normativity involved in TM research (Shove & Walker, 2010), which often benefits some groups more than others (Voß & Bornemann, 2011). Further, similar to the MLP, TM is critiqued for its lacking concepts on agency and power (Davies & Doyle, 2015). Lastly, TM is often critiqued on not challenging, but stabilising an incumbent, capitalist economy (Nadasdy, 2007; Voß & Bornemann, 2011). Crossovers with SPT might help overcome forgetting concepts and therefore also make the normativity more explicit, though this largely depends on the researcher and scope setting. Crossovers might not help with challenging the incumbent capitalist economy.

3.2.2 Social Practice Theory (SPT)

3.2.2.1 Core notions on SPT

Social practice theory is an approach consisting of several interrelated theoretical bodies of literature that uses practices as units of analysis (Hargreaves et al., 2013; Nicolini, 2012; Schatzki et al., 2001). Within SPT, practices take centre stage to the extent that people (and sometimes things) are merely perceived as carriers of the practice, but are not the units of analysis themselves (Reckwitz, 2002; Shove, 2010; Watson, 2012). The approach is often applied to observe and understand the balance between change and stability, i.e. why practices change or why they keep being reproduced. These notions of stability offer researchers the profound challenges that need to be overcome when trying to change practices (Hargreaves et al., 2013), such as the use of innovative technologies. As such, SPT is often applied to big societal problems, such as climate change, obesity, and inequality, while taking into account contextual scales (Labanca et al., 2020; Shove, Pantzar, & Watson, 2012).

Schatzki (2002) distinguishes two types of practices: practices-as-performances and practices-as-entities. The first refers to the enactment in specific times and places and is often unique (Warde, 2005), whereas the second refers to the emergent outcome of these performances in the form of what is generally understood as the idealised type of the practice. Practices-as-entity come to exist due to the constant reproduction of practices-as-performance (Watson, 2012) and in that reproduction concepts of power get interwoven (Shove & Walker, 2010) that make practices self-reinforce (Seyfang & Gilbert-Squires, 2019). This reproduction is itself enforced by the practices linked to a practice, that together form a complex (Shove et al., 2012). Complexes can be formed by overlapping elements within a practice or the fact that practices are performed in sequence (Huttunen et al., 2021) or in any other way depend on each other (Shove et al., 2012). Sometimes the bond between practices is more loosely knit, but still existing, for instance when practices influence each other slightly because they are performed in the same space and for this the term ‘bundle’ is used (ibid.). Note that the terms ‘bundles’ and ‘complexes’ are sometimes used differently or interchangeable (e.g. Cherunya, Ahlborg, & Truffer, 2020; Spaargaren, Weenink, & Lamers, 2016), but this is how the terms are used in this paper.

Many SPT scholars agree that all activity is perceived as practices that form bundles and complexes; there is no context outside practices (Huttunen et al., 2021) or hierarchy between practices (Hargreaves et al., 2013; McMeekin & Southerton, 2012). This is why it is called a ‘flat’ or relational ontology (Geels, 2010; Huttunen et al., 2021; Seyfang

& Gilbert-Squires, 2019; Spaargaren et al., 2016). Some SPT scholars take a less flat take on practices, claiming that practices have different levels of structuration (e.g. Warde, 2005). Further, Røpke (2009) argues for a pragmatic approach that includes broader contexts, e.g. labour division, gender relations, and unequal accessibility to resources, as these contexts shape practices as well as the other way around.

3.2.2.2 Ontological inconsistencies

As already mentioned, there is not merely one Social Practice Theory. To illustrate, some scholars focus on elements that make up practices (e.g. Shove & Pantzar, 2005), whereas others focus on the connection between these elements (e.g. Warde, 2005), or the connection between practices and socio-technical systems (e.g. Spaargaren & Van Vliet, 2000). In empirical studies, especially in the crossover frameworks found in this study, an often recurring form seems to be the version of Shove and Pantzar (2005). As this is the only found interpretation of SPT in crossover frameworks, this is the only interpretation upon which is elaborated here. Shove and Pantzar (2005) made a simplification of the elements found by Reckwitz (2002), that breaks down practices into the elements meanings, materials, and competences (figure 3.3). They state that these elements have no use on their own; only linked together do they produce something, a practice. In the development of a practice, some elements might exist on their own, thus forming a proto-practice, an innovation-in-waiting. Although it is helpful to organize data on social change with only three elements, this is at the expense of potentially simplifying what practices are about (Shove et al., 2012; Spaargaren et al., 2016).

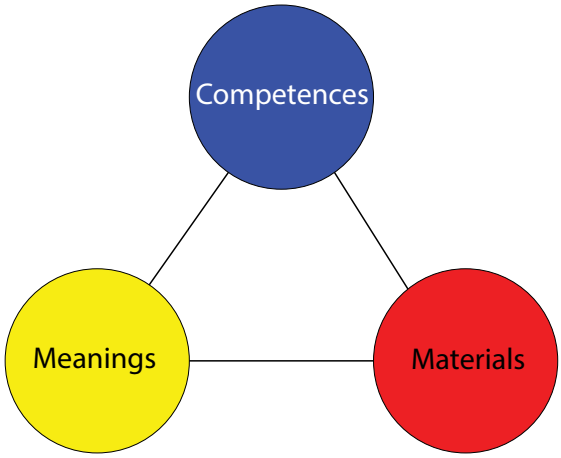

FIG. 3.3 Elements that constitute a practice (based on Shove & Pantzar, 2005)

3.2.2.3 Change in SPT

Watson (2012) distinguishes three ways in which practices can be steered towards change. First, the elements that constitute a practice can change. Second, the practices linked to a single practice can change. Lastly, the carriers of the practice can change. Additionally, Shove, Pantzar, and Watson (2012) mention the relevance of networks between carriers of practices that can help to change practices and Spurling and McMeekin (2014) mention substituting practices themselves, e.g. riding a bike instead of driving a car. Similarly, these first four ways of stimulating change can also function as stabilising factors that help reproduce practices similarly. In academic practice, these four ways to stimulate change have mostly been used contextually or for single practices, but they can be applied on a transitional scale too (Spaargaren et al., 2016). Change on a transitional scale is then conceptualised as change in one or more of these four ways that encompass a complex of practices on the scale of a large system, a system-of-practices (Klitkou et al., 2022; Watson, 2012).

3.2.2.4 Critiques on SPT

SPT has had some critiques as theoretical approach to study transitions. Some scholars (e.g. Geels, 2011) claim that the focus of SPT is not so useful to study transitions;–whereas STR focuses on recurring patterns and mechanisms that guide transitions (see also: Papachristos, 2018), SPT has a more contextual/descriptive focus, allowing for heterogeneity, fluidity and specifics of every single transition. However, contrastingly, several scholars (e.g. Klitkou et al., 2022; Spaargaren et al., 2016) acknowledge this, but also state that this is caused by how SPT for a long time has been used most often empirically: on a relatively small scale, making it difficult to generalise findings beyond their contexts. Some seminal works have shown for decades that SPT can focus on large systems (most famous the work of Shove (e.g. 2003)). Further, as bundles of practices can form a whole system, the unit of analysis is not necessarily small (Klitkou et al., 2022; Schatzki, 2016; Spaargaren et al., 2016). To further deal with this critique of limited explanatory value, in recent years several larger scale studies have been conducted (e.g. Koretsky & van Lente, 2020; Shove & Trentmann, 2018; Taillandier, Dijk, & Vialleix, 2023) and theoretical guidance on conducting such research has emerged (e.g. Schatzki, 2016). Geels' (2011) critique therefore seems to have become outdated.

3.2.3 Reasons for Crossovers

There are various reasons why both MLP and SPT have been used together. Originally, the combination was sought because MLP alone was deemed capable of offering insights about production, but not about consumption, a gap filled by SPT (Crivits & Paredis, 2013; e.g. Grin et al., 2011; Little, Lee, & Nair, 2019). Up to this day this seems the dominant reason to combine both approaches (Mathai et al., 2021; Morrissey, Mirosa, & Abbott, 2014).

However, more recently it is argued that the interpretation of using MLP for production and SPT for consumption is an oversimplification of the uses of these approaches (Heiskanen, Reindl, & Ruggiero, 2024; Keller, Sahakian, et al., 2022; Laakso, Aro, et al., 2021). There are other reasons why the combination is considered fruitful; MLP/TM offer many concepts on producing change, but it offers very little on the dynamics of normality (i.e. why transitions do not happen), for which SPT can be used (Davies & Doyle, 2015; Hargreaves et al., 2013). SPT can also be used to describe other elements than merely consumption, such as production or the creation of rules and norms, but it so far is seldom applied as such. More recently a few examples (e.g. Jakku et al., 2019; Seyfang & Gilbert-Squires, 2019; Svennevik, Dijk, & Arnfalk, 2021) emerged that have used the combination, using SPT concepts (also) for production and setting rules and norms.

Further, scholars stress that the combination provides insights that go beyond individual or structuralistic models (El Bilali, 2020), that it offers a more thorough understanding of the systemic problems and sustainability innovation processes (Hargreaves et al., 2013; Seyfang & Gilbert-Squires, 2019), that SPT can offer new insights on agency and power for MLP/TM (Davies & Doyle, 2015; Grin et al., 2011), and that it offers clarification about the points that are likely to offer resistance when changing practices or regimes (Boamah & Rothfuß, 2018; Hargreaves et al., 2013; Seyfang & Gilbert-Squires, 2019).

Combining the two approaches has resulted in many new insights (e.g. on the aspects of a system that are most likely to offer resistance when transitioning (Hargreaves et al., 2013) or how to investigate starting system changes (O'Neill et al., 2019)) and scholars advise exploring new ways in which these approaches can be combined (Huttunen et al., 2021; Nogueira, Wigger, & Jolly, 2021). However, there are some limitations when using just these approaches. Öztekin and Gaziulusoy (2020) note the limited explanatory value of the MLP and SPT during interventions and suggest the use of a design approach to fill this gap. We see this potential, as earlier research from both STR and MLP already combined with design approaches (e.g. Scott, Bakker, & Quist, 2012). Geels et al. (2015) further note that the approaches offer useful insights for system change, but no concepts to claim that this will actually benefit sustainability.

3.3 Methods

To elaborate on how SPT and STR have been used together and what potentials lie in the combination, a systematic literature review has been conducted.

A literature search has been conducted on Scopus on 12-11-2021 using the terms "Sustainability AND transition AND practice AND theory" and "Sustainable AND transition AND practice AND theory" in abstracts, titles, and keywords of articles, conference papers, and articles in books. Scopus is considered a decent stand-alone database (Bergman, 2012). The result of the search was 787 papers, 548 after removing duplicates. These papers have been appraised by their title, keywords, and abstracts to find the articles that use both SPT and STR. This resulted in 70 papers. These 70 articles have been read in full, and appraised again on whether they used both SPT and STR. This resulted in a body of literature comprising 50 articles. A second search on Web of Science was conducted on 23-3-2023 using the same criteria resulting in 553 extra articles, of which 362 duplicates. After appraising them similarly, 4 additional articles have been found. A third search was conducted on 24-5-2024 which led to 620 new articles, of which 178 duplicates. 7 additional articles have been found in this search. Articles that have been dropped often only used one of the approaches, and words but not concepts of the other, e.g. articles that use SPT with a concept of transition that is not directly related to STR, but to changing large bundles of practices, or articles that use STR with mentions of practices, but usually undefined and without using concepts from SPT to talk about these practices.

As the search terms are words that have been used extensively in contexts outside STR and SPT, conducting this search on full texts was not feasible. Consequently, some articles might have been missed. Snowballing has been used to compensate. References in the found body of literature that explicitly mentioned crossovers were included when they did not show up in the search results. Also, in line with Xiao and Watson (2019) two experts were consulted for additional articles. Through snowballing and expert additions, 15 articles have been added to this amount, resulting in a final amount of 76 articles, as can be found in Appendix A. The combination of systematic searches in online databases, snowballing, and expert consultation cannot be complete, as is often mentioned in literature (e.g. Xiao & Watson, 2019), but the combination of methods should drastically improve results (Shaffril, Samsuddin, & Samah, 2021). Next to this body of literature, several seminal papers on either STR or SPT have been used to aid in understanding either approach.

The approaches have been analysed according to their ontology and theory, as these shape the crossover frameworks. Ontology is "the match […] between entities with which the theory populates nature and what is 'really there'" (Kuhn, 1970, p. 206). These entities provide focus on what are legitimate problems to be solved by science (Greenhalgh et al., 2005; Kuhn, 1970). The element of theory further elaborates on how these entities and the relationships between them and the world are used to explain natural phenomena (Creswell, 2003; Greenhalgh et al., 2005; Kuhn, 1970). For MLP/TM and SPT specifically this means comparing and contrasting how change comes about. 'Transition paths' is the common term for this in the MLP (Geels & Schot, 2007), which is also used in TM (Loorbach, 2010) , and SPT focuses on substituting practices, changing elements, re-locking practices in their complex, and changing the practice performers, or their networks. First, the meta-information was coded, focusing on the systems for which both approaches were used to study and the moment of publishing. Then, deductively the found body of literature was coded regarding ontology and theory. Then, within this subset inductively emerging themes were coded. This was needed to understand under which conditions (e.g. definitions or research context) crossovers can be made. The result is an overview of the discussion on crossovers, ontologically in 4.2 and theoretically in 4.3.

After this first analysis, the body of literature has been scanned on different crossovers that have been made specifically. First, it was coded if articles used crossover frameworks, and these were then grouped together based on similarities. This resulted in six groups of crossover frameworks. As this research primary interest is how these approaches are used together, it includes conceptual, methodological, and heuristic frameworks. These frameworks have then been compared on their strengths and limitations, in part by focusing on the added relevance of the crossovers, the different interpretations of the approaches they use and the different focal points they have. This has resulted in an analysis on the following aspects: the units of analysis, their uses for either complex or homogeneous systems, and the elements of both approaches use to explain transitions, as well as the elements they cannot use anymore due to the specific crossovers. Crossover frameworks have been grouped and visualised based on general similarities, as is common in qualitative research (Creswell, 2003). Visualisations have been created by the authors in absence of existing visualisations, and to generalize system specific elements. Lastly, it was found that most groups of crossover frameworks have been used by a multitude of sources, but there is also one that has been used in only a single article. As the aim of this research is to find potential ways in which crossovers can be created, all have been incorporated. Disregarding a crossover framework for having a single source, would defeat that purpose and weaken our understanding of crossover creation.

3.4 Results

In this section the paradigm of the combination of both approaches is discussed. First, in 4.1 the meta-information of the found body of literature is discussed. The rest of this section is devoted to explaining different elements of the ontology in 4.2 and theory in 4.3.

3.4.1 Meta-information

SPT and STR are mentioned together in papers from 2008 onwards. Over time a slight, irregular increase of papers that use both approaches is visible. At first, this mainly meant mention or discussion of both approaches, where later – slowly starting in 2011 – also frameworks with crossovers were applied, as is shown in figure 3.4. Still most articles that mention both approaches do not make explicit crossovers. Relatively often STR is used for purpose of context, where SPT is used as primary approach. Also, quite often one of the approaches is merely mentioned as suggestions for further research, which illustrates that both approaches have mostly been developed in mutual exclusion.

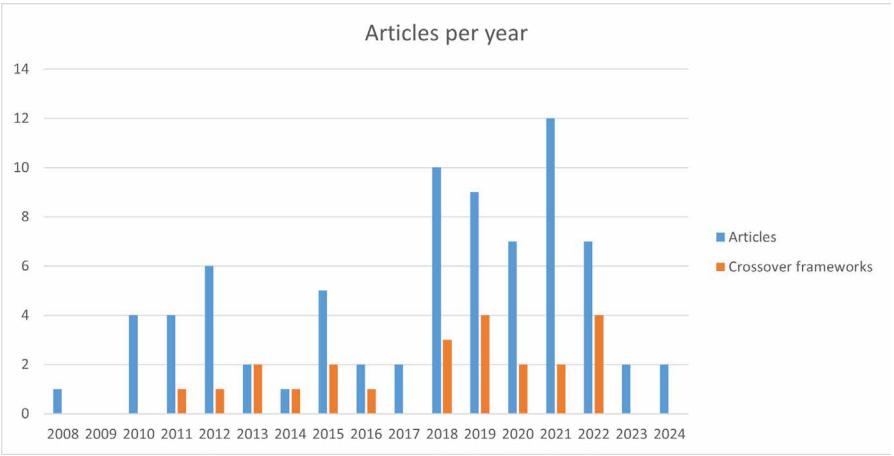

FIG. 3.4 Articles that use SPT and STR per year

TOC

Of these articles 30 were purely theoretical and 44 had at least some empirical elements. Most theoretical papers did not focus on specific systems, but five did. The relative large amount of theoretical papers indicates a perceived theoretical gap that researchers still find difficult to meet with empirical studies; it still requires theoretical understanding of what it would entail to combine the approaches, before they can be used for empirical research on a larger scale, as has for instance been asked by Hargreaves et al. (2013). Some of the empirical papers covered several systems, and one nearly covered all and is therefore not included in figure 3.5 below. The figure shows the systems in which both approaches have been applied and to which crossovers have been applied. Noteworthy, many articles have been published on the energy system using both approaches, but only two apply a crossover framework. Of these articles, most (14/19) focus on consumption or local production (e.g. PV cells) (of which 4 also consider the rest of the system), and regard themes such as lifestyle, energy justice, and bottom-up approaches. Transitions research is then used as a context (e.g. Sovacool, Hess, & Cantoni, 2021). Contrastingly, more than half of the articles published on the food system use crossover frameworks. In food systems research, the topic of interest was diverse, focusing on both the consumer side, the producer side, or both. The use of crossover frameworks in specific systems heavily change their usefulness, as it was found that some frameworks for instance add more value in contexts of either more heterogeneous or more homogeneous practices, as will be further discussed in section 5.

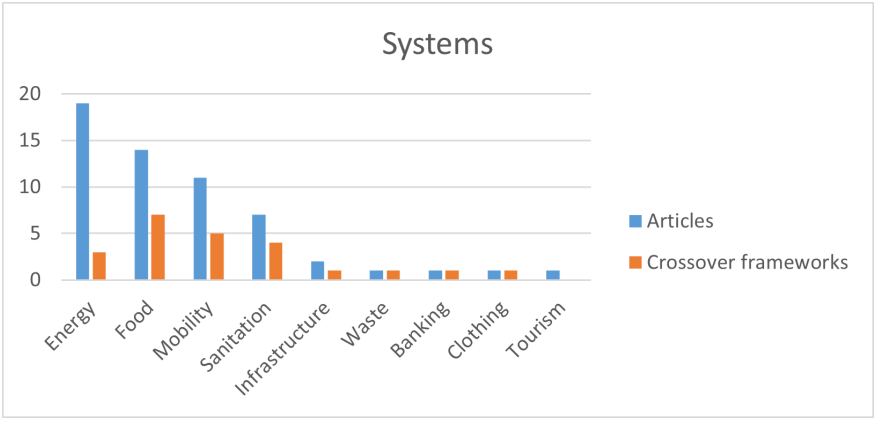

FIG. 3.5 Systems for which both SPT and STR are used

Generally, the small number of articles on crossovers, and specifically of empirical studies shows that crossovers are still in the early stages of their developments, and that even though there is a clear sign of increased interest among scholars, most

authors do not undertake the challenge of creating crossover frameworks. A reason for this could be that some influential articles have warned against it because of the assumed ontological incompatibility (e.g. Geels, 2010; Schatzki, 2011), which shows the importance of making an exposition under which assumptions this incompatibility is perceived and under which it is not.

3.4.2 Ontological comparison between SPT and MLP

The most common notion scholars make when writing about the combination of MLP and SPT is the ontological incompatibility (e.g. Geels, 2010; Huttunen et al., 2021; Laakso, Aro, et al., 2021; Schatzki, 2011; Seyfang & Gilbert-Squires, 2019; Svennevik, 2021; Welch & Yates, 2018). On the one hand this is strange; Geels (2011) agrees with the critiques on the MLP that claim that it does not have a clear ontological background, and that it should more be perceived as a heuristic framework, rather than a theory, in line with interpretive traditions, but not positivist traditions of doing research. As heuristic framework, it offers researchers guidance on which questions to ask, but since the unit of analysis and the ontological foundations often remain highly ambiguous, researchers can use the framework as they consider appropriate, on different scales, privileging the worldview of the analyst (Genus & Coles, 2008). Nevertheless, the MLP does have ontological origins and assumptions (Geels, 2010) that some authors see conflicting with SPT. That is, where the MLP on the one hand takes on a nested, and therefore hierarchical/'vertical' ontology, the ontology of SPT is explicitly flat (Huttunen et al., 2021; Spaargaren et al., 2016). A flat ontology here means that reality is not perceived as existing within multiple layers, but as a series of practices that influence each other. Apart from this dimension, an obvious difference is the scale on which SPT and MLP focus. Where SPT focuses on practices that are performed in their own contexts (that can be part of larger structures/phenomena), MLP focuses on systems or regimes (Watson, 2012). Partly because of this perceived incompatibility, many scholars (e.g. Geels et al., 2015; Hargreaves et al., 2013) do not plead for integrating the approaches, but they see a useful combination in finding crossovers.

Closer examination offers more nuance to these incompatibilities. Some scholars (e.g. Spaargaren et al., 2016; Watson, 2012) for instance argue that systems are built up from practices, meaning that if a system change occurs, this is visible in its practices, and vice versa, if practices change, something must have changed within the system. In other words: "any socio-technical transition has to be a transition in *practices*" (Watson, 2012, p. 489). This notion has resulted in several new concepts to explicitly bridge the scale distance between SPT and MLP. An example

is the concept of 'system of practices', the explicit notion that a system is built up of practices (Kokko & Fischer, 2021; Svennevik, 2021; Watson, 2012). This means that the perceived incompatibility of scale has little to do with the approaches *in* se, but mostly with how scholars have used the theories (Spaargaren et al., 2016). Another emerged concept is 'regime-practice' (contrasting 'niche-practice'), the notion that some practices make up or are influenced by the regime (Crivits & Paredis, 2013; O'Neill et al., 2019; Plummer & Van Poeck, 2020). Used as such, the regime can be studied on a small scale, instead of on a system scale (e.g. Crivits & Paredis, 2013).

Further, the explicit dichotomy of the horizontal and vertical ontologies of SPT and MLP is not always as strict as it is often portrayed. Early MLP literature tended to focus less on the vertical relations of systems, and more on the different types of rules that guide human behaviour (Hargreaves et al., 2013; Rip & Kemp, 1998; Seyfang, Haxeltine, Hargreaves, & Longhurst, 2010); niches were not considered as nested within regimes, but merely more loosely structured than regimes (Geels, 2011). Seyfang et al. (2010) therefore plead for researching more complementarities between SPT and early versions of MLP. Apart from this concept of different levels of structuration in MLP, some scholars note the more vertical interpretation of practices in the work of Shove (2003) and Warde (2005) that is, just as early MLP research, also based on different levels of structuration, based on the work of Giddens (1984). Warde (2005, p. 143) for instance states: "[…] dominant groups exclude others from involvement in activities which they represent as especially worthwhile and where expertise is, hence, socially and personally prestigious." Ontological (in)compatibility largely depends on these exact definitions and interpretations; if on the one hand the regime is defined as a system with actors and infrastructures, this leads to ontological incompatibility (see e.g. Schatzki, 2011), whereas on the other hand the regime is defined primarily as a set of semi-stable rules (Geels, 2011), some authors have found potential for crossovers (e.g. Watson, 2012). When regime is defined as set of rules, these rules can be used to understand how they influence practices. However, when actors and infrastructures are added to the concept of the regime, what constitutes as a practice partly overlaps with what constitutes a regime, e.g. the materials of a practice with infrastructures or the carriers of a practice with actors. This overlap creates an ontological mismatch, as suddenly it differs per aspect how the two approaches relate to each other. It is therefore not merely a terminological mismatch. It could be argued that this inconsistency in compatibility primarily stems from the fact that the MLP functions as a heuristic framework instead of a theory.

Despite these notions to overcome or evade the ontological incompatibilities of the two bodies of literature, some authors state the two approaches are best used apart from each other, as they both have strengths that will generate specific results,

which will be diminished by integration (e.g. Geels, 2010; Moore et al., 2018). It is argued that due to the ontological differences, using them independently means that in fact different worlds are perceived that are hard if not impossible to compare.

3.4.3 Theoretical comparisons

Both SPT and MLP/TM are concerned with stimulating sustainability transitions (Hargreaves et al., 2013). To analyse this, similar terms have popped up in both fields, each with slightly different meanings, caused by the specific theoretical background in which they have been developed. A dominant theme for MLP/TM is the concept of transition paths; phase out, disruption, and reconfiguration are concepts that have been developed in MLP/TM and they have been compared and contrasted in the literature with similar elements in SPT that uses its own vocabulary for this that indicates its different ontological foundations. With this structure, this section goes deeper into the notions of how change is conceptualised in both approaches. In the found articles, MLP was mostly used for technological change, and SPT for consumption or social innovation, as these topics seem to be less developed in MLP (Hargreaves et al., 2013).

3.4.3.1 Phase-out, Destabilisation and Disappearing Practices

Phase-out of unsustainable technology has increasingly been accepted as a necessary and viable measure to stimulate sustainability (Koretsky & van Lente, 2020). It was found that both within MLP and SPT similar concepts are used that refer to the evolutionary process of emerging and disappearing elements. Within MLP/TM, the concept of phase-out usually relates to the destabilisation of regimes and the role industries play therein (e.g. Cherunya et al., 2020; Koretsky & van Lente, 2020; Rolffs, Ockwell, & Byrne, 2015; Welch & Yates, 2018). It might be part of other transition paths, e.g. substitution or obsolescence, or happen on its own (Cherunya et al., 2020; Koretsky & van Lente, 2020). Because of the focus on actors and regimes, the focus of phase-outs in empirical research seems to be less on technology (ibid.), e.g. Mickwitz et al. (2021) speak about destabilisation of path-dependencies and lock-ins of regimes and Koretsky and van Lente (2020) highlight the importance of the changing practice element of meanings in their work on cloud seeding. The focus on phase-outs stimulates research in 'forgotten' themes in MLP such as multiplicity of regimes and dynamics of everyday life (Huttunen et al., 2021), countering common sources of critique on MLP (Geels, 2011). Note

that in theory these themes can be researched anyway, but the focus on phase-out seems to stimulate it. Within SPT, the concept of destabilisation of elements or practices is also a common theme (e.g. Koretsky & van Lente, 2020; Shove et al., 2012). Elements already differ slightly in every performance of a practice (Shove et al., 2012). Further, elements might disappear, become dormant, or become part of other practices (Shove et al., 2012). Conceptually, SPT therefore has additional relevance to MLP/TM, as destabilising regimes do not necessarily lead to destabilised practices (Cherunya et al., 2020). For this, other interventions might be needed, e.g. articulation of system components that can destabilise practices (Laakso, Aro, et al., 2021). Further, a phase-out of a technology might be the end of a practice, a niche, or a regime, but SPT shows how elements of such a practice might still live on.

3.4.3.2 Disruption and Breaking Practices

Disruption is (part of) a transition path where a high-intensity effect stimulates a long-term change (Kivimaa et al., 2021), such as for example a new technology such as autonomous vehicles that disrupt the (regime of the) mobility system (ibid.). Both MLP/TM and SPT make use of this concept of disruption. Within SPT disruption is a recurring theme in multiple dimensions, but the discoursal differences expose the ontological and theoretical differences with MLP/TM. Disruption might relate to disruptive technologies, breaking of links between elements that might weaken the reproduction of practices, practices (or the lack thereof) that disrupt the reproduction of other practices, and practitioners that might cross thresholds to either continue as practitioners or defect (Kivimaa et al., 2021; Shove et al., 2012). For MLP/TM, Geels and Schot (2007) define disruption as a gradually and infrequently occurring high-intensity effect from either the landscape or the niche on the regime, that for instance brings forth a substitution in regime technology. SPT can perceive disruption in multiple dimensions, yet Kivimaa et al. (2021) stress that not all dimensions of disruption necessarily influence each other, e.g. the disruptive technology of electric vehicles (dimension of practice element of materials) does not necessarily largely disrupt transport practices (dimension of practice). However, naturally it is possible for these different dimensions to influence each other, e.g. when consumers actively invest in renewable energy (dimension of practice element of materials), this does change the energy production process (dimension of practice). Aligning disruptive technology with disruptive practices can sometimes be considered a positive thing, as in this last example, but sometimes disruption is actively sought after by explicitly changing one and not the other. For instance, replacing meat with vegan burgers has proven successful because of the explicit

similarities between the two products, in terms of cooking, consuming, sensory aspects, and nutritional values (ibid.). This way a disruptive technology (practice element of materials) can largely strengthen the reperformance of its practices, be it in a small variation.

3.4.3.3 Reconfiguration

A more subtle transition path is reconfiguration, that focuses on changing institutions, actors, practices, and constituent elements of practices in such a way that the new combination also entails elements of the old combination (Geels et al., 2015). Mazur et al. (2015) for instance illustrate this by elaborating on the development of new practices in the German car industry where actors purposefully remain stable. Change in reconfiguration is perceived as a processual phenomenon, involving constant adaptation and reflections (Keller, Sahakian, et al., 2022). The agenda for the use of the concept of reconfiguration is different in both bodies of literature. In SPT it is used to describe the inner dynamics within and between practices, taking the impact of practices beyond the context of their performances. Change is considered to happen when one element of practice is changed, stimulating change in other elements, or when connected practices change each other (Shove & Walker, 2010). An example of this is the building of trust (practice element of meaning) that grew stronger as tenants of a Brazilian ecovillage started participating in community chores, which in turn led to car-sharing (Laakso, Aro, et al., 2021). In the MLP the concept of reconfiguration is often used to blur the hierarchies of the nested levels (niche, regime, and landscape) (Laakso, Aro, et al., 2021). Laakso et al. (ibid.) go further and state that reconfiguration should not just blur the hierarchies of a nested system, but also blur the distinction between different regimes, where certain elements may circulate between different systems, because practices are influenced by so many different factors (e.g. producing, promoting, adopting, or aligning technologies; enlisting users; protecting novel technologies; adding practice elements to the repertoire of practice complexes).

3.5 Frameworks with Crossovers

In the found body of literature, 21 articles developed or made use of crossover frameworks. Crossovers have been made in several ways, here divided into six groups. Apart from these frameworks STR has also been used as a context for SPT. Such research focuses on social practices, but does this in the context of socio-technical transitions (e.g. Cherunya et al., 2020; Heiskanen et al., 2024) or specific socio-technical designs (e.g. Ulsrud, Rohracher, Winther, Muchunku, & Palit, 2018). It therefore does not use MLP labels such as niche and regime on practices, as many crossover frameworks below do, but focuses on concepts such as the introduction of innovations, the complexity of change in transitions and the many aspects that need to be altered for transitions to take place, or the institutions and (infra)structures in which practices are embedded. Such a way to deal with both approaches functions well, but has very little to offer in terms of crossovers. Similarly studies that use both approaches next to each other (e.g. Banos et al., 2022; Laakso, Heiskanen, Matschoss, Apajalahti, & Fahy, 2021) offer insights from both approaches, but it remains implicit how these insights ontologically relate.

The six groups of crossover frameworks summarised in table 3.1 must all deal with the perceived ontological incompatibility of the two approaches. Table 3.1 shows the different concepts of the approaches that interplay with one another, the different focal points they have, and in which context they will prove most useful (i.e. contextual scale or system scale and the number of regimes and practices that can be studied fruitfully with the framework). All frameworks can be used on both scales, but sometimes a systemic scale requires combining many practices, which can heavily increase the complexity of the study. These frameworks have been compared on their strengths and limitations, by focusing on the added relevance of the crossovers, as is shown in table 3.2. This has resulted in an analysis on aspects as the units of analysis, their uses for either complex or homogeneous systems, and the elements of both approaches use to explain transitions, as well as the elements they cannot use anymore due to the specific crossovers. Lastly, the crossover frameworks are evaluated on their use of change, as described in section 3.4.

So far, most of the interpretation of what can be achieved with crossovers between the approaches stem from just a few sources, to which most articles in this review refer. These are Watson (2012), Crivits and Paredis (2013), and Hargreaves et al. (2013), the last of which base their crossover again on the work of Elizabeth Shove (2003).

The popularity of these articles might stem from the relative simplicity of crossover frameworks (containing few components), while having a broad application (for many contexts). This makes them easy to understand and transferable to different contexts. Sovacool and Hess (2017) plead for creating crossovers with care. They state researchers need more understanding of the epistemological underpinnings of the approaches, to get more nuanced ways of comparing, contrasting, and combining them. This is important, as theoretical frameworks not only open our minds, but also close them (Sovacool & Hess, 2017) and stimulate different ethical stances when it comes down to intervening (Jørgensen, 2012). Table 3.1 shows these crossover frameworks, the authors that use these and the concepts that are in interplay with each other in these frameworks. Many groups have several similar ways in which the crossover frameworks have been created. Group differentiation has taken place when crossover frameworks connect different types of concepts between the two approaches. The first four groups discuss crossover frameworks for specific moments in time, whereas the last two describe crossover frameworks that to a certain extent incorporate an element of process. The first three crossover frameworks have a clear basis in SPT and mainly add elements of MLP to create crossover frameworks, whereas the last three crossover frameworks borrow more evenly from both approaches. All these crossover frameworks can be regarded analytical frameworks, with the exception of crossover framework five, which is more a heuristic framework, and crossover framework six, which is more a methodological framework. The frameworks have different cases in which they function optimally, e.g. being able to capture either few or many practices and regimes, as is explicated in the table. For empirical researchers this is a vital distinction to work pragmatically. As part of the advantages and limitations, table 3.2 offers an overview of the transition paths that can be researched with the crossover frameworks. Reconfiguration is the dominant transition path that can be researched with these crossover frameworks. Lastly, the crossover frameworks have different interpretations of the relation between the researched context and the system, i.e. either the system is built up from contexts, or the system is analysed parallel to the contextual influences thereof.

TABLE 3.1 Six groups of crossover frameworks

No	Crossover framework	Key-authors	Concepts in interplay	Key concepts	Base approach	Number of practices and regimes	Scale (local/ system)
Crossover frameworks for specific moments in the transition							
1	Multi-level Practices	Bachus and Vanswijgenhoven (2018); Crivits and Paredis (2013); Keller, Noorkõiv, and Vihalemm (2022); Langendahl, Cook, and Potter (2013); Little, Lee, and Nair (2019); Svennevik (2021); Svennevik, Julsrud, and Farstad (2020); Watson (2012); Muylaert and Maréchal (2022); Svennevik (2022)	Niche and practice, regime and practice, system and practice complex	Niche-practice vs. regime-practice; complex of practices as a system	SPT	Best used for complexity of practices, with a limited number of regimes	Local to system
2	System of Practices and Shared Elements	Svennevik, Dijk, and Arnfalk (2021)	Practice complex and system, shared elements and regime and system	Complex of practices as a system; shared elements throughout the system	SPT	Best used for complexity of practices, with a limited number of regimes	Local and system
3	Spatial Practices	Cherunya, Ahlborg, and Truffer (2020); Kokko and Fischer (2021); Van Welie, Cherunya, Truffer, and Murphy (2018)	Practice and space and regime, space and service regime, service regime and system regime	Practice vs. competing regimes, based on space.	SPT	Best used for complexity of practices, with a limited number of regimes	Local to system

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TABLE 3.1 Six groups of crossover frameworks

No	Crossover framework	Key-authors	Concepts in interplay	Key concepts	Base approach	Number of practices and regimes	Scale (local/ system)
4	Practice-Regime intersection	Cass, Schwanen, and Shove (2018); Hargreaves, Haxeltine, Longhurst, and Seyfang (2011); Hargreaves, Longhurst, Seyfang (2013); Morrissey, Mirosa, and Abbott (2014); Seyfang and Gilbert-Squires (2019); Gazull, Gautier, and Montagne (2019)	Practices and regimes,	Practices that influence regimes; regimes that influence practices	SPT & STR	Best used for systems with several (but not many) practices and regimes	Local and system
Crossover frameworks with time element							
5	System Fractures	O'Neill, Clear, Friday, Hazas (2019); Rauschmayer, Bauler, Schäpke (2015)	Niche and practice, regime and practice, practice elements and reconfiguration	Niche-practice vs. regime practice; Reconfiguration of practice elements in niche- and regime-practices	SPT & STR	Best used for one or few practices and single regime	Local and system
6	Practices in Backcasting	Camilleri, Attard, and Hickman (2022); Davies and Doyle (2015)	Practice elements and regime, practice elements and reconfiguration	Regime-practice vs. backcasting; backcasting vs. reconfiguration	SPT & STR	Best used for single practice with one or several (but not many) regimes	Local and system

TABLE 3.2 Strengths and limitations of the crossover frameworks

		Strengths	Limitations
1	Multi-level Practices	Insight in the stability of the rules that guide a practice; insight on niche-regime interaction on a local scale; insight in change as conceptualised in SPT.	Limited input from STR; limited grip on blurred distinction between levels of MLP; limited insights in influence of multiple regimes; no element of time that would give insight in the transitioning; mostly useful for reconfiguration and less for other transition paths.
2	System of Practices and Shared Elements	Minimised gap between units of analysis of MLP and SPT; insight in system coherencies.	Limited input from STR; limited grip on blurred distinction between levels of MLP; limited insights in influence of multiple regimes; no element of time that would give insight in the transitioning; mostly useful for reconfiguration and less for other transition paths.
3	Spatial Practices	Insight in complex, heterogeneous contexts; insight in differences and similarities of different service regimes; insight the influence of space on regimes; insight in regime plurality; insight in blurred distinction of niches and regimes.	Limited insight from dynamics between MLP levels; no element of time that would give insight in the transitioning; mostly useful reconfiguration and less for other transition paths.
4	Practice-Regime intersection	Insight from both SPT and STR; stimulation to research new points of interest.	Limited usefulness in complex systems; limited understanding of practices that inform niches and landscapes and vice versa; no element of time that would give insight in the transitioning; limited ability to describe any transition path.
5	System Fractures	Insight in system change early on; insight in the transitioning; insight in all kinds of transition paths.	Limited insights in influence of multiple regimes; limited insights from practice bundles and complexes; limited use of landscape concept.
6	Practices in Backcasting	Insight in strategizing of futures for governance and policies; insight in regime plurality.	Limited input from STR; limited insights from practice bundles and complexes; limited insight in how change can come about; mostly useful reconfiguration and less for other transition paths.

3.5.1 Multi-Level Practices

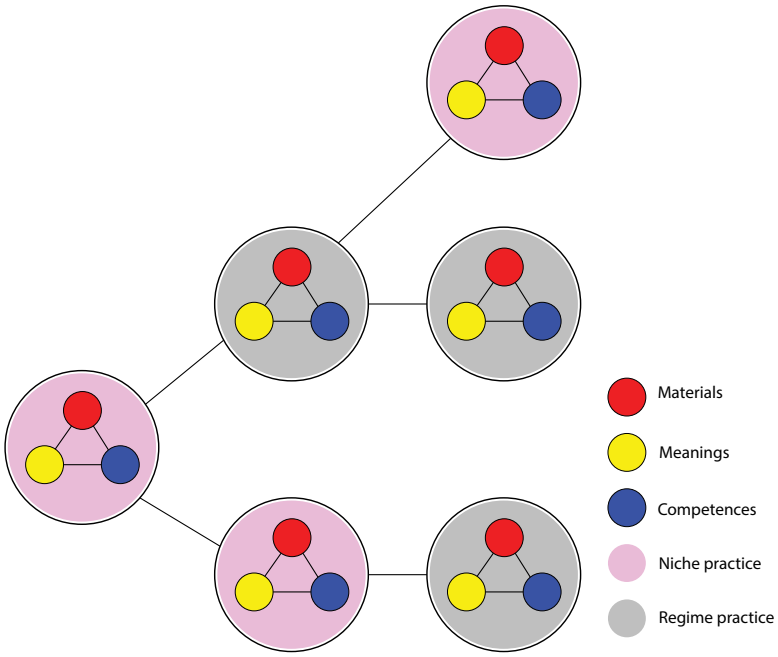

FIG. 3.6 System of regime- and niche-practices, based on Watson (2012) and Crivits and Paredis (2013)

This framework group, as visualised in figure 3.6, perceives the system as a set of interlinked practices. It offers insights in the interaction between niche-practices and regime-practices, whilst staying true to the dominant horizontal ontology of SPT. The distinction between niches and regime here offers insight in the stability of the rules that guide a practice, i.e. niches have fast changing rules, whereas regimes are more stable. This is the most widely used group for crossovers and encompasses several variations. Some (e.g. Langendahl, Cook, & Potter, 2016; Muylaert & Maréchal, 2022) for instance add the concept of landscape practices or practice elements, e.g. practices that lead to peak oil that will then influence other practices, such as cycling. Watson (2012) uses this framework with the elements of Shove and Pantzar (2005) (meanings, materials, and competences) as basis of a practice, allowing to observe overlap in these as practices form bundles. Crivits and Paredis (2013) on the other hand divide a practice in the elements agency, social-cultural structure, and material-functional structure, allowing for differentiation of (temporary) dominance of agency over structure (niche) or structure over agency (regime) depending on the specific practice in a bundle.

Bachus and Vanswijgenhoven (2018) also use this interpretation of a practice and, contrasting Langendahl et al. (2016), perceive the landscape as the set of rules that influences the structure elements in both niche- and regime-practices. This group of frameworks therefore allows for multiple interpretations of what a practice is and can answer different types of research questions, based on this distinction, even though the crossover is still designed similarly. Note here the division of niche-regime-landscape as different sets of system rules (Geels, 2011), instead of different sets of a system (as e.g. Moore et al., 2018), or just very ambiguous (Jørgensen, 2012), as it is often used. A different interpretation of regime is likely to encounter ontological frictions between the two theories. The conceptualisation of niche-regime-landscape as different sets of system rules is somewhat similar to the 'vertical axis' of SPT that was already present in the work of Warde (2005), who mentions different levels of structuration. With this verticality incorporated in a practice, it becomes clear where change is happening in a complex. Further, it can be researched how different levels of stability have an influence on the composition of a complex, of practices, and its elements.

The strength of this framework is the focus on common notions of systemic change in both MLP and SPT. For STR, it focuses on the dynamics of niche-regime interaction (Pekkarinen et al., 2020), which through this framework can be observed very well. This framework group also allows insights in the elements that make up practices, as well as the bundles and complexes of practices around a practice that all influence changing practices (Shove et al., 2012). The framework can give answers on research questions regarding several topics, e.g. contextual interaction of new (i.e. niche-) practices with established (i.e. regime-) practices within a transition, or overlap and differences between elements between regime-practices and niche-practices, which can give a better understanding of reconfiguration.

Apart from these strengths, there are also some limitations, depending on the specific interpretation of what constitutes a practice. First, in general, the framework is primarily focused on practices, and therefore lacks several concepts from MLP that could have additional value. If, more specifically, several regimes influence a practice, this is more difficult to capture when a practice is conceptualised through the elements meanings, materials, and competences. In the description of the structuring elements of Crivits and Paredis (2013), however, this can be captured. For instance, material-functional structure can be further divided into different influencing regimes. How different practices are influenced by different regimes can therefore be an explicit research topic. Other MLP elements, such as transitions paths or the protection of niches are not explicitly mentioned and difficult, if not impossible, to capture. Further, as is often mentioned (e.g. Laakso, Aro, et al., 2021), the hierarchies between niches and regimes are often more blurred than they are

usually portrayed within the MLP. Whereas SPT can capture some of the complexities of different levels of structuration and different regimes influencing practices, this framework makes it more difficult to grasp that. And as such, it runs the risk of underplaying the distinctive contributions in either field, caused by the different units of analysis (Hargreaves et al., 2013). Lastly, the framework group is well equipped to capture change at a specific moment, but it is less equipped to deal with system transformative change, as it does not capture an element of time. Transition paths are therefore difficult to distinguish using this framework. Keller et al. (2022) come close by focussing on intervention points in a transition such as niche stimulation or regime destabilisation, but also they do not really offer concepts for the process of transitioning. To deal with transformative change anyway, this framework can be used twice, either on different moments or for both new (i.e. niche) and established (i.e. regime) practices, of which the comparison can be used to better understand the transitioning in a single moment in time. Used as such, it is possible to understand reconfiguration, by comparing overlapping practices and practice elements, but other transition paths might be more difficult to capture. Also, research on the moment when practices are breaking/disrupting can be used to understand their changing (Svennevik, 2022).

3.5.2 System of Practices and Shared Elements

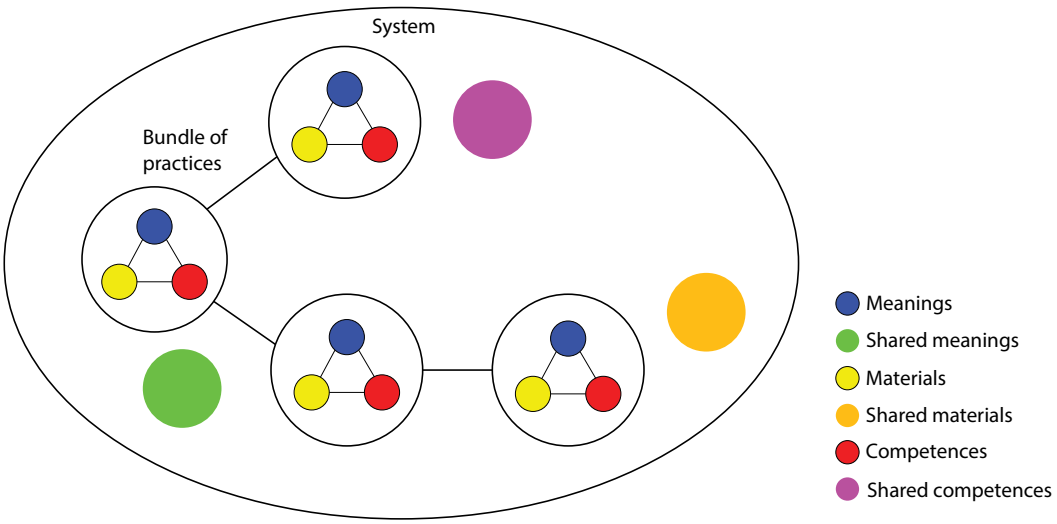

FIG. 3.7 System of Practices and Shared Elements, based on Svennevik et al. (2021)

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The second framework, as visualised in figure 3.7, is based on the work of Svennevik et al. (2021). The framework uses additional practice elements next to the original elements from Shove and Pantzar (2005). The premise is that several elements are shared by all practices and together form a system (Svennevik et al., 2021). These shared elements can be formed for instance by 1) infrastructures, 2) laws and policies, 3) business models, and 4) social norms, all of which in turn can be divided under the headings of the original elements of Shove and Pantzar (2005), i.e. the first three can be regarded as shared materials, and the fourth as shared meanings (Svennevik et al., 2021). Practices are therefore not divided into niche-, regime-, and landscape-practices as in the previous framework, but a similar concept of the regime is formed by the different rules of these shared elements that together influence practices.

There are some strengths to this framework. First, it minimises the gap between the units of analysis in SPT and STR, which is sometimes (e.g. Cohen & Ilieva, 2015), but less and less (e.g. Spaargaren et al., 2016) perceived as a problem. Further, adding new, shared elements to the complexes of practices highlights the coherency of a system and illustrates how all practices are linked. This crossover framework can answer research questions on topics such as the reasons for reproduction of practices, given a certain explicit regime.

There are several limitations to this framework. First, as these shared elements are conceptualised as elements that are shared between practices (Svennevik, 2021; Svennevik et al., 2021), it becomes impossible to elaborate on different regimes that influence different practices differently, or the influence of niches that do not follow the same rules; practices cannot be contested using this framework. This makes the framework mainly applicable in very coherent systems. Further, as this framework is mainly based on practices, very few heuristics of MLP have any relevance, e.g. niche-regime interaction. Lastly, similar to the previous framework, this framework offers no element of time, making it more useful for describing or explaining a moment in time than describing or explaining the process of transitioning. Also here, comparing new practices (i.e. niche) with established practices (i.e. regime), the system in two moments in time, or on a moment of practice breaking might still provide insights in the transitioning (e.g. see Svennevik et al., 2021), especially perceived through the notion of reconfiguration, as this provides understanding of remaining practices and practice elements. Other transition paths, such as disruption or phase-out, will be difficult to understand with this element of time. Nevertheless, due to these fundamental limitations, one can wonder to what extent this can still be considered a crossover framework or merely a practice framework with a less horizontal ontology.

3.5.3 Spatial Practices

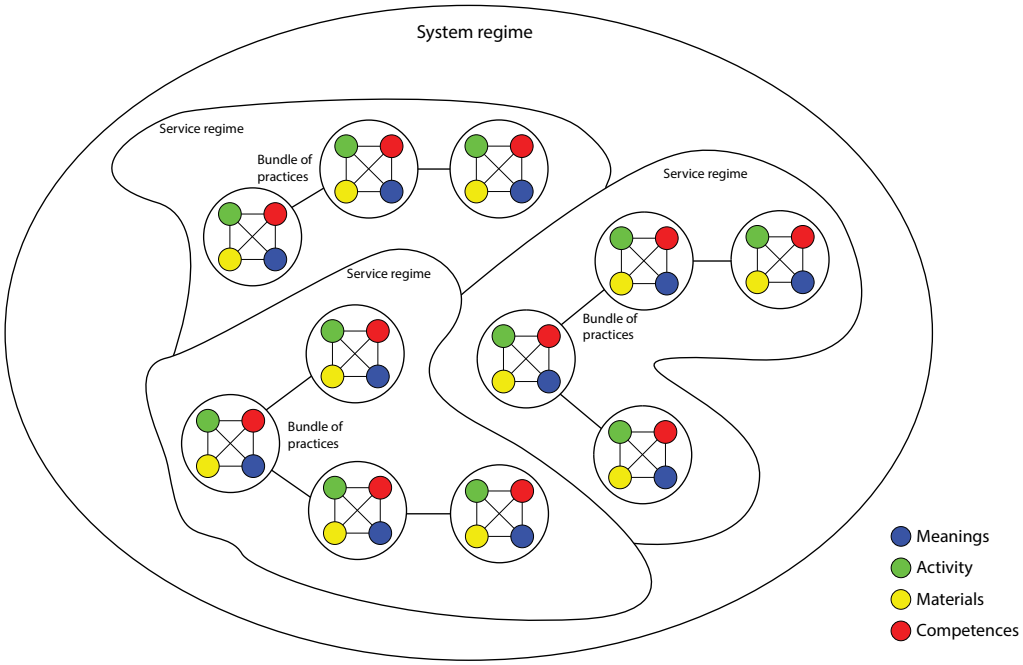

FIG. 3.8 Spatial practices as service regime, based on Kokko & Fischer (2021)

This framework group (see figure 3.8) is formed by a spatially layered interpretation of reality and useful in settings with a multitude of urban services, such as solid waste, sanitation, or drinking water (Van Welie et al., 2018). When multiple regimes are present to deliver a single service, such as the electric power market in the United States of America, it makes no sense to speak of a coherent system regime, as it is first divided into multiple service regimes. A service regime is a regime formed around a specific set of technologies, user routines, and organisational forms (Van Welie et al., 2018). This distinction between system regime and service regime creates a layering based on space, wherein specific service regimes take hold. As practices compete with each other for space, different service regimes influence the victors of every location (Kokko & Fischer, 2021). In such a space, a bundle of practices together forms a service regime. Several service regimes further form a system regime. This framework does not explicitly distinguish between niches and regimes, but can elaborate on the different types of structuration of the different service regimes (Van Welie et al., 2018). The interpretation of what constitutes practices differs per author, e.g. Van Welie et al. (2018) uses five dimensions that

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make up practices in a service regime (infrastructure and artefacts, organizational mode, time and space, rationale/meaning, and social interaction), whereas Kokko and Fischer (2021) use the traditional elements of Shove et al. (2012) with the addition of the element activity, that is used to describe the time and space in which activities are performed.

The advantage of this layered approach, is the applicability in complex, heterogeneous contexts, where system regimes are built up by sometimes competing service regimes, for instance as is common in the Global South (see e.g. Kokko & Fischer, 2021; Oates, 2021; Van Welie et al., 2018) or in systems with multiple competing infrastructures and technologies, such as the waste system in The Netherlands that functions differently per municipality; waste is for instance separated by consumers and/or waste companies, and gathered using for instance private containers and/or public underground storage systems. The framework can be used to analyse the differences and similarities of practices in different service regimes, which seems essential to understand change on the level of the system. The added element of activity (Kokko & Fischer, 2021) or the similar dimension of time and space (Van Welie et al., 2018) is useful in understanding practices for which the different system regimes compete. This is one of the few frameworks that explicitly allow for analysing the influence of a multiplicity of regimes on practices. Similarly, the framework has worked itself around the fact that the dichotomy between niches and regime is not as strict as is often portrayed, by naming all sets of rules 'regimes', while acknowledging that every regime is different and can be more or less structuring. This framework could potentially also be useful to describe a system with practices that are not spatially divided, but are divided differently, e.g. culturally.

Although this approach offers useful concepts, there are several limitations of the framework. The nuance of interpreting the service regimes as different sets of rules, makes it possible to describe these contexts. However, it also makes more difficult to theoretically explain them, as for instance it becomes unclear how to translate the notions of niche-regime interaction. Also, again, the framework does not offer any notions on process, but merely elaborates on a stabilised moment in time. Therefore, similar to the previous two frameworks, it can be used to compare new (i.e. niche) and established (i.e. regime) practices, practices in two moments in time, or practices in the moment of breaking. By comparing practices and practice elements, a reconfiguration path can be better understood, but other transition paths might be difficult to capture.

3.5.4 Practice-Regime intersection points

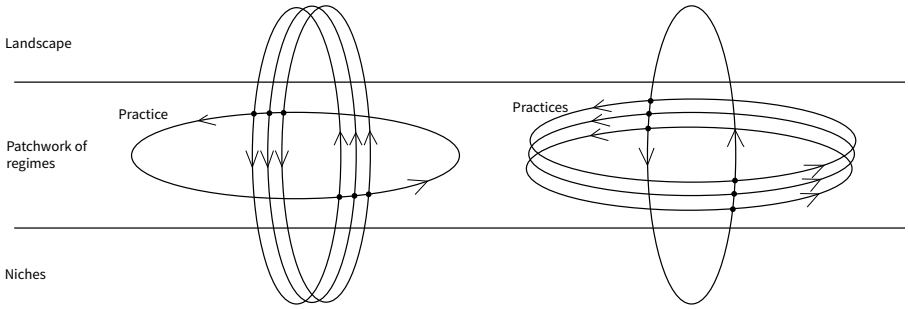

FIG. 3.9 Intersections between niches and regimes, based on Hargreaves et al. (2013)

The fourth framework (see figure 3.9) is a constellation of different intersections between practices and regimes, based on the work of Hargreaves et al. (2013) and further used for instance by Seyfang and Gilbert-Squires (2019) and Morrissey et al. (2014). The intersection points show which practices influence which regimes, and vice versa. These intersection points show where the combination might help or hinder the transition (Hargreaves et al., 2013; Morrissey et al., 2014). In addition to the System-of-Practices Framework (e.g. Watson, 2012), regimes here can be defined as rules, but also as (infra)structures that influence practices (e.g. Cass, Schwanen, & Shove, 2018).

Even though it is often mentioned that the three elements that constitute a practice (Shove & Pantzar, 2005) are reconfigured together (Shove et al., 2012), quite often the element of meaning is used to focus on change in practices (e.g. Kokko & Fischer, 2021; Seyfang & Gilbert-Squires, 2019). This framework is more open than that, as it focuses on any practice that manages to influence regimes and vice versa, and therefore can offer understanding on a wider variety of change instigators; compared to the Multi-Level Practices framework, this framework is open to a wider set of heuristics from STR, as it is not built up from SPT with additional elements from STR, but instead offers equal viewpoints from both approaches. Another strength of the focus on the intersection points between practices and regimes, is that it potentially broadens the scope of practices and regimes that are considered relevant, e.g. researchers that normally focus on MLP will be less likely to have a technology bias or a focus on state actors and dominant market actors to the neglect of actors within civil society (Hargreaves et al., 2013). Compared to the frameworks above, the object of study is therefore broader and could answer research questions on topics, such as the practices that form policies, or the critical point of systems in which to intervene with the most impact.

The framework offers a rich understanding of a system, which can naturally be considered a strength, but at the same time this is can also be considered a limitation for systems that are more complex and have many different regimes and practices that all influence each other; it becomes more difficult to grasp which specific practices and/or regimes are the key for systemic change. Further, as the framework only makes use of the relation between regimes and practices, it lacks concepts for explaining the relation between practices and niches and/or the macro landscape. These could easily be added, but the added realism of the framework is at the cost of explaining power on greater complexes of practices. Lastly, similar to previous frameworks, the element of time is not incorporated, making the framework more useful for describing and explaining specific situations in the transition than a transition as a whole. It can be used to describe how new regimes have disruptive influences on practices and vice versa. Also, to some extent it can be used to describe reconfiguration, but the framework offers less grip to do this to the same level of detail as previous frameworks.

3.5.5 System Fractures

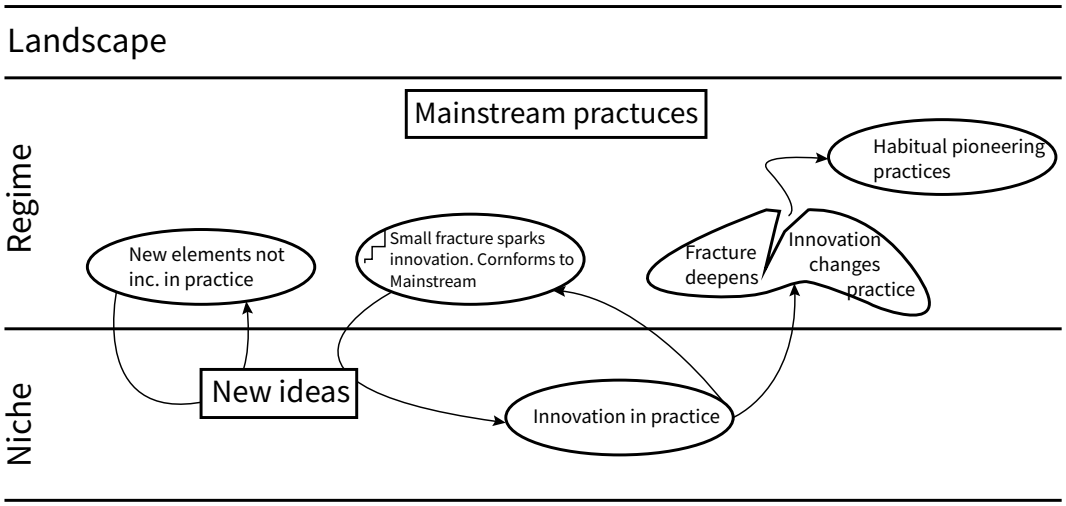

FIG. 3.10 System fractures, based on O'Neill et al. (2019)

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The fifth framework (see figure 3.10) elaborates on how change comes about through fractures in practices that offer the possibility for systems to transition. As it explains how this change takes place instead of offering a lens through which one could study this, it can be considered a heuristic framework instead of an analytical framework.

This framework offers some similarities with the Multi-level Practices framework based on the division of niche- and regime-practices, with the addition of several progress stages (O'Neill et al., 2019). As such, the framework is designed to witness fractures in system practices that might later become windows of opportunity for system change. The development of proto-practices, as introduced by Shove et al. (2012) is used to explain initial change that further transforms in the interaction between niche- and regime-practices (Köhler et al., 2019). Interaction might lead to conformation of the niche-practices to the regimes or transformational change that fundamentally change regime-practices. Rauschmayer et al. (2015) designed an alternative with some similarities. Instead of focusing on fractures, they focus on how these can be achieved. They therefore add elements from TM, noting that practices can change when subject to transition arenas, a network of diverse frontrunners that tackle and discuss societal problems and solutions (Loorbach, 2010). This group of frameworks can help explain why some minor changes eventually lead to larger changes.

The strength of the framework is that it can distinguish fractures, small scale changes, which might stimulate system change. As institutional change is often too grand to witness as it happens (Little et al., 2019), this addition of SPT to MLP offers a richer and empirically more practical way to perceive change, based on important contributions of both fields. As this framework offers an element of time, contrary to earlier frameworks, it becomes possible to describe and explain elements of the progress within the transition, regarding all described transition paths phase-out, disruption, and reconfiguration, also depending on how many of the steps are taken into account.

However, similar to the Multi-level Practices framework, the limitation is that it is difficult to differentiate between multiple regimes. But next to that, one major disadvantage of the framework is that much of the horizontal ontology is let go, making it difficult to explain change, or the lack thereof, through the bundles and complexes of practices. However, the use of practices make it difficult to invoke concepts as landscape pressure, as very few – if any – practices can be considered landscape practices (Labanca et al., 2020). As such, the framework misses some essential features of both approaches, a known risk of combining them (Hargreaves et al., 2013).

3.5.6 Practices in Backcasting

This framework group (see figure 3.11) is more a methodological framework than an analytical framework. It interprets practices as a combination of the elements meanings, skills, and materials, similar to Shove et al. (2012), sometimes with the added element of rules, which can be interpreted as laws, regulations, norms, or (infra)structure, and access (Davies & Doyle, 2015). The framework is also used with only the three elements (Camilleri, Attard, & Hickman, 2022). This element of rules thus links to the concept of regimes (Geels, 2011). Then, the framework is used as envisioning tool to stimulate thinking of practices in far futures and backcasting these to medium-far and near futures (Camilleri et al., 2022; Davies & Doyle, 2015). This method of backcasting is a common tool in Transition Management (ibid.). Contrary to the double use of for instance the multi-level practices framework, practices are not compared to other practices, but to ideas of future practices. In this framework, rules are perceived as part of the practices and therefore backcasting makes users of the tool not only envision practices, but also regimes that are needed to support these practices. This allows for a vertical element in practices, as is common in the work of Warde (2005). The framework can help answer research questions on topics, such as the desired futures of different practitioners in the field, and help stimulate making roadmaps.

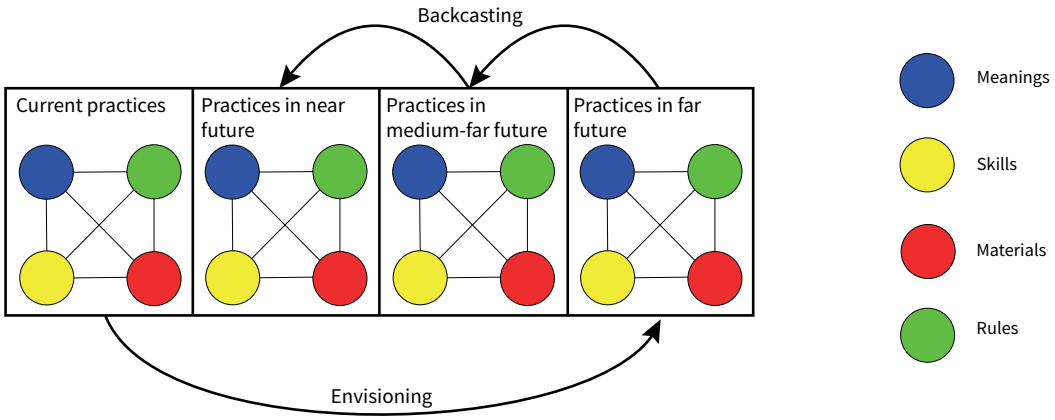

FIG. 3.11 Practices in Backcasting, based on Davies & Doyle (2015)

The strength of this framework is its use for strategizing about futures, and is therefore useful as a practice-based governance tool to help stimulate policies that will make a transitional difference, as they are based on practices (Shove, 2010). Whereas backcasting traditionally is focused on technology or social acceptance

thereof, taking practices as unit of analysis allows for a greater social dimension (Camilleri et al., 2022; Davies & Doyle, 2015). The interpretation of rules as a practice element, makes it possible to elaborate on multiple regimes that influence a practice, or should influence it in the future. Used as such, the framework can be used to further elaborate on reconfiguration, and less so on other transition paths.

There are several limitations of the framework. First, the framework is mainly useful for single practices or small bundles of practices, as the transitional consequences of bigger envisioned bundles will be significantly harder to grasp. This also shows that the strength of the horizontal ontology gets lost, as it is not useful anymore to interpret reality as a combination of practice bundles. Further, at the same time, the framework offers very few explanatory concepts from TM to understand if certain envisioned practices are likely achievable. The different stages of practices offer a sense of the needed progress for the envisioned futures, but it remains unclear how these changes can be rolled out (Davies & Doyle, 2015). As there is no distinction between niche-, regime-, and landscape-practices, niche-regime interaction or landscape pressure is of little explanatory value for this framework. Nor does the distinction between strategic, tactical, operational, and reflexive levels, as is common in TM (Loorbach, 2010), offer any further explanatory value. The framework is therefore very similar to design, visioning, and intervention based approaches in SPT (e.g. Sahakian, Moynat, Senn, & Moreau, 2023; Scott et al., 2012).

3.5.7 On adaptations of the approaches

It can be noted that in these different crossover frameworks, scholars take more freedom with SPT than with the MLP. Additional elements to the model of Shove and Pantzar (2005) are sometimes freely added to practices. For instance shared elements (Svennevik et al., 2021), activity (Kokko & Fischer, 2021), rules (Davies & Doyle, 2015), or time and place, and social interaction (Van Welie et al., 2018). Freedom with MLP is seldom explicitly taken, with exceptions such as explicit use of older MLP literature (Hargreaves et al., 2013), or the distinction between service regime and system regime (Van Welie et al., 2018). Because of the ambiguity of certain concepts, e.g. regimes (Sovacool & Hess, 2017), there is nevertheless further differentiation between the uses of MLP that is often not explicitly mentioned when using these approaches together. As TM has an unclear ontology, freedom with the approach is already common practice, but due to its limited use for crossovers it does not show in these frameworks specifically.

3.6 Discussion

This research gave an exposition of the loaded debate and assumptions that lie beneath the argumentation that MLP and TM are ontologically incompatible with SPT. Whereas many scholar claim that SPT and MLP cannot be used together due to ontological differences (e.g. Geels, 2010; Laakso, Aro, et al., 2021; Schatzki, 2011), this research shows that crossovers can in fact be made ontologically, as long as the right definitions are used. The discussion regarding ontological compatibility is delicate, as these definitions, especially in STR, are often used rather loosely (Geels, 2011). With an exposition of the ontological discussion, this research further builds on a growing body on crossovers (e.g. Hargreaves et al., 2013; Keller, Sahakian, et al., 2022; Watson, 2012). The remainder of this discussion tackles three topics. First, it relates findings of this research to earlier overviews of crossover research. Then it discusses to what extent crossover frameworks help overcome critiques on MLP, TM, and SPT. And lastly, this discussion questions the extent to which crossovers fulfil their promises.

3.6.1 Crossover research

Most articles referring to crossovers make use of one specific crossover (e.g. Crivits & Paredis, 2013). Only one overview was found that connects SPT with MLP, which is the work of Keller et al. (2022). They focused on overall insights of connecting these approaches. Keller et al. (2022) state that 1) one can zoom in on practices and zoom out on regimes/systems, 2) practices and regimes influence each other, and the intersection points between them are interesting points for analysis, 3) the regime is not a completely formal, there are degrees of formality, 4) multiple regimes influence a practice and researching both practices and regimes allows insights in how regimes interact, 5) both producers and consumers play important roles in the transition, 6) 'sticky', persistent practices are useful to study as they can hinder transitional change, and 7) some practices can play a role on the landscape level. This research largely confirms these seven insights. However, regarding the seventh, this research showed that although some authors consider practices at a landscape level (e.g. Langendahl et al., 2016), this is also contested by others (e.g. Bachus & Vanswijgenhoven, 2018). Some authors might consider practice elements at the landscape level (Keller, Sahakian, et al., 2022), but regarding the ontological discussion, this would also have to relate to individual practices (Shove et al., 2012) and it remains the question what the concept of landscape can really offer to crossovers. For now it remains ambiguous if these elements are simply shared by more practices (e.g. in the System

of Practices and Shared Elements framework) or if they are more structured/'sticky' than others (e.g. in the Multi-Level Practices framework). Further, the result section shows that different crossover frameworks, relating to different insights, have different ontological assumptions. This means that not all insights are necessarily true at the same time. For example, Hargreaves et al. (2013) might refer to regimes as (infra) structures in the Practice-Regime intersection points framework (regarding insight 2), whereas in the Multi-Level Practices framework (regarding insight 6) regimes can only be levels of structuration. Researchers should therefore be reminded of the ontological implications of their crossover frameworks and not take these insights for granted.

3.6.2 Overcoming critiques of MLP, TM, and SPT

This research shows that so far there is no ultimate way to make crossovers, but different crossovers show different potentials to understand, explain, and forecast transitions, for instance with practices that shape regimes and vice versa, or the interaction of regimes and niches in different locales. In doing so, crossovers can help to overcome several of the critiques on SPT, MLP, and TM. SPT can largely aid in overcoming critiques on MLP and TM, as discussed here though five critiques from section 3.2. First, the MLP is critiqued to be unusable on small scales and their dynamics (e.g. Banos et al., 2022; Geels, 2020). Several crossover frameworks can help overcome this, such as the Multi-Level Practices and Spatial Practices framework, both of which can also be upscaled so as to be applicable for larger scales. Second, the MLP and TM are critiqued as not being able to deal with power relations, regarding how actors relate to structures (e.g. El Bilali, 2020; Svensson & Nikoleris, 2018). Crossovers do not help with this interpretation of power, though they can help with other interpretations of power, as SPT understands power to occur in practices and as an aspect thereof (Schatzki et al., 2001), this can for instance be studied using the Practice-Regime intersection point framework. Other approaches are needed to further discuss power relations of actors to structures in transitions. Third, TM is critiqued for simplifying transitions too far, as not all its concepts can be operationalised at the same time (e.g. Voß & Bornemann, 2011). The crossover framework of Practice in Backcasting might help with this, as it studies practices, and there is nothing outside of practices. If the right and enough practices are studied depends on the application of the framework. Fourth, TM is also critiqued on being normative (Shove & Walker, 2010), which remains the case with this crossover framework, but it might become more explicit. Fifth, TM is critiqued on stabilising an incumbent, capitalist economy. Though this might be the case in some applications of TM, this is not presupposed in backcasting, and therefore also not in the Practices in Backcasting framework, though this depends on its application.

SPT has had several critiques for which crossover frameworks can help to overcome them. We discuss two, based on section 3.2. First, SPT is critiqued for being too descriptive to help steer transitions (e.g. Geels, 2011). The Practices in Backcasting framework can be used to also become prescriptive. Second, SPT is critiqued on being unable to offer explanatory concepts (ibid.). Some scholars state this is mostly an empirical, and not a theoretical problem, caused by the small scale in which many studies have been conducted (e.g. Klitkou et al., 2022; Spaargaren et al., 2016). This small scale can refer to either contextual research, or research of singular practices without taking into account other related practices in the system. This critique is already somewhat overcome by SPT studies (e.g. Koretsky & van Lente, 2020; Shove & Trentmann, 2018). Yet, some of the crossover frameworks might further help in researching large scale phenomena. For instance, the System of Practices and Shared Elements framework, the practice-regime intersection points framework, and the system fractures framework might help make it easier for researchers to analyse large phenomena. Other crossover frameworks, such as the System Fractures framework, do not offer additional help in researching large phenomena.

3.6.3 Promises and deliverables of crossovers

Lastly, this exposition of frameworks shows that it is difficult to create crossovers without letting go of core notions of either SPT or STR, as is for instance shown in the diminished horizontal ontology in the Multi-Level Practices and the System of Practices and Shared Elements framework or the less usable concepts of niches and landscape in the Practice-Regime intersection points framework. As might have been expected due to earlier warnings (e.g. Geels, 2010) and rising framework complexity, crossovers so far are modest in how they couple concepts. A true coupling between SPT and STR has not been created. Therefore, although ontological connections can be made, the crossovers frameworks do not do what they promise, i.e. using insights from both theories while staying true to the foundations of either approach. Some of the foundations are kept, whereas others are implicitly let go. For instance, the System of Practices and Shared Elements framework places practice elements outside of practices to help describe larger systems, which contrasts basic notions of SPT that there is nothing outside of practices (Shove et al., 2012). This makes it also difficult to combine frameworks, as each of them is built on (slightly) different ontological foundations. However, as has already been shown in the Multi-Level Practices framework and the Spatial Practices framework, the elements that constitute a practice can often be altered relatively easily. The remaining danger herein is always to oversimplify the concept of what a practice constitutes for the sake of creating pragmatic tools (Spaargaren et al., 2016).

3.7 Conclusion

3.7.1 Found crossovers

This paper primarily aimed to elaborate on how SPT and STR have been used together so far, exposing what the strengths and limitations of the different crossovers are, offering researchers and policy makers tools to study and steer transitions, for instance by using the Practice-Regime intersection points framework to find where to intervene. By doing so, the secondary aim was to set a research agenda for future researchers interested in researching sustainability transitions and changing practices for sustainability. It tried to fulfil these aims by covering an exposition of the paradigm of the combined approaches, focusing on ontology and theory, and by doing this, elaborated on the debate of possible crossovers between SPT and STR. Considering the first aim, the article covered six groups of crossover frameworks that each in their own way make use of the combined approaches. As the frameworks make use of both approaches, they can be interpreted as more complex than either. The frameworks each make their own specific crossovers and by doing so, have their specific strengths and limitations, as explicated in the result section.

Using different elements from either approaches, the crossover frameworks function best in different settings, for instance complex settings (e.g. the Multi-Level Practices or Spatial Practices framework), prescriptive settings (e.g. Practices in Backcasting framework), or in search of intervention points (e.g. Practice-Regime intersection points framework). Only two less applied framework groups offer an explicit element of time, namely the System Fractures framework and the Practices in Backcasting framework, which is surprising as transitions have different speeds and aspects of non-linear change, both of which cannot be captured without an element of time. Also how practices can change (i.e. by changing practice elements, by changing practice connections, or by changing practice carriers or their networks) is impossible to study without an element of time; only that the change is measurable. The other four frameworks have to be used more creatively (e.g. twice in different moments in time or specifically when practices are breaking) to account for change. As such, all of these frameworks can be used to understand how situations have changed, but they offer less help in understanding how the changing specifically took place.

3.7.2 Research agenda

Further for the research agenda, on a theoretical level there are still many questions and untouched concepts in the combined approaches of which seven important items are listed. First, the transition paths not covered in section 3.4.4, e.g. substitution or de-alignment and re-alignment (Geels & Schot, 2007) currently lack understanding through crossovers. Five of the current framework groups (i.e. all except the System Fractures framework that is applicable more broadly) are particularly useful for reconfiguration. Future researchers might develop frameworks that take focus on other transition paths. Second, specifically for combinations with the MLP, in many crossovers the role of the black-boxed macro-landscape gets lost. Future research that focuses on the combination of the approaches might take a further look at the relevance of the concept, which is already a returning critique on the MLP (Geels, 2011; Labanca et al., 2020; Shove & Walker, 2010). Third, more research should be conducted regarding interventions to further steer practices in transitions (Öztekin & Gaziulusoy, 2020). There is already research regarding interventions and practices and interventions for transitions, but only very limited in crossovers. Especially crossovers with TM, which is already very normative, might prove useful for that. Fourth, these approaches together offer useful concepts on change, but no concepts on if this change is actually more sustainable (Geels et al., 2015). Future researchers could look further into combining these approaches with indicators for sustainability. Fifth, although there are studies on power dynamics in STR (e.g. Avelino & Wittmayer, 2016), this remains under-researched in STR (El Bilali, 2020), and although SPT might offer concepts to study this (Schatzki et al., 2001), crossover research has not explicitly delved deeply into this topic so far. The Spatial Practices framework might have gone the furthest and might offer a starting point for future researchers. Lastly and perhaps most importantly, as most framework groups do not use an element of time, future research might look further into this. Researchers might try to tackle this research agenda with unused combinations of the approaches (e.g. with TIS or other interpretations of SPT), and on systems that remain largely under-researched with crossovers, e.g. the architecture, engineering and construction system that is known for its routinized practices (Wamelink & Heintz, 2015) and high impact on the environment (WEF, 2016), have not, to the knowledge following from this research, been explored with a combination of both SPT and STR.

3.7.3 Limitations

There are several limitations to this study, of which we mention three. First, regarding methodology, the found body of literature cannot be considered complete. Some works have probably been missed due to the specific search terms used and the specific databases used for this research. However, as both Scopus and Web of Science have been used, and the analysis of the found body of literature did not result in other crossover frameworks, it is not expected that many crossovers have been missed. Relating to results, this study solely aimed to find crossover frameworks between STR and SPT. We expect that many related articles have not emerged from the literature review, as they did not do this explicitly. This relates for instance to interventions, designing, or visioning based on SPT (e.g. Hoolohan & Browne, 2020; Scott et al., 2012), which is very close to the found Practices in Backcasting framework, but not a crossover framework itself. Lastly, the found crossover frameworks all contain many different aspects, which adds difficulty in their application. Although transitions are complex, and it makes sense to use frameworks that can capture that complexity, application of other, often simpler frameworks might also prove useful.

Researchers have to acknowledge that every used framework in the end opens our eyes for specific aspects, but also closes them for others. Especially for sustainability transitions that prove to be very complex, involving many actors differently, the choice of framework needs to be made openly and consciously. This research might help in making that choice.

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Research question	Chapter	Methods	Purpose
1) Which dynamics in the execution of interorganisational construction projects are relevant to realise their circular ambitions, and how do these projects contribute to the transition towards a circular economy?	Chapter 2	Case studies: Group interviews. Workshop	To understand how practices can change in construction projects to stimulate setting and realising circular ambitions
2) How have Social Practice Theory and Sustainability Transitions Research been used together so far and what are the strengths and limitations of the different crossover frameworks?	Chapter 3	Systemic literature review	To understand how SPT and STR can be used together
3) How do practices (mis)align with each other regarding circular design strategies and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?	Chapter 4	Case studies: interviews, observations, document analysis. Workshops	To understand what helps and hinders the transition towards a CE for different circular design strategies
4) Which reconfigurations have taken place in the system-of-practices in which circular building hubs reside regarding reuse of secondary building components and how is it deemed likely to transition in the future?	Chapter 5	Interviews, observations, focus group, workshops	To understand recent and future changes regarding CBH's and their role in the transition

FIG. 4.1 Overview chapters

4 Aligning practices towards a circular economy in the architecture, engineering, and construction sector

Seven transitions in different stages of reconfiguration

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Chapter 2 showed that dynamics for circularity have a great influence on setting and realising circular ambitions in construction projects, but also that their influence diminishes deeper outside the boundaries of construction projects. Therefore, a more systemic research is needed to understand which interorganisational behaviour is and needs changing to speed up the transition towards a circular economy in the architecture, engineering, and construction sector. Chapter 3 provided crossover frameworks that can be applied to study this transition. Chapter 4 does this. Further, many of the dynamics found in chapter 2 can be applied to transitions in general, and do not necessarily relate

only to the transition towards a circular economy. To better understand what is typical for circularity, chapter 4 focuses on different circular design strategies (e.g. design for prevention, or design with regenerative resources), as these different interpretations have different behavioural consequences.

ABSTRACT The architecture, engineering, and construction (AEC) sector is in need of a transition towards a circular economy. This paper offers an analysis of two cases with a wide variation regarding project dynamics in the Netherlands. Alignments and misalignments were analyzed between practices concerning seven design strategies for circular design based on social practice theory and concepts from the multi-level perspective. Results show that many misalignments still hinder the transition, mostly concerning the use of secondary resources, such as notions regarding quality, beauty, and safety among project team members or rapid decision-making processes of the municipality that misalign with the uptake of design with secondary resources. This paper offers directions for reconfiguration, such as better tuning between project planning and urban planning and taking up a more flexible stance regarding the function of the building. This research is interesting for practitioners and researchers focusing on the transition towards a circular economy in the AEC sector.

KEYWORDS Circular construction, social practice theory, transition, practice alignment

4.1 Introduction

The Architecture, Engineering, and Construction (AEC) sector stands out as one of the world's largest contributors to CO_2 emissions and waste, while also consuming significant amounts of energy and resources (UNEP, 2020). Consequently, there is a pressing need for a transition. This transition involves shifting from a linear economy, characterized by the 'make-use-dispose' approach (Kirchherr et al., 2018), to a circular economy (CE) that emphasizes the creation of social, financial, and environmental value through a systemic perspective on the entire life cycle of buildings and their components (Hossain et al., 2020).

The transition towards a circular AEC sector requires radical systemic changes in how buildings are procured, designed, and constructed (Kristensen, Mosgaard, & Remmen, 2021; Leising et al., 2018), that go beyond traditional project boundaries

(Ababio & Lu, 2023; Vosman, Coenen, Volker, & Visscher, 2023). The transition is complex (Mickwitz et al., 2021) and poses various challenges, such as laborious collaboration between different organizations (Eikelenboom & van Marrewijk, 2023), the lack of consensus in defining circularity (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019; Kirchherr et al., 2017; Wiarda, Coenen, & Doorn, 2023), insufficient practical knowledge (Adams, Osmani, Thorpe, & Thornback, 2017; Gerding, Wamelink, & Leclercq, 2021), lack of usage of tools that would create practical knowledge (Çetin, Gruis, & Straub, 2022), lack of knowledge transfer across projects (Eikelenboom & van Marrewijk, 2024), the lack of standards and standardized practices for circularity (Benachio et al., 2020), lack of time to realize ambitions (Arora, Raspall, Fearnley, & Silva, 2021), lacking markets for secondary materials (Adams et al., 2017), lack of knowledge on when secondary materials become available (Koutamanis, van Reijn, & van Bueren, 2018; Vandervaeren, Galle, Stephan, & De Temmerman, 2022), uncertainty regarding future cycles of materials (van Stijn, Eberhardt, Jansen, & Meijer, 2021), and other ambitions that require the attention of project actors (Kooter et al., 2021). Lastly, the sector is known for its conservativeness (Wamelink & Heintz, 2015), often due to lock-in mechanisms (Akinade et al., 2020; Coenen, Visscher, & Volker, 2023), its lack of trust, and risk avoidance (Ruijter, van Marrewijk, Veenswijk, & Merkus, 2021). All these hinder the transition towards a CE.

All these barriers are related to practices that hinder other practices. Practices are interpreted as a type of behaving and understanding that appears at different locales, in different times, by different bodies and minds (Reckwitz, 2002). A practice's internal logic can, through change, start to misalign with other practices in a system. Therefore, the focus of this paper is on alignment and misalignment of practices and how these relate to setting and realizing CE ambitions. Alignment is here conceptualized as practices that stimulate other practices on setting or realizing circular ambitions and misalignment on practices that hinder this. For example, notions of good project management (sticking to budgets, planning, and scope) misalign with flexibility for contractors to change design solutions to achieve circular goals in different ways (Kooter et al., 2021). We are aware that the concept of alignment also exists in organizational sciences and might have a different meaning in that context. Circular design strategies, which describe which circular design choices can be made and with which tools, are vital for the AEC sector to achieve its circular ambitions (CB'23, 2023).

Ultimately, we are interested in the reconfiguration of practices, so that misalignments can be overcome. The research questions this paper aims to answer are therefore: *how do practices (mis)align with each other regarding circular design strategies, and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?*

To analyze these (mis)alignments, Social Practice Theory (SPT) is used, as it is an often used lens to study changing practices (Schatzki et al., 2001; Shove et al., 2012). Many examples exist of its use in the AEC sector (e.g. Collinge, 2024; Eikelenboom & van Marrewijk, 2023; Gherardi, Nicolini, & Odella, 1998). As SPT is often used to describe transitions (Spaargaren et al., 2016), but lacks elements to explain transitions (Geels, 2010), this study adopts some concepts from the multi-level perspective (MLP), which has become more common in the last decade (e.g. Crivits & Paredis, 2013; Hargreaves et al., 2013; Watson, 2012). Also the MLP has often been used in the AEC sector (e.g. Gibbs & O'Neill, 2015; Kooter et al., 2021; Van Bueren & Broekhans, 2013b). The two approaches are complementary in their units of analysis (Hargreaves et al., 2013; Sovacool & Hess, 2017): the first focuses on routinized practices; the second on systemic rules.

This research uses a case study method for two cases with a wide variation of project dynamics, as found by Kooter et al. (2021), to study alignment and misalignment of practices with a focus on construction projects with circular goals. Project X is the construction of an office building, made using project dynamics that Kooter et al. (2021) found to be helpful for setting and realizing circular ambitions. Project Y is a project for renovation of an educational building in which these dynamics played a minimal role, but where instead traditional project dynamics (e.g. risk aversion and short-term orientation (Ruijter et al., 2021; Wamelink & Heintz, 2015)) were dominant.

This paper is set up as follows. Firstly, we delve into SPT and its adopted concepts from the MLP. Next, we explain the qualitative research methods used to study these cases. Further, the results section illustrates how (mis)alignments of practices influence the operationalization of circular design strategies. The discussion of these results includes reflections and focal points for reconfiguration to further stimulate the transition towards a CE in the AEC sector. And finally, the paper finishes with a conclusion.

4.2 Social Practices in the Circularity Transition

4.2.1 A practice-theoretical understanding of transitions

We understand transitions as a structural change of a societal system (e.g. a technological system) that itself resides in a system of systems (e.g. political, legislative, economical) that affects formal structures (e.g. physics, legislation, economics), informal structures (e.g. culture, ideologies, discourse), and practices (e.g. routines, habits, procedures) (de Haan & Rotmans, 2011). Transitions encompass many different actors (Geels, 2005), concern multiple aspects (Heurkens & Dąbrowski, 2020), are path-dependent, and progress non-linearly (Wittmayer & Loorbach, 2016). In analysing systemic changes, Social Practice Theory is increasingly used as approach that takes practices - not structures or individual choices - as unit of analysis (Schatzki et al., 2001; Shove et al., 2012).

Practices, such as brick laying, or designing schools, consist of an array of activities that require knowledge, skills, and artifacts (Schatzki et al., 2001). Practices are self-reinforcing (Seyfang & Gilbert-Squires, 2019). The constant reproduction is further enforced by practices on which an individual practice depends; together these form a complex (Shove et al., 2012). Complexes are formed by overlapping elements between practices, the sequence in which practices are performed (Huttunen et al., 2021), or similarity of space (Spaargaren et al., 2016). In the AEC sector these complexes are for instance formed by the supply of materials and building components, their assembly on a construction site, and the procurement, design, and engineering processes. Scholars urge that these practices should be studied together to further drive CE transition (e.g. Ababio & Lu, 2023). All these practices, though uniquely performed in every project contain standards, for instance stemming from building law, industry standards, or relating to standards of design processes. Complexes contain a teleoaffective structure, a 'range of normativized and hierarchically ordered ends, projects and tasks, to varying degrees allied with normativized emotions' (Schatzki, 2002, p. 80). In the AEC-sector, contractual relationships (Kesidou & Sovacool, 2019) play a central role in this teleoaffective structure. Generally SPT scholars agree that all activity is perceived as practices; there is no context outside practices (Huttunen et al., 2021) or hierarchy between practices (Hargreaves et al., 2013; McMeekin & Southerton, 2012).

The potential to change practices lies in 1) replacing or altering the elements, 2) the ways they are 'interlocked' in their complex, 3) changing the practitioners that perform these practices, or 4) by changing the networks in which these practitioners interact with each other (Shove et al., 2012). Similarly, stabilizing these four ways can stimulate reproduction of practices. With its focus on practices (i.e. not actors), this study takes the first two options into account.

SPT tells us that practices are ever changing (Schatzki, 2002). To help us get a grip on how stable and interlocked a practice is, we adopted concepts from the MLP.

4.2.2 Adopted concepts from multi-level perspective

The MLP is an often used perspective to study transitions (Köhler et al., 2019) – also in combination with SPT (e.g. Hargreaves et al., 2013; Langendahl et al., 2016; Watson, 2012). It offers the concepts 'niche' and 'regime' that can be operationalized to study different levels of practice stability. We understand niches as the locus of radical innovations (both in technology and practices) and regime as the locus of established rules that help stabilize existing systems (Geels, 2011).

Institutional, organizational, and psychological barriers enforce the regime's resistance to change (Brown & Vergragt, 2008; Van Bueren & Broekhans, 2013b). Contrastingly, niches are constantly changing (Schot & Geels, 2008). Smith (2007) distinguishes seven dimensions in which the concepts differ, which we operationalized, as can be seen in table 4.2:

TABLE 4.1 Niche-regime distinction, based on Smith (2007)

	Regime	Niche
Principles	Mainstream guiding principles (e.g. profit and loss)	Alternative guiding principles (e.g. minimize ecological footprint, closing loops)
Technologies	Tried and tested technologies and infrastructure (e.g. design with concrete structure)	New technologies and infrastructure (e.g. design with reused concrete)
Industrial structure	Industrial structure *en masse* (e.g. subcontracted labor, volume building)	Alternative industrial structure (e.g. use of secondary building components)
User relations	Traditional user relations and markets (e.g. passive and conservative consumers)	Active user relations and markets (e.g. actively steering clients)
Policy	Following policy and regulations (e.g. MPG[3] minimum is standard)	Challenging policy and regulations (e.g. lowering MPG goals for a project)
Knowledge	Knowledge based on existing competencies and business practice (e.g. standardized designs/ solutions)	Knowledge base for alternative guiding principles (e.g. knowledge of low-impact materials)
Cultural, symbolic meanings	Broadly shared cultural, symbolic meanings (e.g. markets and regulations)	Alternative cultural, symbolic meanings (e.g. circular housing)

Following Watson (2012) and Crivits and Paredis (2013), we use these concepts of 'niche' and 'regime' in SPT. Systems are perceived as sets of interlinked practices, where each practice is influenced by either niches or regimes, as can be seen in figure 4.1.

We follow Crivits and Paredis (2013) that distinguish practices in elements of agency, material-functional structure, and socio-cultural structure. This interpretation is chosen for its broad interpretation of agency (including motivation, values, and capacities) that is important in this specific transition (Kooter et al., 2021), and its explicit focus on structures (both cultural and functional) that influence the AEC sector (Genovese, Acquaye, Figueroa, & Koh, 2017; Van Bueren & Broekhans, 2013b).

3 MPG is Milieu Prestatie Gebouwen, the Dutch standard on shadow costs, which are based on Life Cycle Analyses. The current standard is achievable without extensive measures.

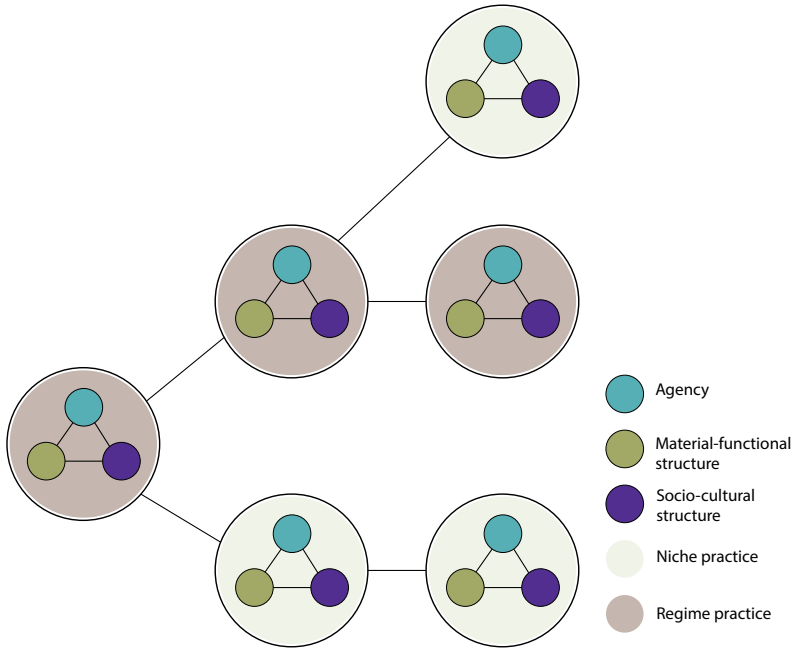

FIG. 4.2 System-of-practices (based on Crivits and Paredis (2013) and Watson (2012))

When practices are stable they are usually performed relatively effortlessly, but when some practices start changing, especially when niches form, misalignments become apparent (Phipps & Ozanne, 2017). Circularity offers concepts that are both new and old (Rockow, Ross, & Becker, 2021) and (mis)align with existing practices. Here 'sleeping' practice elements (Shove et al., 2012) show, as they align with circularity and similarly contrasting notions might become apparent as circularity puts stress on eminently present routines.

Reconfiguration is a transition path in which the adoption of new elements in regime practices make them slowly change from within (Berggren, Magnusson, & Sushandoyo, 2015). We argue that for the transition towards a circular economy in the AEC sector, reconfiguration is the most likely transition path, because this conservative, risk avoiding sector (Dunant et al., 2017; Ruijter et al., 2021) seems to slowly change from within, mainly through efforts of large public and private organizations (Kooter et al., 2021). This paper investigates (mis)alignments in the transition and which reconfigurations are deemed likely to overcome misalignments.

4.2.3 Dynamics supporting circular construction

Kooter et al. (2021) found fourteen dynamics in and around construction projects that stimulate circular construction, divided in prerequisites, project dynamics, and contextual influences (see table 4.3). A dynamic is defined as a "process of relating activities across boundaries to maintain patterns of change and continuity through time, and to the forces that produce these patterns" (Cropper & Palmer, 2008, p. 636), and can therefore here be interpreted as activities that stimulate the formation or reconfiguration of practices. The framework fits earlier findings (e.g. Benachio et al., 2020; Hart et al., 2019), but has up to this date, to the knowledge of the authors, never been questioned on its completeness or on how specific dynamics change routinized practices. Incompleteness is likely, as recent research (e.g. regarding partnering (Vosman et al., 2023)) suggests yet uncovered dynamics. We started our research with the hypothesis that when these dynamics are present more alignments would show, and vice versa when these dynamics are absent more (fundamental) misalignments would show. As a result of this study, we reflect on the completeness and effects of different dynamics of the framework. This reflection can be found in the discussion.

TABLE 4.2 Dynamics supporting circular construction, based on Kooter et al. (2021)

Category	Dynamic
Prerequisites	Top-down support
	Partnership based on increased equality
	Shared circular goals
	Involvement of intrinsically motivated people
Project dynamics	Transparency and trust
	Flexibility
	Reciprocal relationships
	Project team identity
	Struggle for new roles
	Pioneering leadership
	Continuity in staffing
Contextual influences	Sector and organization cultures
	Knowledge flows
	Power and tension

4.3 Methods

4.3.1 Data gathering and analysis

For this research, a case study method is used, because this allows for a rich understanding of a complex phenomenon (in this case the transition to a CE in the AEC sector) (Yin, 2013). This is important, because the transition to a CE is hindered by opposing values (Kooter et al., 2021) and a rich understanding of these values is needed to overcome their opposition. As research to this transition has increased, this study aims to test, nuance, and elaborate on existing research (Ketokivi & Choi, 2014) by applying a framework (i.e. the System-of-practices framework) that, to the knowledge of the authors, has not been used for research on this transition yet.

4.3.2 Case selection

Two Dutch construction projects with circular ambitions have been researched. One operationalizes dynamics supporting circularity (Kooter et al., 2021), whereas the other uses traditional dynamics (see table 4.4). The cases have been chosen for their project dynamics on either side of the spectrum and this allows us to test this existing theory. The wide variation between the cases further allows to better see if the patterns of (mis)alignments hold and their polarity regarding project dynamics allows us to perceive them as critical cases (Miles & Huberman, 1994), so to better understand the possible directions of the circularity transition in the AEC sector.

The projects had to be in the realization phase or later and circular ambitions had to be present. Cases were brought forth by a consortium of practitioners (i.e. public clients, architects, contractors, and industry organizations), thus forming a short-list. Although more circular construction projects exist that consortium members were not part of, there are only few in the Netherlands and the short-list can be considered representative. For both ends of the spectrum, three cases were brought forth by the consortium that fit all criteria. The final selection was based on their polarity regarding project dynamics. The presence of these dynamics was determined in explorative interviews and validated in in-depth case studies.

TABLE 4.3 Project dynamics in two cases, based on Kooter et al. (2021).

	Project X (operationalizing dynamics supporting circularity)	Project Y (traditional dynamics)
Prerequisites	Clear top-down support for all companies in project team	Within the project team only top-down support in architecture firm
	Partnership based on increased equality and collaboration	Traditional partnership
	Collaborative formulation of shared circular goals	Goals are formed by the architect
	Involvement of intrinsically motivated people throughout project team	Only architect was motivated for circular goals
Project dynamics	Communication is explicitly transparent	Knowledge remains with specialists and is not communicated to other project members
	Flexibility regarding budget and scope. Only planning was inflexible	Minimal flexibility regarding budget and no flexibility regarding scope and planning
	Partnerships are reciprocal through alliances	No time was given to establish reciprocal relationships
	The shared circular goals formed an identity for the team	Lack of time and shared goals hindered formation of team identity
	Traditional roles were continuously questioned and reestablished	The architect aimed to take on new roles but was pushed to stick to traditional role
	The client took on a pioneering role of leadership for circularity	The architect aimed to take on a pioneering role for circularity, but struggled with this until the end
	Continuity in staffing was present for all companies.	Continuity in staffing was present for all companies, but not all actors joined the project at the same time
Contextual influences	Organization cultures stimulated circular construction, with the exception of installation companies	Although most companies underlined the circularity transition, most did not stimulate circular construction
	Reasonable knowledge was present among most actors and consultants and Early Contractor Involvement contract stimulated further knowledge development	Knowledge on circularity was largely missing. Lack of specialists made actors hesitant to experiment
	Explicit displays of power remained absent until later stages of the realization phase. The project was set up explicitly with increased equality	Actors were prone to follow client without much questioning of the assignment

4.3.3 Case studies and data collection

Research has been executed by conducting 19 semi-structured interviews (as shown in table 4.4 and 4.5), 8 observations of team meetings, three workshops, and a document analysis of contracts, project agreements, and vision documents for validation of interview results. Interview questions focused on the elements that comprise a practice (agency, material-functional structure, and socio-cultural structure), and the relations between practices. Examples of questions are 'which values influence your choices in setting circular goals?', and 'how do other actors influence you realizing circular ambitions?' In this paper, actors and organizations have been anonymized for privacy reasons.

TABLE 4.4 Interviewees case with project dynamics supporting circularity (project X)

Case with project dynamics supporting circularity (project X)	
No.	Interviewee
1	Civil servant of municipality
2	Consultant to the contractor
3	Architect
4	Client
5	Installation consultant
6	Contractor
7	Interior architect
8	Corporate Social Responsibility (CSR) manager client
9	Constructor
10	Consultant client (ambitions)
11	Project leader installation company
12	Contract lawyer
13	Project manager

TABLE 4.5 Interviewees case with traditional project dynamics (project Y)

Case with traditional project dynamics (project Y)	
No.	Interviewee
14	Architect
15	Client
16	Contractor
17	Contractor
18	Project manager
19	User

4.3.4 Data analysis (within case)

Transcripts of the interviews have been analyzed using Atlas.Ti. First, focusing on teleoaffective structures (Schatzki, 2002), a distinction between practices has been based on assignments, often materialized in contracts. Further, per practice, the practice elements (i.e. agency, material-functional structure, and socio-cultural structure) have been used as codes. Secondly, using inductive coding, components of practice elements were grouped. Lastly, we coded when interviewees mentioned other practices that influenced their practice. Based on this set of codes, we analyzed whether setting and realizing circular goals (mis)aligned with other practice elements. We grouped these (mis)alignments based on the seven circular design strategies, as defined by CB'23 (2023). We used the CB'23 framework and not dominant frameworks like the R-model (e.g. Potting, Hekkert, Worrell, & Hanemaaijer, 2017), as this is made specifically for the AEC sector. It for instance allows to differentiate between design for disassembly and reusing itself, which are very different, and also includes design with renewable resources. The design strategies are:

- Design for prevention, which focuses on reduction of objects, building components, and materials.
- Design for quality and maintenance, which focuses on prolonging life of buildings, components, and materials.
- Design for adaptability, which focuses on making adaptations easier in the future. This includes design for flexibility (i.e. creating spaces that can house various functions).
- Design for disassembly and reusability, which focuses on enabling reusing building components later without damaging components.
- Design with existing building (parts), which is self-explanatory.
- Design with secondary resources, which focuses on reusing building components and materials again.
- Design with renewable resources, focuses on materials that can be renewed (e.g. biobased materials).

Some (mis)alignments concern all of these. These were grouped under 'circularity in general'. We visualized the system-of-practices for each circular strategy. The units of analysis are practices (not actors), and the visualized distances are based on ease of representation and do not resemble perceived distances between practices.

Practices have been divided into niche or regime. This distinction was made using table 4.1, based on Smith (2007). Practices can be considered regime on certain elements, but niche on others. Making distinctions as such eliminates the often contested dichotomy between niches and regimes (Genus & Coles, 2008;

Smith, 2007). Distinctions have been determined in a multi-step procedure. First, one researcher determined the categories based on quotes. Then, a second researcher challenged these assumptions in dialogue. Third, the rest of the research team challenged these distinctions.

4.3.5 Cross case analysis

In the cross case analysis, explanations were sought for similarities and differences between results within the cases. This was coded inductively. Emerging themes regarded context, project dynamics for circularity, and formal contracts. In a second round of inductive coding sub-themes within these three categories were formed that explained differences between the projects per design strategy.

4.3.6 Validation and reliability of findings

Three workshops have been conducted to validate results. Workshop participants were consortium members: architects, contractors, public clients, and academic researchers, who have worked together semi-annually for over three years. In the workshops preliminary results were presented, which were discussed in public and deepened in smaller groups that focused on pattern explanations. This helped us understand which reconfigurations were deemed most important for the transition.

4.3.7 The cases

Case with project dynamics supporting circularity (Project X)

Project X is the development of several buildings for utility purposes including an office building, a work hall, and a parking garage. The design focused on becoming energy neutral in use, having limited CO_2 emissions (measured with the MPG, the national standard), and reusing as many building components as possible. Energy neutrality has been achieved, the CO_2 emission limitations have been accomplished mostly due to the wooden construction, and secondary resources played a dominant role in the design process, but only in 'unimportant' elements of the building. The project was initiated because the client company had to move to a new site within the same municipality. The municipality had plans to redevelop the site of the old building, ended the lease of the land, and offered help to find a new location.

The case with traditional project dynamics (Project Y)

Project Y is the renovation of an educational building, focusing on both public and private education. The client, the owner of the building, is a public organization, but the main user is a private organization. Although the board had circular ambitions, for practical reasons very few ended up in the tender. The ambitions concerned energy reduction (e.g. by updating installations), energy generation (i.e. by using solar panels) and updating installations to remain operational for 10 years. This scope derived from uncertainty regarding larger urban development. During the project, the architect aimed to raise circular goals by using bio-based materials and designing for disassembly. The project was initiated because installations were almost outdated and unsafe. Because the user wanted to remain in the building during renovation, realization took place during summer, which also caused pressure on the design phase.

4.4 Results

The results first discuss the two cases, by elaborating on the system-of-practices in either case, the division of practices in regime- and niche-practices, and (mis) alignments concerning the seven circular design strategies, including circularity in general. Lastly, this section discusses reconfigurations of practices that actors deem necessary to overcome misalignments.

4.4.1 Niche- and regime-practices

In project X, many practices are leaning towards niche, as is illustrated in appendix B. The most notable exceptions to this are practices involving installations. Not only were circular ambitions not realized, actors also found it difficult to set them and challenge business-as-usual. They considered reuse extremely difficult, because components had become outdated. Further, colleagues were skeptical if secondary resources could live up to the quality of new components (interviewee 5,11).

Project Y was dominated by relatively regime-practices, as illustrated in Appendix B. Contrastingly, the architect had alternative guiding principles, involving design for disassembly and incorporating biobased materials, but because of influencing regime-practices, the architect struggled changing business-as-

usual (interviewee 14, 16). Further, two aspects seemed dominant for this regime reinforcement. First, the limited time and small scope hindered developing mindsets for innovation (interviewee 15). More concretely, especially the given horizon to remain operational for 10 years and the limited time in the design phase (interviewee 17) hindered thinking out of the box. Second, the traditional contract stimulated a culture to follow the client's wishes, instead of challenging them, as is more common with Early Contractor Involvement contracts (interviewee 17).

Being niche for many practices means that actors are actively trying to achieve circular goals, but not necessarily realizing them. Reflection on activities was clearly present for actors involved in these niche-practices (e.g. in project X, the architect wondered if the design of the building should follow from an overview of available building components, instead of vice versa). This was less so for actors working on regime-practices in both projects. The installation employee (interviewee 11) for instance explained his linear rationale: 'often it is cheaper, easier, and faster to build with primary resources.'

Below the alignments and misalignments of these practices will be presented per circular strategy, based on CB'23 (2023): 1) circularity in general, 2) design for prevention, 3) design for quality and maintenance, 4) design for adaptability, 5) design for disassembly and reusability, 6) design with existing building parts, 7) design with secondary resources, and 8) design with renewable resources. We present a selection here. A more complete overview can be found in Appendix B. In all figures, the niche-regime division will be presented. The numbers and letters in every figure correspond with the text below.

4.4.2 Circularity in general

Figures 4.2-4.4 show the system-of-practices and the (mis)alignments regarding circularity in general. As many (mis)alignments were vital, we made a distinction between (mis)alignments regarding setting circular ambitions, and (mis)alignments regarding realizing these. Figures 4.2 and 4.3 show these regarding setting ambitions, and figure 4.4 regarding realization.

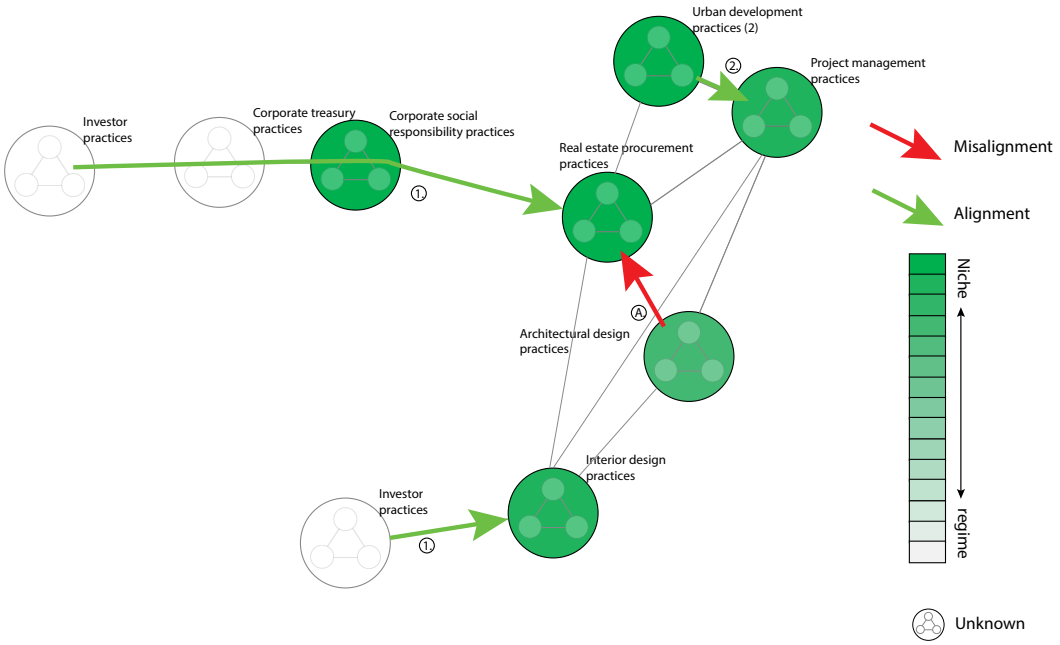

FIG. 4.3 circular goals in general (ambitions) project X

Several practice alignments seemed pivotal for circular goals in general regarding ambitions in project X (see figure 4.2), two of which are highlighted here. 1) ESG ratings influenced investor practices and stimulated creating policy on circular goals for the client and interior architect (interviewee 7, 8), which showed in the tender. These ESG ratings did not push for very ambitious policies (yet), but the mechanism to influence circularity policies showed with the incorporation of biodiversity ambitions. 2) The municipality owned the land on which the client was going to build, which allowed setting circularity demands and ambitions as part of the urban development (interviewee 1, 4, 8). As such, the municipality functioned as a fail safe for circularity ambitions, as the ambitions in the real estate tenders were higher. The municipality used a combination of hard, extralegal demands and a set of soft ambitions. The first was an option as they owned the land, but the latter was always an option that they could use to set goals that matched the culture of specific clients.

Also, several misalignments were deemed important, of which two are discussed here (see figure 4.2). A) The function was considered unnegotiable by the architect if it conflicted with circularity goals (interviewee 3, 9, 13). The architect for instance elaborated on using concrete slabs on top of the wooden floors: ‘if you’re constructing a house for a private client who cares greatly for sustainability, I don’t

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mind if the floor is not fully soundproof. However, if you're constructing an office for 500 people who have to concentrate on their work, I think you need to consider the best solution within the chosen system; I don't consider it a sustainability failure if you choose for good acoustics, it's a boundary condition.' Similarly, an empty plot was chosen, as no existing building fitted the functional demands (interviewee 13).

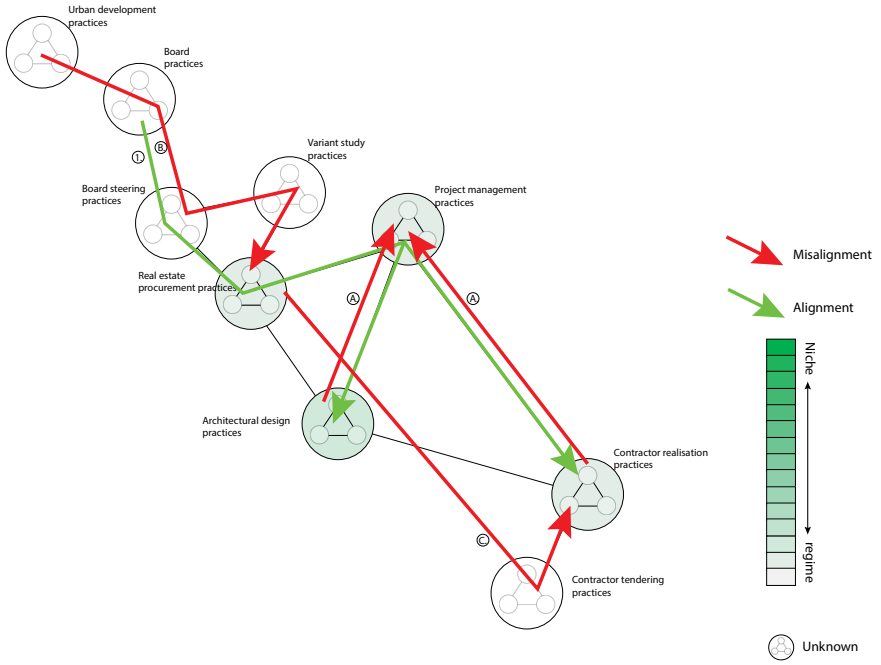

FIG. 4.4 Circularity in general (ambitions) project Y

Several alignments for setting circular ambitions in general, played an important role in project Y, of which one is highlighted here (see figure 4.3). 1) It was understood that public clients (have to) steer the circularity transition, making private companies follow through procurement. However, the board of this public client largely followed societal trends; they would not dare to be a frontrunner, only an early adopter (interviewee 14, 18, 19).

Several misalignments played a pivotal role in setting circular ambitions in general for project Y, five of which are mentioned here (see figure 4.3). A) When the client is not challenging the other actors (i.e. architect and contractor) regarding circularity, they have very few moments to suggest circular ambitions to the project manager, only around the quotation/tender (interviewee 15, 17). Here actors have to be

precise: after that moment is gone, very little is likely to happen. B) Because the urban development vision remained uncertain, it was uncertain what the client wanted with the future of the building (interviewee 15, 19). The client therefore decided to keep the building open for 10 years, which hindered many ambitions, as their investment would be too large for this time period. C) The traditional contract, as used in the procurement phase, technically allows for innovation, but culturally contractors do not feel the urge to be innovative under such contracts (interviewee 16, 17), but follow the ambitions the client sets. For instance, reclaimed steel was not considered although it fitted the formal ambitions of all actors.

The difference between project X and Y regarding setting circular ambitions in general have several origins, of which we list two here: 1) the municipality could raise the bar in project X, as they owned the land, but they were not involved similarly in project Y. 2) As the project was considered small, the client of project Y never perceived the project potentially innovative and applying dynamics supporting circularity seemed too much effort. Contrastingly in project X, the building was perceived as a showcase of the circular ambitions of the client. Application of dynamics supporting circularity in general was stimulated from the start of the project.

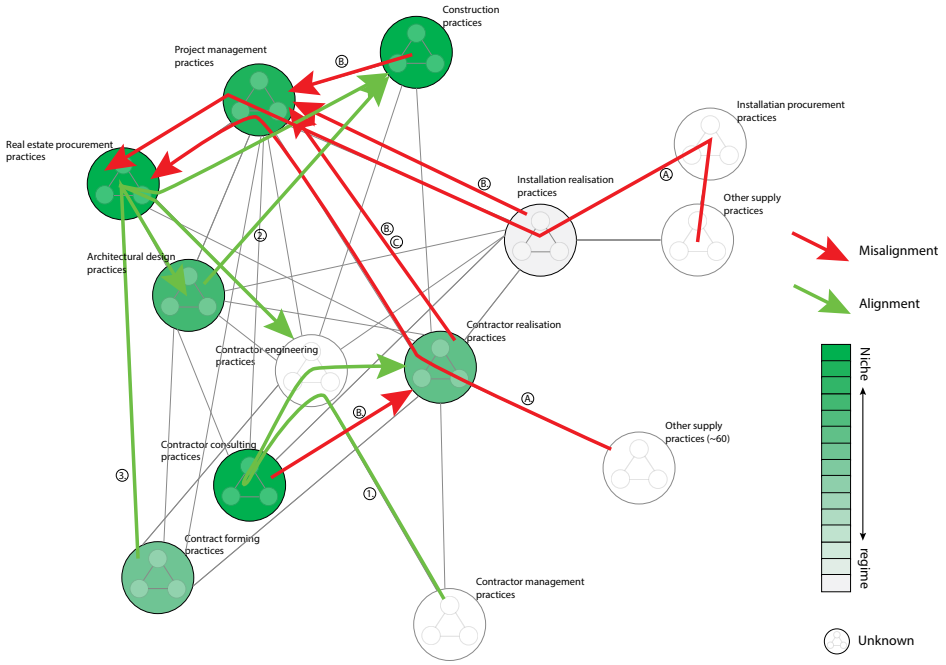

FIG. 4.5 circular goals in general (realization) project X

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Realization of circular goals in general had several practice alignments in project X, of which we highlight three (see figure 4.4). 1) The contractor managers hired a consultant to win the tender. This allowed her to gather lessons from earlier projects and teach these to the project team (interviewee 2). Setting up a company CV to win the tender resulted in an accumulation of practical knowledge that could be shared with the project team of the contractor. 2) Functional segregation, dividing functions into separate buildings, allowed the constructor to design unique solutions for each building, based on functional demands (interviewee 3, 4, 9). 3) An Early Contractor Involvement contract stimulates a learning environment (interviewee 4, 12). Dealing with change is deemed difficult for private parties. The early contractor involvement contract allows for a change mindset, allowing actors involved to try new things and experiment. Further, even though the contract is no requirement for contractors to share their circularity expertise, it does stimulate a setting in which it is more likely.

Some misalignments were also present that hindered realizing circular goals in general, of which we highlight three (see figure 4.4). A) Earlier agreements between contractors and suppliers make realizing some circular goals impossible (interviewee 6), as not every supplier is a previously defined preferred supplier. Similarly, for installations (interviewee 11) preferred suppliers seemed mainly chosen because of their use of safety and quality measures and finances, at the cost of circularity (e.g. with no or limited packaging). B) Lack of ready knowledge led to longer procedures, which made deviating from business-as-usual, though asked for, extra difficult within the limited amount of time that was set for the construction project (interviewee 2, 4, 13). Deviating from business-as-usual became more difficult as market pressure grew and actors (i.e. contractor, constructor, and installation company) had a limited amount of time to spend (interviewee 2). C) Circularity realizations lead to other-than-standard outcomes, which involves risks. As contractors traditionally carry these risks, they often veto them beforehand (interviewee 3, 4, 9).

Some misalignments for realization of circularity in general were crucial in project Y, of which we mention two. A) As the project manager divided the assignments in parts, relying on the expertise of the responsible actors, the architect was unable to steer the project to common circularity goals, as he was not involved in certain parts of the renovation (interviewee 14). B) Changing routines requires extra time. Pressure from the user (that only wanted to close for a brief period in summer) and the installations (that were getting outdated) limited available time (interviewee 15, 18). Here differences in circular solutions become apparent, for instance, wood has become mainstream enough, whereas reuse is considered too niche under traditional contracting.

Differences between project X and Y regarding realization of circularity in general dominantly stem from two sources: 1) limited time in project Y made it difficult to change business-as-usual. Although time constraints were also mentioned in project X, they were not experienced as limiting. 2) The Early Contractor Involvement contract of project X pushed for an innovative culture with mentioned project dynamics that was absent in project Y. Use of this contract is by many considered a hassle (workshop 3).

4.4.3 The System-of-practices

Throughout project X and Y, practices influence each other, which is further illustrated in a complete overview in Appendix B. Influence of one practice on the next can take multiple forms (e.g. setting norms, transferring knowledge, or delivering secondary building components) and extend far from traditional project boundaries. This means the transition does not only take place within construction projects, but also in practices around projects and the interdependencies between them.

Project X is more complex than project Y. This partly stems from the size of the projects - project X comprises more aspects and therefore more practices - but a key difference stems from the different contracts: in project X an Early Contractor Involvement contract is used, which adds practices in the heart of the project. The case with traditional project dynamics (project Y) used traditional contracting (i.e. a top-down structure where the client takes ownership of the design, and late involvement of actors, such as the contractor), which limits the amount of practices. This will be further discussed below.

4.4.4 Design for prevention

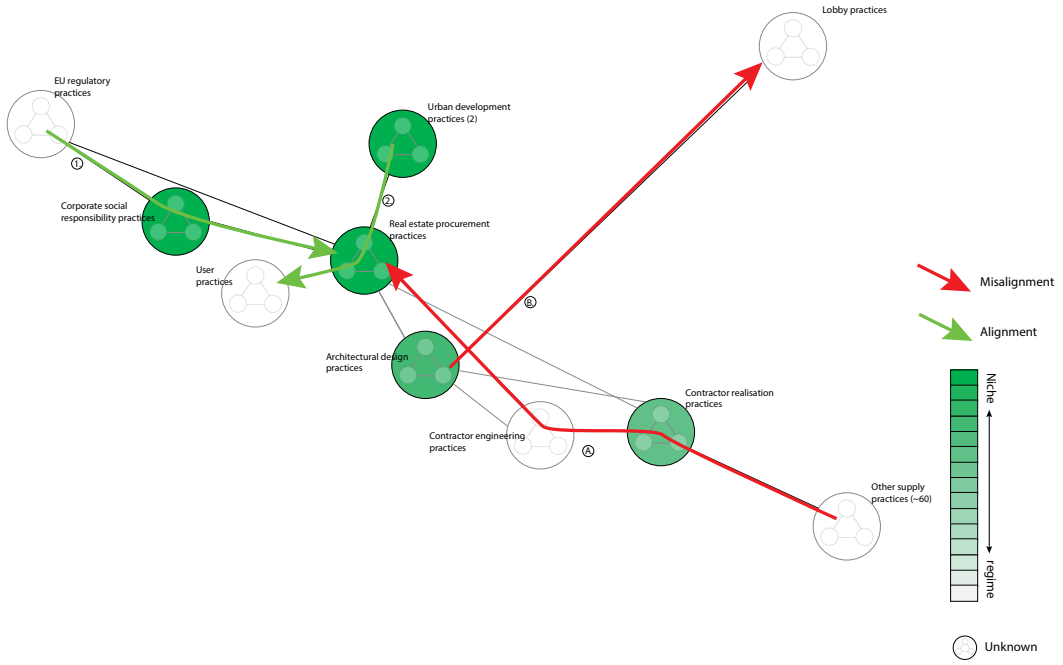

FIG. 4.6 Design for prevention (project X)

Several alignments help design for prevention in project X (see figure 4.5), of which we highlight two. 1) Measuring environmental impact, obligatory in upcoming EU legislation, already influences reduction policies (interviewee 8). Reporting CO_2 impact already stimulates reduction. The CSR manager explained: 'we always anticipate legislation before it strikes us' (interviewee 8). 2) Reducing energy use, as demanded by both the client and the municipality, aligns with cost reduction (interviewee 1, 4, 13). That makes it easy to achieve, contrasting other circular ambitions (e.g. reuse or green roofs).

Some misalignments also play a role for design for prevention in project X (see figure 4.5), of which we mention four. A) Energy reduction (or even neutrality) requires more materials (e.g. in insulation and solar panels), some of which are critical and/or toxic (interviewee 5). B) There is distrust about the LCA scores of materials in the NMD (national environmental database) that functions as the basis of MPG calculations (interviewee 3), for instance because they are considered lobby results. As the NMD is being updated regularly, LCA information changes often. This hinders the uptake of the MPG as sustainability criterion and its use as transition tool to keep raising the bar.

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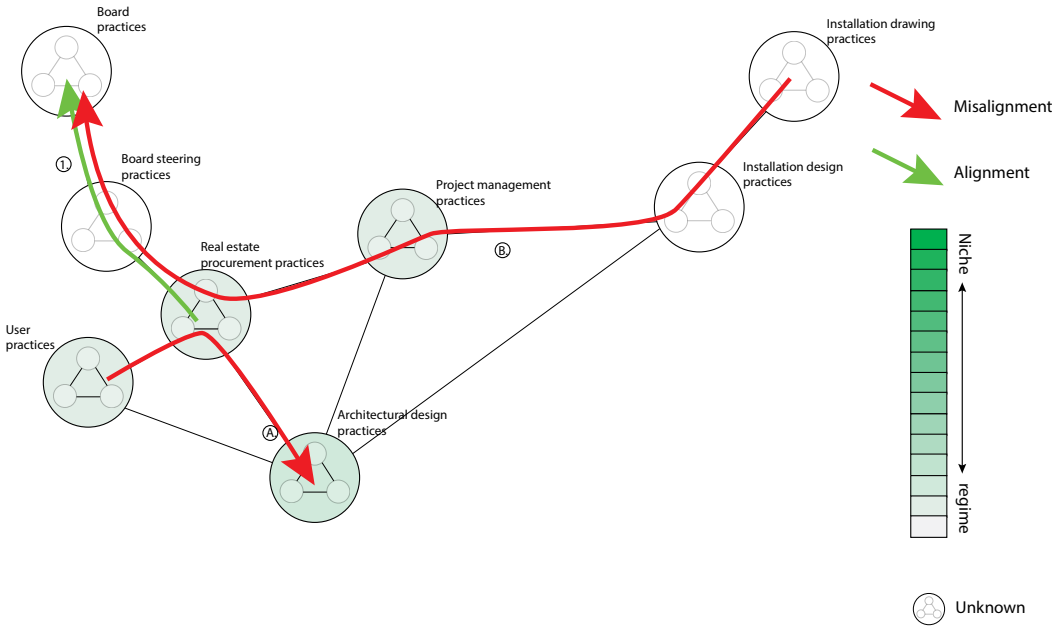

FIG. 4.7 Design for prevention (project Y)

We highlight one alignment for design for prevention for project Y (see figure 4.6). 1) The board of the client company wanted to reduce energy consumption. Many energy reduction solutions (e.g. solar panels) pay themselves back within the 10-year scope of the building and were therefore also attractive financially (interviewee 15).

In project Y, two misalignments were dominant in design for prevention (see figure 4.6). A) The user only accepted renovation during the summer months, which put pressure on the design phase. Time limitations made it less attractive to calculate impact of the design solution on the building (interviewee 14), which was a time-consuming activity itself. B) Personnel shortages for installation design resulted in unfinished drawings when production started, resulting in wrongly produced building components. The architect (interviewee 14) said: 'if you look at what we saved by designing with wood, and compare that to what we had to throw away because of mistakes… to me that is out of proportion.'

Though not always explicitly mentioned, logically all (mis)alignments of project X apply to project Y. However, project Y has some extra challenges. The most striking differences between the two projects is 1) the calculations (e.g. MPG) of project X that impacted design decisions. These were absent in project Y, due to lack of time. Further, the proactive attitude towards EU legislation regarding impact measurement

in project X contrasts the regime attitude (following policy and regulations) in project Y, due to prevalence of other values (e.g. financing education instead of education buildings). This hindered setting shared circular goals.

4.4.5 Design for quality and maintenance

Design for quality and maintenance played a central role in project X, of which 1 alignment is especially striking. 1) What the architect considers a good building (interviewee 3) largely relates to how materials age. Here steel cladding was chosen as façade material, because it would be able to withstand the harsh environment. He said: 'we could have used [wood] as façade material, but that would be greenwashing. […] That façade has a different component, namely that it should stand the test of time.'

For design for quality and maintenance in project Y, we want to highlight 1 alignment. 1) Similar to project X, what is considered a good building, partly depends on how materials age (interviewee 14).

One misalignment for design for quality and maintenance played a central role in project Y. A) The architect was given a scope of 10 years. Solutions that would last shorter were discarded, but solutions that would take long to pay themselves back were also not considered, as 'a new owner could do that too' (interviewee 18).

Whereas both projects have similar alignments, the mentioned misalignment of project Y specifically stems from the limited time frame that is based on uncertainty of future urban developments. This hindered the prerequisites of dynamics for circularity, such as involving intrinsically motivated people and formulating shared circular goals.

4.4.6 Design for adaptability

We highlight one alignment for design for future proofing in project X. 1) Design for flexibility, here interpreted by the interior architect as boxes in a larger space that could be changed (e.g. moved or taken down), makes it easier to continue working when the function changes (interviewee 7). It is therefore perceived as the smart, cheap (on the long run), and easy choice.

Design for adaptability did not play a dominant role in project Y, but similar statements were made by the architect (interviewee 14), as the building that was to be renovated was designed very adaptable itself.

4.4.7 Design for disassembly and reusability

We highlight 1 alignment for design for disassembly and reusability for project X. 1) Design for disassembly is considered a better job than traditional design (interviewee 9), as this gives them a) a challenge they often lack, and b) extra hours and therefore money.

For project Y, 2 misalignments were important for design for disassembly and reusability. A) The contractor is used to making things as simple as possible (interviewee 16). This is often cheap, easier to make, and requires less (stress on) personnel. Creating demountable building components seldom is simple. B) Because the expected life expectancy of buildings is so long, it remains uncertain what will happen with building components in the future. This hinders effort for designing for disassembly (interviewee 15, 18).

An important reason for the differences between project X and Y can be found in the contracts: project X used an Early Contractor Involvement contract before the traditional (UAV) contract and project Y used only a traditional (UAV). This offered less time for the architect who initiated design for disassembly in project Y (interviewee 14, 15, 17, 18) to convince the client and contractor (interviewee 16). Consequently, the client, though unopposed, remained skeptical until the end of the project and the contractor first remained unaware of the design values. Most actors were not intrinsically motivated for circularity and shared circular goals were never formulated.

4.4.8 Design with existing building (parts)

One important misalignment in project X for design with existing building (parts) is highlighted here. A) None of the existing buildings were considered able to house the intended function (interviewee 13); design logic stemmed from function, not availability.

We highlight one important misalignment in project Y for design with existing building (parts). A) It requires time and money to do a proper inspection beforehand. Here, an inspection had taken place, but not properly. When it turned out the building was constructed differently than expected, many last-minute changes were required at the cost of time and (therefore) circularity (e.g. due to production mistakes).

The most important difference between the projects is that reuse of buildings did take place in project Y, but was never seriously considered in project X. In project Y, the function of the building remained, which was not an option in project X; the client was pushed to move.

4.4.9 Design with secondary resources

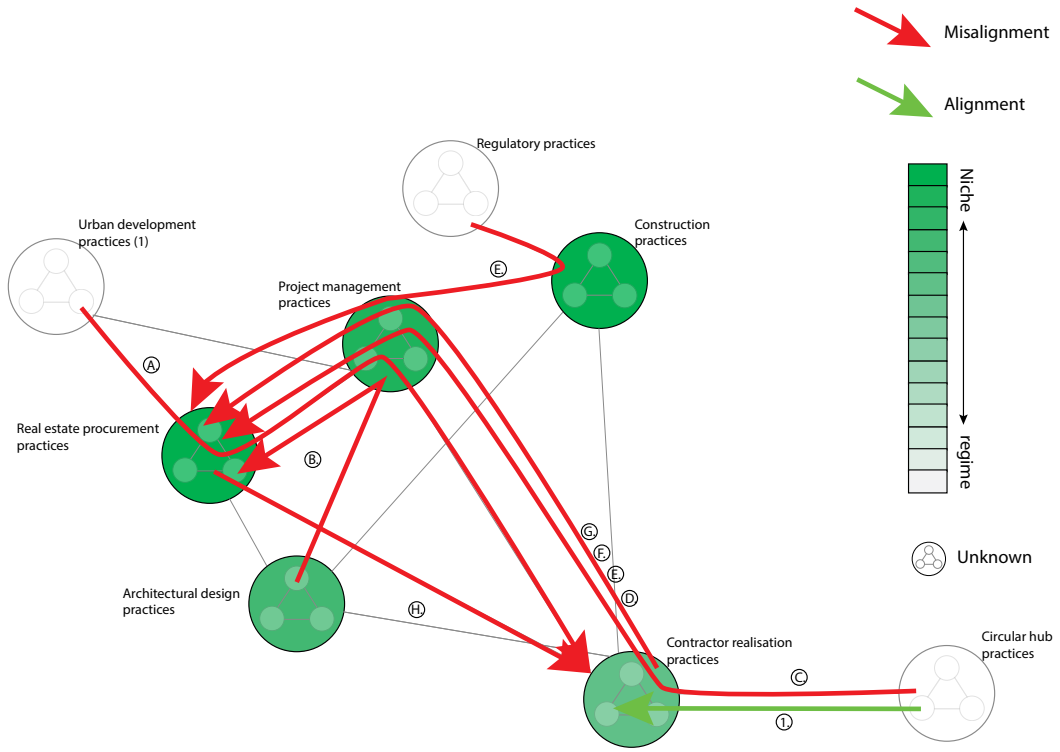

FIG. 4.8 design with secondary resources (project X)

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Although the system-of-practices for design with secondary resources is riddled with misalignments, we highlight one alignment in project X too (see figure 4.7). 1) Actors shared an idea that to stimulate circularity, the message of circularity's importance should be repeated (interviewee 6). Therefore, secondary resources were chosen as solutions on small scale (e.g. a single wall with reused plasterboard). Building components were not available for larger scales, such as a complete building.

Many misalignments hinder the uptake of reusing building components (see figure 4.7), of which we highlight nine. A) the rapid decision-making process of the municipality (here: to develop a new neighborhood) limits time for projects to find secondary building components (interviewee 3, 4, 5, 9, 13). Time constraints further stemmed from European procurement law that sets time frames for procedures (interviewee 4). Renegotiating about time constraints was not considered, as 1) there is no culture to do so, and 2) extra time is not considered to lead to a better project (interviewee 13). B) Functional design limitations were considered so important that reused building components did not enter the design discussions until these were overcome (interviewee 3, 13). For instance, the oddly shaped plot pushed the architect to make a design that fitted that without first considering potential secondary resources. C) Circular hubs are still relatively small and unable to offer materials for a complete large building (interviewee 6, 7, 12). Some suppliers offer secondary resources too, but not in the needed quantities for large buildings. Therefore, clients set soft demands for reuse (interviewee 4, 6, 8). D) Labor costs for repairing or remanufacturing building components often make secondary resources more expensive than primary resources (interviewee 3, 5, 6, 9, 11). This is especially problematic, as many actors think these should be cheaper, as is for instance the case in clothing. E) There is no norm regarding reuse and it is impossible to give guarantees, resulting in huge risks for the contractor (interviewee 4, 5, 6, 9). For norms, actors are subjected to the whims of the specific civil servant they encounter. Lastly, changing norms is unlikely, as this is expensive and conflicts with upcoming laws on safety, which require actors to prove the performance of building components (interviewee 9). F) Contract penalties for building performance create financial risks for contractors to reuse building components, as they do not know the exact state these are in (interviewee 6). G) Contractors aim to reduce labor hours, as these 1) take time, 2) are expensive, and 3) often lead to physical problems of employees (interviewee 6). Repairing and remanufacturing of building components, however, often increase labor hours. H) Subjective standards for building aesthetics often do not match with reuse (interviewee 3, 11, 13). Often this results in extra materials (e.g. lowered ceilings for reused installations) to cover them up.

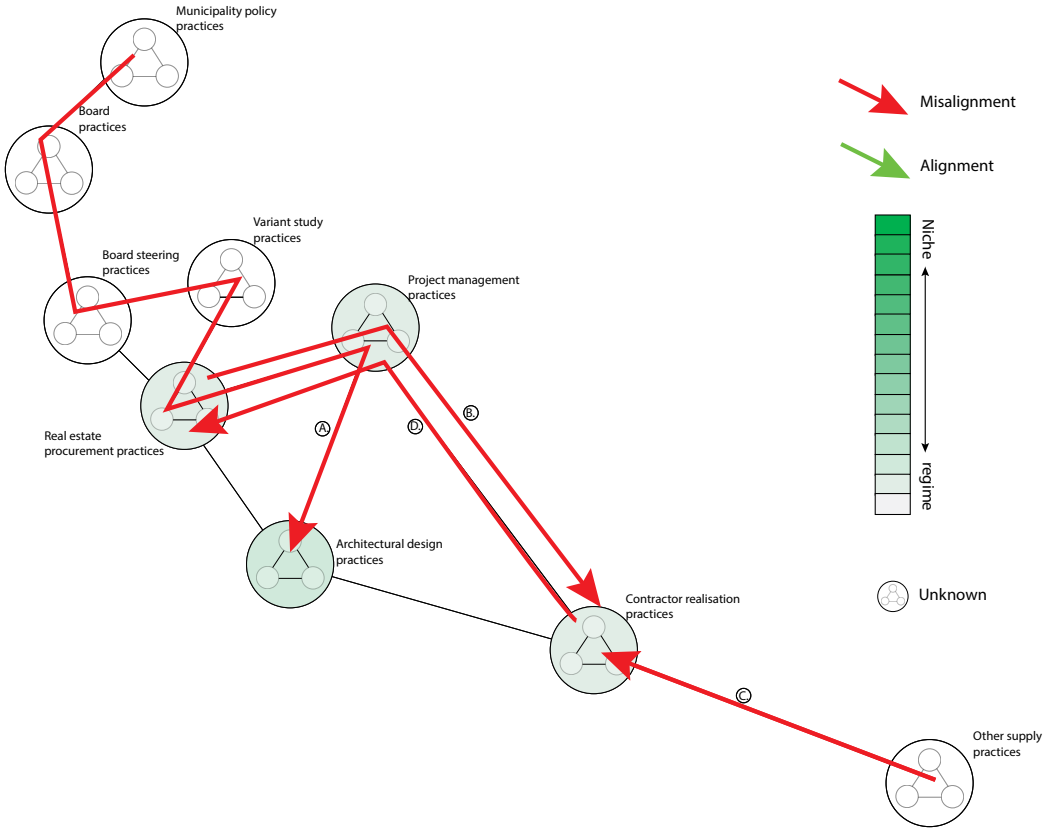

FIG. 4.9 Design with secondary resources (project Y)

Many misalignments hinder the uptake of secondary resources in project Y (see figure 4.8), of which we highlight four. A) Architects mention that they find it hard to change their practice and do something they are not good at (especially reuse of building components), whereas they are good at some circular aspects, such as future proofing (interviewee 14, 18). Addition of consultants is needed to the project to make this happen. This misaligns with municipal ambitions. B) The traditional contract technically allows for innovation, but culturally the contractor is not stimulated by it (interviewee 17). They often do not feel any tendency or mandate to change business-as-usual, but instead follow the client's ambitions. For instance, reclaimed steel was not even considered, even though it fitted everybody's ambitions. C) The small market for secondary building components makes reuse unlikely (interviewee 14, 15, 17). D) As contractors cannot give guarantees for secondary building components, reuse becomes very difficult to achieve (interviewee 15, 17).

Misalignments between the projects mostly overlap. Some differences occur, as project X went further in the pursuit of secondary resources, which allowed for alignment.

4.4.10 Design with renewable resources

We highlight one alignment for design with renewable resources in project X. 1) Wood is perceived to be a very beautiful material (interviewee 3, 7). It also results in less material use for the interior, as wood is considered to be so dominant aesthetically (i.e. containing many visual stimuli), that additions often diminish quality of space (interviewee 7).

Several misalignments play an important role, of which two are mentioned here. A) Traditional methods of budgeting hinder choosing wood, as it is more expensive (interviewee 3). However, using wood diminishes costs elsewhere, for instance regarding interior and foundation (interviewee 3, 7), so calculations on the costs have to incorporate these aspects too. B) Wood details highly impact the environmental impact. The bare steel connection elements usually have highly toxic coatings.

Several alignments regarding design with renewable resources play an important role in project Y of which we highlight two. 1) In recent years, material prices have risen extremely. Prices of wood however do not seem to rise as fast as others, making wood increasingly attractive (interviewee 14). 2) The use of renewable energy (using solar panels) pays itself off within 10 years, within the limited scope of the project, so procurers guided installation employees towards that direction.

The most noteworthy difference between the projects stems from the impact of wood prices on materialization choices. In project X, wood pricing had a major impact on the project budget, as the load bearing structure was made with it. In project Y, the wooden construction was considerably smaller in size.

4.4.11 Reconfigurations of practices

This last part of the result section focuses on reconfigurations. Interviewees and workshop participants mentioned several reconfigurations they deemed necessary to overcome misalignments, of which some are already taking place (mostly in project X) and some are envisioned. Some reconfigurations change the elements of a practice; other reconfigurations concern the system-of-practices by adding practices to the system and interlinking existing practices differently. Only once (the second reconfiguration mentioned here) a change in practice performers was mentioned.

Regarding reconfigurations taking place, some interviewees mentioned dominant reconfigurations, especially concerning relatively niche (according to Smith's (2007) elements) practices in project X, here presented following their teleoaffective structure from procurement to realization. ESG ratings stimulated creating circular policies in general, which in turn stimulated circular ambition setting in project X (interviewee 7, 8). Also, the way in which ambitions have been set, changed (interviewee 2, 6, 8, 10, 12, 13). First, hard and soft circular ambitions stemmed from both the client and the municipality. Second, the client set ambitions regarding building performance and collaboration, instead of design choices. This also required different skills of employees (interviewee 8): 'you see that predominantly with the procurers. We used to have employees who were trained to procure for bottom prices. We do not have those anymore.' Further, searching for architects that know about circularity seems easier (interviewee 4, 8). Where several years ago, clients had to be picky, now it has become relatively common practice. One client (interviewee 8) said: 'in 2010-2012 we specifically selected a circular architect, whereas now it is not needed anymore; all of them have the knowledge.' However, this does take different forms, affecting design strategies differently. For instance, the architect of project X (interviewee 3) specialized in design with renewable resources, whereas the architect of project Y (interviewee 14) specialized in design for adaptability. For other design strategies, they needed input from specialists. Knowledge about circularity largely stems from internal specialists from workgroups or sustainability departments (interviewee 1, 6, 9, 14, 16, 17) or external consultants (interviewee 2, 8, 10). Lastly, another important reconfiguration regards emerging circular building hubs to find secondary materials (interviewee 2, 3, 4, 6, 7). This mostly impacts construction calculations (interviewee 9), and logistics (interviewee 2, 6). Many of these reconfigurations were only considered with an Early Contractor Involvement contract (interviewee 6, 12, 17, workshop 3).

Some reconfigurations are expected to overcome misalignments in the future, here again presented following their teleoaffective structure from procurement to realization. Regarding circular ambition setting, interviewees mentioned they expected to be guided by future ESG ratings, EU laws and legislation (interviewee 8), and a change in MPG legislation (interviewee 2). Interviewees and workshop participants showed different interpretations of how this would affect tenders and contracts. All agree that ambitions should be made clearer from the start, but differences arose for how strict they must be set. Some (interviewee 6, workshop 3) state that ambitions should be loose, so actors can operationalize abstract ambitions per project, whereas others (interviewee 2, 10, 12, 14, workshop 3) state that ambitions should be strict, so actors are stimulated to work harder to realize them.

Also, different trade-offs between ambitions were mentioned. First, some (interviewee 9, workshop 2) mentioned safety measures should be loosened to better allow design with secondary resources. Second, others (workshop 3) said users might need to suffice with suboptimal buildings regarding function and quality of materials. Both remarks have been questioned by others (interviewee 3, 14, workshop 3). Further, innovation seems hindered by a culture of risk avoidance that is embedded in contracts with high penalties to secure building performance (interviewee 3, 6, workshop 3). Refraining from penalties when regarding circular solutions was mentioned as possible solution. Lastly regarding setting project ambitions, interviewees (2, 3, 6, 9, 13, 14, 16, 17, 18) mentioned that more time should be given to realize circular ambitions as this is the most important reason circular ambitions are often not realized. Further, interviewees saw potential in reconfiguration of the design process: instead of designing and searching for secondary resources after, local secondary resources should form the start of the design (interviewee 4, 8). Some (interviewee 6, workshop 2, 3) mentioned it was impossible to realize many circular ambitions in one project, without it taking long and becoming very expensive. However, they saw potential in raising the number of ambitions over time. Further, it was mentioned suppliers should offer more secondary resources or components with smaller environmental impact (interviewee 6, 14). Lastly, as employees of installation companies have very little idea on how to become more circular, it was mentioned that reconfigurations should focus on changing agency, to stimulate circular mindsets (interviewee 5).

4.5 Discussion

It has often been mentioned that the transition towards a circular economy in the AEC sector requires radical change for multiple actors, at multiple dimensions, involving multiple aspects (e.g. Heurkens & Dąbrowski, 2020). The results presented in this paper confirm this and further show how practices in diverse construction projects (mis)align to set and realize circular goals according to different strategies for design for circularity. In this discussion, we further reflect on these results of chapter 4, focusing on how our findings add to or confirm literature on circular construction projects, circular dynamics, the use of Social Practice Theory, and possibilities for practice reconfiguration.

4.5.1 Circular construction Projects

This study adds to the literature on circular construction projects with its unique focus on practice (mis)alignments in four major ways. First, in general, even though alignments exist, many misalignments still play an important factor in setting and especially realizing circular goals. Misalignments exist within traditional project boundaries, but also stretch far outside them (e.g. lobby or investor practices). This highlights the systemic nature of the transition, as mentioned by others (e.g. Kristensen et al., 2021; Vosman et al., 2023). Both cases showed many misalignments, but project Y, which did not adopt Kooter et al.'s (2021) dynamics, showed more fundamental misalignments. This was worsened by the traditional contract that stimulated regime practices.

Second, the number of misalignments for circular goals in general illustrates that change in general is already difficult to accomplish in such a complex system. Further, the change towards a circular economy, based on these design strategies, should also be considered multi-facetted. It is often mentioned that circular economy is an umbrella concept (e.g. Desing et al., 2020; Wiarda et al., 2023) and these results add to the literature how design strategies have misalignments with each other or even themselves. Circular design strategies, though clearly multi-facetted, are still perceived by many as having to result in a coherent outcome (e.g. Hart et al., 2019), not as potential trade-offs, as time and money for instance are used. Perceiving these seven design strategies as potential trade-offs would stimulate a more realistic way forward in the transition - or transitions - towards a circular economy in the AEC sector.

Third, more in depth, the relation between design strategy and business-as-usual seems crucial in the formation of misalignments. For instance design for prevention, design for quality and maintenance, and design for adaptability have similarities with business-as-usual, as fits earlier research (e.g. Rockow et al., 2021). Design for prevention for instance often reduces costs directly (as is already a common goal in practice). The value of these design strategies are therefore apparent while designing the building. Contrastingly, design with secondary resources has many misalignments with both business-as-usual and other circular design strategies. For example, reuse of building components might lead to additional materials to cover them. Further, the strategy for instance misaligns with the availability of secondary building components at circular hubs and suppliers, the money it costs the client, and the given amount of time for the project to search for secondary building components, in line with Arora et al. (2021). Closing loops seems therefore unlikely in the near future. Based on this research, it seems design with secondary resources requires the most radical reconfigurations throughout the system-of-practices.

Fourth, this research confirms earlier research that standards (Benachio et al., 2020), and knowledge (Gerding et al., 2021) are still lacking. However, contrasting previous research (e.g. Çetin et al., 2022; Eikelenboom & van Marrewijk, 2024), we noticed that standards are being developed (e.g. regarding fire safety for wooden constructions), that digital tools (e.g. MPG measurements) are increasingly used to inform design decisions on circularity, and that consultants can help with knowledge transfer between projects. This is still an early stage in that development and was mostly observable in project X, which made use of Kooter et al.'s (2021) project dynamics. However, in line with previous research, knowledge and tools for knowledge development for designing with secondary resources are still mostly lacking (Koutamanis et al., 2018; Vandervaeren et al., 2022).

4.5.2 Circular dynamics

This study further shows that in general when Kooter et al.'s (2021) dynamics are present, more practice alignments are present, and when these dynamics are absent, more and more fundamental misalignments are present. Several of these dynamics (i.e. partnership based on increased equality, involvement of intrinsically motivated people and all project dynamics) seemed to have a dominant role in niche formation. Niche formation seemed most important for design strategies that are less like business-as-usual, such as design with secondary resources. Other dynamics (i.e. top-down support and shared circular goals) helped raise the circularity bar in general. Kooter et al.'s (2021) dynamics, however, do not incorporate new practices

or practices outside traditional project boundaries, such as regarding circular hubs, hiring external experts, or urban miners, for knowledge and building components, and changing or getting exempted from regulations. These seem most pressing for design with secondary resources. This research shows (mis)alignments stemming from these practices, highlighting a dynamic of partnering anew, in line with Vosman et al. (2023) and Gerding et al. (2021). Also, more fundamental, this research shows that although these dynamics are considered important, some factors, such as time availability, can hinder their uptake.

4.5.3 Social Practice Theory (SPT) and multi-level perspective (MLP)

The use of the theoretical lens of this research adds to existing literature of SPT and MLP and further shows how concepts of these approaches can complement each other, as mentioned by others (e.g. Crivits & Paredis, 2013; Hargreaves et al., 2013; Watson, 2012). First, this research especially adds understanding of how these can be combined in systems-of-practices. Further, one cannot conclude that being niche leads to practice alignments and being regime leads to practice misalignments; even though most practices in the core of the system-of-practices of project X are relatively niche (on many of Smith's (2007) elements), many misalignments still stem from them. Second, similarly, the contract forming practice (i.e. the practice that produces the contract between client and contractor) that is considered relatively regime itself, functioned as a great potential stimulus for niche formation. In project X, where this practice produced an early contractor involvement contract, this contract stimulated experimentation regarding many aspects of niches (e.g. alternative principles, technologies, and industrial structures). In comparison with project Y, the advantage of the early contractor involvement contract mostly shows in design for disassembly and reusability, design with existing building (parts), and design with secondary or renewable resources, as these divert further from business-as-usual. Lastly, both cases showed that in general niche practices further stimulated other niche practices and that regime practices further stimulated other regime practices.

4.5.4 Reconfigurations

As shown in the result section, interviewees and workshop participants mentioned many potential reconfigurations. In general, some of these focus on niche formation (e.g. changing meaning of installation company employees, as is also mentioned by Kooter et al. (2021)). Other reconfigurations focus on overcoming misalignments directly (e.g. distributing more time to projects, in line with Arora et al. (2021)). Further, some focus on regime reconfigurations (e.g. more driving ESG ratings). Interviewees and workshop participants seemed most agreed on boundary conditions for projects, such as time, and laws and legislation (in line with Ababio & Lu, 2023), but less on the trade-offs between function, quality, and safety to realize circular ambitions. Some of these have been mentioned earlier in research. Lacking quality of secondary materials is a common notion (e.g. Hart et al., 2019) and Eberhardt et al. (2022) for instance mention safety rules as barriers. But this research also shows the systemic nature of the safety, as reconfiguration is not just needed in law making practices, but also in for instance contractor procurement practices. Similarly, the priorities given to creating an optional function is also a largely shared counter value to many circular ambitions, especially design with secondary resources. This was for instance perceived leading for architectural design, procurement, and contractor practices. Also, if a design strategy is chosen that is unlike business-as-usual, interviewees recurrently pleaded for contracts based on building performance and collaboration, instead of design solutions. This is in line with earlier assumptions (Bougrain, 2020). This highlights that not every design strategies are not developed similarly, but that they are in different stages. Lastly, in line with Gerding et al. (2021), this research highlights the growing body of knowledgeable actors regarding circularity and the necessity to have specialists involved early on in the process. This research further elaborates on earlier findings, as it highlights the different specialties relating to circularity, for instance architects who are knowledgeable regarding design for adaptability can lack the specialism for design with secondary resources.

4.6 Conclusion

This paper aimed to answer the following research question: *how do practices (mis)align with each other regarding circular design strategies and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?*

Several conclusions can be drawn, of which we highlight seven regarding (mis) alignments. First, construction projects are complex, and setting and realizing circular goals depends on alignment of many practices in and beyond traditional boundaries of construction projects. This finding is in line with earlier research (e.g. Eikelenboom & van Marrewijk, 2024). Second, initiation for circular ambitions primarily lies with the client, but municipalities that own land can function as back-up by setting their own ambitions. The importance of the role of the client has been hinted at in earlier research (e.g. Coenen et al., 2023), but little has been written about its crucial role (i.e. that without an explicitly willing client, many circular initiatives are likely to fail) in this phase of the transition. In the future more initiative might come from other parties, for instance stimulated by ESG ratings. These ESG ratings seemed to have a small role in setting circular ambitions now, but their attributed value hints their potential role in the transition if they develop. Third, contrasting some design strategies with many alignments and similarities with business-as-usual (e.g. design for prevention), design with secondary resources has most misalignments throughout the system-of-practices. Reconfigurations throughout the system are needed. This finding is a nuance of earlier research that highlights difficulties regarding reuse (e.g. Harala, Alkki, Aarikka-Stenroos, Al-Najjar, & Malmqvist, 2023). This research shows that this mostly relates to direct reuse, whereas design for disassembly and reusability seem achievable with more ease. Fourth, the biggest misalignment that hindered setting and realizing circular ambitions involved time limitations, for instance stemming from area development on municipal level, as was the case for both projects. For instance, in project X, the municipality set a deadline for when the company should move to its new location. This misalignment was especially true for design with secondary resources. This contrasts notions in both the industry and academic literature (e.g. Charef, Morel, & Rakhshan, 2021) that this might be related to money. Fifth, following previous research, other important misalignments involve lacking markets for secondary resources. Sixth, contrasting ideas on quality, function, and safety hinder realization of circular ambitions, especially regarding design with secondary resources. This has been mentioned earlier in the literature. Rules on safety have for instance been mentioned and contrasting ideas on quality are also common. This research adds

to that as it shows the systemic nature of notions on safety that is not just enforced in rules (or the lack thereof), but also in procurement (e.g. regarding preferred suppliers). Seventh, contracts highly influence the mindset of actors in construction projects and can stimulate niche formation, important for design strategies that require innovative mindsets, this confirms earlier expectations (Bougrain, 2020). Also, this research adds to this with an exposition of how other elements of tenders impact this innovative mindset: 1) tendering on collaboration (positively), 2) high penalties for building performance (negatively), and 3) stacking (circular) ambitions (negatively).

This research shows that several reconfigurations already take place, such as gaining familiarity with wooden constructions, and rising importance of ESG ratings in policy making. This research confirms earlier research (i.e. Kooter et al., 2021) that project dynamics supporting circularity highly affect these reconfigurations, but it adds to earlier research that dynamics regarding adding new practices to the system-of-practices (e.g. urban mining) are also important.

Further, this research highlights potential reconfigurations that seem crucial to realize circular ambitions, for instance concerning 1) time availability in projects to accomplish circular ambitions, in line with Arora et al. (2021), 2) stimulating the market for secondary resources, in line with earlier research (e.g. Adams et al., 2017), and 3) changing perceptions regarding safety, quality, and function, that hinder uptake of circular design strategies. Whereas barriers regarding these have been mentioned in earlier research (e.g. Eberhardt et al., 2022), this research shows the systemic nature of these barriers. For instance, safety does not merely regard rules and regulations, but also who becomes a preferred supplier for the contractor and who does not.

These findings have several implications for practitioners. Perhaps most urgently, practitioners would be advised to track down the origin of their decisions and perceive the consequences of them, so all involved actors can be taken responsible for aligning practices for circularity. Very practically this means for instance that area developers make decisions fast enough so actors involved in the area can allocate resources (e.g. time and money) for their construction purposes with circular goals. Another example is that clients allocate the right amount of time for projects with circular ambitions, or that contractors do not merely aim to realize circular ambitions in projects, but also involve their procurement departments to reassess their preferred suppliers. Further, practitioners would be advised to be both open and very explicit in their discussions regarding values. The transition, or indeed transitions, towards a circular economy in practice shows several conflicting values, for instance regarding safety, quality, and function, and actors would be

advised to reassess if their original values should have the same priority they have previously received. Lastly, practitioners would be advised to be explicit about their interpretation of circularity, as this research shows that (mis)alignments between different practices are very different for each of them.

This research also adds to research on SPT and MLP, elaborating on systems-of-practices. It uniquely showed how regime practices can interlock and make it difficult for niche practices to emerge. Further, it showed that sometimes regime practices can stimulate niche practices, as was the case for contract forming practices. Lastly, in line with earlier research, it showed that the distinction between niche and regime is gradual. Smith's (2007) dimensions offer a helpful framework to bring nuance to this. This is particularly helpful in the AEC sector, where being completely niche is unattractive, due to the money and legislation involved.

There are some limitations to this study. First, methodologically, these are two in-depth cases. This allowed detailed mapping of alignments and misalignments within a system, at the cost of missing (mis)alignments, for instance on design with reused objects that was never considered a serious option for project X. Second, analytically, as this research focused on practices, it has less to offer regarding actors.

This research showed the possibilities and difficulties of changing routinized practices in the AEC sector. Future research might focus on specific reconfigurations, and practice (mis)alignment deeper into the supply chains. Lastly, many (mis) alignments were found regarding learning and transitions that have been left out of this study, such as consultants that inhibit learning in organizations. Future studies might focus on these elements. This might create a better understanding of one of the most important transitions we face today.

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Research question	Chapter	Methods	Purpose
1) Which dynamics in the execution of interorganisational construction projects are relevant to realise their circular ambitions, and how do these projects contribute to the transition towards a circular economy?	Chapter 2	Case studies: Group interviews. Workshop	To understand how practices can change in construction projects to stimulate setting and realising circular ambitions
2) How have Social Practice Theory and Sustainability Transitions Research been used together so far and what are the strengths and limitations of the different crossover frameworks?	Chapter 3	Systemic literature review	To understand how SPT and STR can be used together
3) How do practices (mis)align with each other regarding circular design strategies and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?	Chapter 4	Case studies: interviews, observations, document analysis. Workshops	To understand what helps and hinders the transition towards a CE for different circular design strategies
4) Which reconfigurations have taken place in the system-of-practices in which circular building hubs reside regarding reuse of secondary building components and how is it deemed likely to transition in the future?	Chapter 5	Interviews, observations, focus group, workshops	To understand recent and future changes regarding CBH's and their role in the transition

FIG. 5.1 Overview chapters

5 Circular Building Hubs as inter-mediate step for the transition towards a circular economy

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Chapter 4 illustrated alignments and misalignments throughout the system-of-practices for all circular design strategies for two different construction projects. It shows that some circular design strategies are closer to business-as-usual resulting in aligning practices the in current systems-of-practices, whereas other circular design strategies are very different and application of these design strategies highlights many misalignments. Most misalignments are found for design with secondary resources. Chapter 4 shows some recommendations to overcome these misalignments, but mostly illustrates the barriers for applying this design strategy. Therefore, chapter 5 dives deeper into the phenomenon of circular building hubs, as these are often advocated as the way forward for reuse of secondary resources in for instance policy documents. Circular building hubs already show in the system-of-practices of chapter 4. Chapter 5 zooms in on these.

ABSTRACT Despite growing government and market interest to use Circular Building Hubs for reusing construction components, few academic articles have been written about the subject. Whereas we do know about spatial requirements for different types of hubs, we know little about the potential of hubs to answer to the challenges of reuse in the present and future, and their potential to drive systemic changes towards a circular economy. Using various qualitative research methods, this article aims to respond to this research gap by applying social practice theory and the multilevel perspective on past and future practice reconfigurations within the system-of-practices in which these hubs reside. Results show that within hubs reconfiguration from demolition to deconstruction and repair and refurbishment practices have been developed. However, selling components remains a challenge, and procurement for reuse and design skill remain underdeveloped. Practitioners expect the system-of-practices to professionalize in the coming years, resulting in further market growth for secondary components. In the long term, practitioners expect hubs to shrink or disappear because the balance between supply and demand will be controlled digitally. Hubs are therefore a driver for the transition, but only as intermediate step, not as solution for a circular economy. This article is particularly interesting for academics studying CE and transitions, and policy makers interested in developing circular building hubs.

KEYWORDS Social Practice Theory, Transitions, Circular Building Hubs, Circular Economy, Reconfiguration

5.1 Introduction

The architecture, engineering, and construction (AEC) sector is one of the most polluting sectors, responsible for around 37% of global CO_2 emissions and energy consumption (UNEP, 2022), and 50% of global material use (de Wit, Hoogzaad, Ramkumar, Friedl, & Douma, 2018). Implementation of a circular economy (CE) is by many perceived as a possible answer. For building design, CE can take form in seven design strategies (CB'23, 2023): 1) design for prevention, 2) design for quality and maintenance, 3) design for adaptability, 4) design for disassembly and reusability, 5) design with existing building (parts), 6) design with secondary resources, and 7) design with renewable resources. Of these, design with secondary resources proves especially difficult to implement (Andersson & Buser, 2022; Hanemaaijer et al., 2023; Nußholz, Rasmussen, & Milios, 2019; van Uden, Wamelink, van Bueren, & Heurkens, 2024a).

Design with secondary resources can entail recycling, refurbishing, repair, and reuse (Desing et al., 2020). Recycling of mineral materials is already quite common (e.g. in the Netherlands around a third of total mineral use), but this mostly relates to downcycling of concrete and bricks. The strategies of refurbish, repair, and reuse are considered more local and sustainable (Ghisellini, Cialani, & Ulgiati, 2016). Yet, markets for these products are small or absent (Munaro et al., 2020), the quality of building components is often low (Ababio & Lu, 2023; Adams et al., 2017), data of existing buildings is missing (Koutamanis et al., 2018; van den Berg, Voordijk, & Adriaanse, 2021), investment costs are high (Ababio & Lu, 2023), and guarantees are often difficult to give (Kooter et al., 2021). Despite EU-wide increased taxes on landfills, reuse and recycling rates have not gone up significantly (Sáez & Osmani, 2019), which is often explained by a missing logistical structure for reuse (e.g. Nußholz et al., 2019), hesitant behavior regarding procurement (Adams et al., 2017), and lacking design skills (Gerding et al., 2021; van den Berg, Schraven, De Wolf, & Voordijk, 2024). In recent years, in response to this problem in the Netherlands, visions of Circular Building Hubs (CBHs) emerged in municipal and provincial documents (e.g. Amsterdam, 2019) and several CBHs popped up.

Various definitions of CBHs exist (Tsui, Furlan, Wandl, & van Timmeren, 2023), but it is here defined according to the practices they enable: physical locations where construction and demolition waste in the form of building components from disassembling sites are transported to, sorted, inspected, prepared, repaired, refurbished, remanufactured, and temporarily stored, so they can be reused or repurposed later as secondary building components in construction projects. This makes them different from industrial clusters that focus on recycling, craft centers that focus on business-to-consumer sales, and virgin material hubs that have a purely logistical function. In practice, many terms describe something similar to CBHs, such as urban mining facilities or construction waste marketplaces, although the latter often concerns recycling more than reuse (Caldera, Ryley, & Zatyko, 2020). CBHs are not necessarily new, but renewed interest in these hubs partly stems from their circular potential (e.g. Amsterdam, 2019), expected regulations regarding reuse of construction demolition waste (Deloitte, 2017), employment possibilities (Van Buren, Demmers, Van der Heijden, & Witlox, 2016), and uncertainties regarding global supply chains, as became evident during the Covid-19 lockdowns (Dumée, 2022; Wuyts, Marin, Brusselaers, & Vrancken, 2020). These hubs would offer greater economic independence.

Some challenges for CBHs are discussed in non-academic literature. Van Hoogdalen (2022) for instance mentions problems relating to upscaling, shared ownership, and difficulties of demanding hub use in tenders. Also the lack of data structures that accompanies the physical structures is often mentioned (Metabolic, Amsterdam, & Copper8, n.d.).

So far, despite their emerging popularity, CBHs have not been studied well in academic literature. Recent studies have mostly focused on spatial parameters to choose optimal locations (e.g. Tsui et al., 2023; Yang et al., 2023). However, also more fundamental, we know little about the changes in practices of hubs that enable them to answer to the challenges of reuse in the present and the expected changes in practices in the future that might change this. To answer these challenges, hubs must be able to compete against the practices of virgin supply chains. This requires a business case that can challenge virgin resources, but also practice development, not just in CBHs, but throughout the supply chain.

To research this, we made use of both Social Practice Theory (SPT) and the multi-level perspective (MLP). SPT is an often used lens to study changing practices (Schatzki et al., 2001; Shove et al., 2012). Practices are interpreted here as a type of behaving and understanding that appears at different locales, in different times, by different bodies and minds (Reckwitz, 2002). In recent years this lens is also applied more often on systemic scales in studies of systems-of-practices (Spaargaren et al., 2016; Watson, 2012). Contrasting many other cultural theories, SPT explicitly focuses on the materials that help (re)produce practices (Shove et al., 2012), which is helpful in studying CBHs that are shaped by the materials they concern. Unsurprisingly, SPT has often been used for transition research, because in the end every transition is a transition in practices (Watson, 2012). It has also been used as such in the AEC sector (e.g. Eikelenboom & van Marrewijk, 2023; van den Berg et al., 2021; van Uden et al., 2024a). The MLP is also an often used lens to study transitions (Köhler et al., 2019). We use it here to better understand CBHs role in challenging virgin resource chains and to give an explanation of the change that is and is not happening in their alternative supply chain. In recent years, the combination of these approaches has been used for similar purposes (van Uden, Wamelink, van Bueren, & Heurkens, 2024b), also in the AEC sector (e.g. van Uden et al., 2024a). The combination has proven especially useful for studying reconfigurations, changes in practice that contain both new and old elements (van Uden et al., 2024b).

With this theoretical background, the aim of this research is to better understand reconfigurations in practices regarding the system in which CBHs reside. For this, we want to understand 1) recent reconfigurations in practices regarding CBHs and other practices in the system in which they reside (e.g. also including design and procurement), and 2) future reconfigurations practitioners deem likely for practices regarding CBHs and the system in which they reside. These aims require a scope that goes beyond a single practice, but instead concern many interlinked practices that together form the whole system they are part of, that is the system-of-practices that makes up their supply chain. This leads to the following research question:

— Which reconfigurations have taken place in the system-of-practices in which circular building hubs reside regarding reuse of secondary building components and how is it deemed likely to transition in the future?

This question will be researched in the case of the system of circular hubs in the Netherlands. We take a systemic perspective, as changes in this transition or the lack thereof are the result of collaborations of multiple actors (Coenen et al., 2023; Kooter et al., 2021; Wamelink & Heintz, 2015). This means that this research concerns not just practices on the grounds of CBHs (i.e. storage, repair, and refurbishment practices), but the whole supply chain of which they are a part.

This article is built up as follows. First, the operationalization of SPT and MLP is discussed. Second, we elaborate further on the mixed qualitative research methods for this study. Third, the results are discussed, focusing on past reconfigurations, and envisioned future reconfigurations. Fourth, we discuss the results in the context of earlier research on reuse of building components, logistical hubs, and niche protection. And lastly, we elaborate on the research question and conclude that CBHs should be perceived as an intermediate step, in this transition and not as ultimate solution for a CE.

5.2 Practices in Transition

We understand changes in the system-of-practices, such as the change towards CE in the AEC sector, as a transition, which comprises structural changes of a socio-technical system (Köhler et al., 2019). They are complex, comprising many different actors (Geels, 2005), practices (de Haan & Rotmans, 2011), aspects (Heurkens & Dąbrowski, 2020), such as laws and regulations, market developments (de Haan & Rotmans, 2011), and visions of directions (Desing et al., 2020; Kooter et al., 2021). They are path-dependent and progress non-linearly (Wittmayer & Loorbach, 2016).

An often used lens to study transitions is the multi-level perspective (MLP) (Köhler et al., 2019), which we use here to give context for this transition and additional explanation for early change development. In the MLP transitions are understood as a result of interactions between different levels of structuration (Geels, 2011): the niche (the locus of radical innovation), the regime (the locus of established rules that stabilize the existing system, and an exogenous socio-technical

landscape (Geels, 2011). We can interpret the landscape as climate change and macro ambitions (e.g. the Sustainable Development Goals developed by the United Nations) to counter this. This landscape puts pressure on the regime (e.g. rules and regulations of countries and unwritten rules of how to conduct business), which in turn allows niches (e.g. the quickly changing rules that govern practices in CBHs) to challenge the regime. The regime is not a single coherent whole, but a combination of stabilized rules regarding markets and user preferences, science, culture, technology, policy, and industry. Regimes are relatively stable, which is enforced by institutional, psychological, and organizational barriers for innovation (Brown & Vergragt, 2008; Van Bueren & Broekhans, 2013b), such as formal regulations, and long-lasting relationships between suppliers and clients. Contrastingly, niches are constantly evolving (Schot & Geels, 2008). Niches gain momentum when transition directions become more apparent and stable, when learnings have resulted in more stable configurations of elements, and the networks of involved actors have grown significantly. When niches and regimes interact, they often merge together, resulting in a stretched regime (Laakso, Aro, et al., 2021). In this merging, regimes often prove not to be static systems, but contain dynamics of their own (Laakso, Aro, et al., 2021; Smith, 2007). Niches are often portrayed as technological innovations, but they can also be predominantly market and/or logistical changes (Raven, 2006). Practices around CBHs can therefore be conceptualized as niches, contrasting the regime of virgin building component suppliers, which both are embedded in a system of systems with markets, science, cultures, technologies, policies, and industry.

Even though CBHs have often been developed from existing regime demolition practices, in their current form they are often 'companies in companies', similar to R&D programs (Schot & Geels, 2008). Whether something is niche or regime should therefore not be determined by the actor, but by the rules that guide the performance of practices. This take aligns with the neo-institutional origins of the MLP (Geels, 2020). Niches are often built up in a protected environment, so they can develop without having to compete with the regime immediately (Smith & Raven, 2012). Protection can include shielding (holding off selection pressures), nurturing (supporting innovation), and empowerment (making niches competitive), all of which can influence each other. We use these notions of niche protection in the discussion section to understand which elements allow the system-of-practices in which CBHs reside to change. Scholars anticipate that the transition towards a circular economy in the AEC sector makes the regime change in such a way that the new regime contains both elements from the old regime and niches, which is called reconfiguration (Kooter et al., 2021; Ruijter et al., 2021; van Uden et al., 2024a). This reconfiguration takes place in the form of changes within practices throughout the system and requires practices to continuously re-align with one another to create systemic change (Laakso, Aro, et al., 2021; van Uden et al., 2024a).

The MLP is often praised for its explanatory power regarding transitions (Geels, 2010), but critiqued for its inability to describe the making or unmaking of rules that constrain or enable actions or practices (Genus & Coles, 2008). Lately, therefore scholars more often apply and promote transition research that also uses one of diverse behavioral sciences (Kaufman, Saeri, Raven, Malekpour, & Smith, 2021), of which Social Practice Theory is a dominant one (Cherunya et al., 2020; Crivits & Paredis, 2013; Koretsky & van Lente, 2020; e.g. Watson, 2012). This research incorporates SPT, which can be of additional value, as it focuses on the formation, stabilization, and breaking of practices (Schatzki, 2002; Schatzki et al., 2001; Shove et al., 2012). It can therefore help in establishing how everyday life influences systemic change (Kaufman et al., 2021). Use of SPT further allows to better understand change as it is happening (O'Neill et al., 2019; van den Berg et al., 2021). Contrastingly, some authors have stated that a synthesis of MLP and SPT results in ontological incompatibility (Geels, 2010; Hargreaves et al., 2013). However, several studies have shown that given the right definitions, conceptual frameworks can be developed that make use of crossovers (Geels, 2010; van Uden et al., 2024b), an interplay of concepts that make use of concepts from both approaches (e.g. Muylaert & Maréchal, 2022; Watson, 2012).

Before diving into crossovers, this section elaborates on SPT. The focal points of SPT are practices. Every practice encompasses elements, regarding materials, meanings, and skills (Shove et al., 2012). Practices enforce themselves (Seyfang & Gilbert-Squires, 2019), which helps their reperformance. This is further enforced by the practices on which the practice depends, the system-of-practices in which a practice is performed (Shove et al., 2012; Watson, 2012). The system-of-practices around these hubs are for instance formed by materials, regarding building components that pass through the hubs from demolition place to new construction sites, the meanings regarding secondary material use that in turn affect other practices, and the skills of overseeing the impact of a design decisions on practices throughout the system.

Every practice, though constantly uniquely performed, knows certain standards, normativized ends and emotions (Schatzki, 2002). In the case of CBHs practices, which we consider niche, these are constantly changing (Schot & Geels, 2008). Yet, even in niches, changed practices often contain elements of earlier versions of the practice, due to the regime that influences the boundaries in which a niche can develop (Laakso, Aro, et al., 2021; Shove et al., 2012; Smith & Raven, 2012). Although practices can be replaced by other practices, this would require financial, institutional interventions, via network or regulations and policies (Kivimaa & Kern, 2016; Laakso, Aro, et al., 2021). Quite often practices (both niche and regime) are reconfigurations of earlier versions of that practice, containing both old and new elements (Laakso, Aro, et al., 2021; Shove et al., 2012). Broken elements

can become dormant, re-emerge later, or form parts of other practices (Shove et al., 2012). As such, reconfigurations in SPT can be a part of an element, a practice, and the interlinkages of practices, up to the levels of a system-of-practices.

This research does not aim to synthesize the MLP and SPT, but makes use of a crossover, which connects the two approaches in three different ways. First, the MLP is used as a context to help understand how we can interpret systemic change in a system-of-practices. This is a common way to conduct research that does not lead to any ontological connections (Cherunya et al., 2020; Heiskanen et al., 2024). An important part of this are the notions of niche protection (i.e. shielding, nurturing, and empowerment) that are perceived as parts of practices themselves and form elements to be on the lookout for. As such, they do not interfere with the ontology of SPT. Further, the systemic focus of the MLP is a reminder to not look at one single practice (e.g. repair), but to focus on systems-of-practices. Second, the different levels of the MLP are interpreted as levels of structuration of practices. The logic that practices have different levels of structuration is already common in the work of Warde (2005) and has since been used explicitly in several crossover studies (e.g. Little et al., 2019; van Uden et al., 2024a; Watson, 2012). To keep the 'flat ontology' of SPT (Schatzki et al., 2001), the notion that the three levels of the MLP are nested should be let go, as was already suggested by Geels (2010). Third, a combination of practice reconfigurations can become a system reconfiguration, as it is used in the MLP.

With these approaches, we can understand both the change that is happening right now and potential future transitioning. In the methodology section we further elaborate on the operationalization of these approaches.

5.3 Methods

This research is centered around the case of the system-of-practices around CBHs in the Netherlands. The Netherlands is often considered a frontrunner for CE in general (e.g. Walker et al., 2022) and CBHs specifically (Tsui et al., 2023). We defined the scope by taking the hubs as focal point and incorporated practices in the scope of demolition of an old building to design of a new building. This resulted in the incorporation of practices of building deconstruction, sorting, repairing and refurbishing, procuring, and designing with secondary materials. An emergent theme during early interviews (Creswell, 2003) were selling practices, which we then incorporated in the research scope.

This study made use of a variety of qualitative research methods to research this case: interviews, observations, focus groups, and workshops. They were organized in three rounds of interviews and observations and after each round a focus group or workshop was conducted for validation and deepening of the results. An overview of this can be found in figure 5.2. The combination of interviews and observation was used to understand practices as they are performed, and have been performed in the past. Observations served as triangulation of the interview results, as is often asked for practice theory research (e.g. Hargreaves, 2011), and further enriched the interview results.

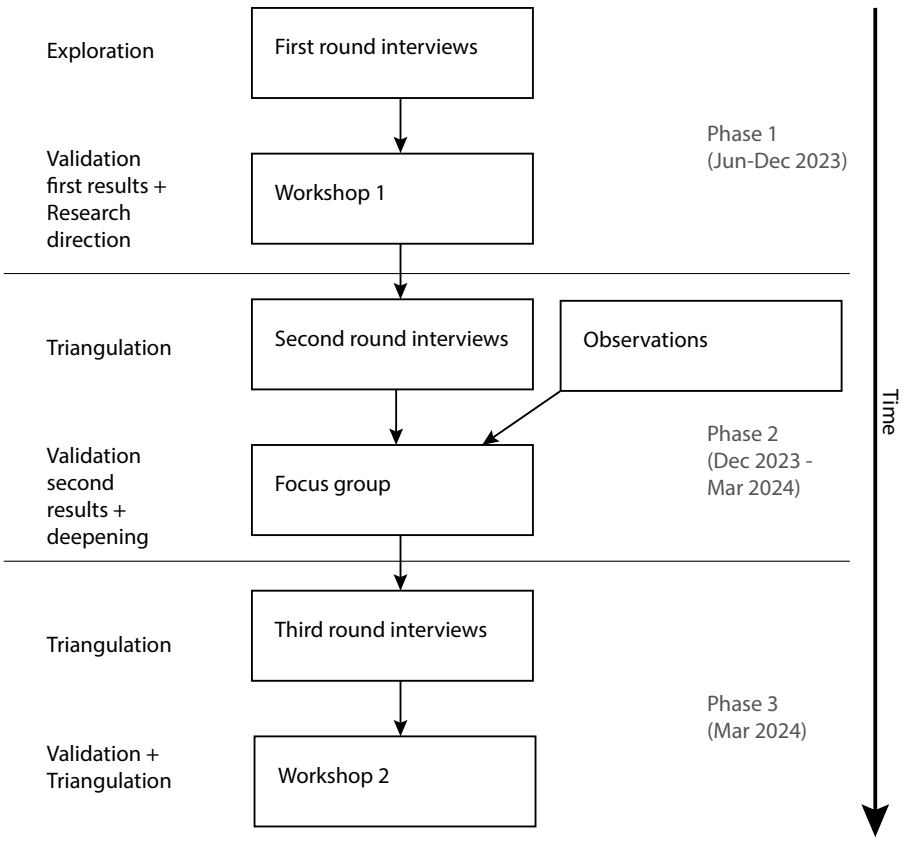

FIG. 5.2 Overview research methods

As we still know little about CBHs and this study aims to identify relevant themes (Hennink et al., 2020), hubs were chosen based on their diversity so that it would become apparent if any of these elements would explain differences in practices or that they would be universal (Mason, Augustyn, & Seakhoa-King, 2010). Differences were sought after regarding size (i.e. among the largest and the smallest firms in the Netherlands), reliance on material gathering (components gathered by themselves or by other companies), and locations in the Netherlands. An overview can be found in table 5.1. Further, to understand CBHs in the CE transition in the case of the Netherlands, all hubs had to be based in the Netherlands, deliver business-to-business, be active already so practices can be observed, be big enough to supply to construction projects, and provide building components, not just raw materials.

TABLE 5.1 Overview of CBH's

Hub	Size (employees)	Part of existing organization	Family company	B2B or B2C
1	85+65 flexible	Yes, demolition/deconstruction	Yes	B2B
2	70	Yes, demolition/deconstruction	Yes	B2B and B2C
3	5+3 flexible	Yes, diverse	Yes	B2B and B2C
4	200+220 flexible	Yes, demolition/deconstruction	No	B2B
5	5	Yes, contractor	Yes	B2B
6	5+5 flexible	Yes, diverse	Yes	B2B and B2C
7	3+3 flexible	No	No	B2B and B2C
8	250	Yes, demolition/deconstruction	Yes	B2B

In total 8 hubs were found that fulfilled all criteria, and 14 interviews with hub employees have been conducted, with four additional observations at hub locations and a fifth at a deconstruction site. Observations regarded the activities that were taking place, such as deconstruction, sorting, repair, cleaning, and work in the sawing mill at the hub. During observations, questions have been asked to understand why practices were being performed the way they are. Special attention was paid to the materials related to the practices, as these often enforce practice reperformance (Shove et al., 2012). Through snowballing, other practices and their performances were found, resulting in 7 interviews with architects with experience in construction projects with reuse ambitions, 2 interviews with an online sales platform, 2 interviews with non-academic researchers on circular construction hubs, and 1 supplier that took back materials from hub companies. On average interviews lasted about an hour, ranging from 22 minutes, to 1:41 hours. Questions focused on barriers and enablers, determining practices (including practice elements, i.e.

meanings, materials, and skills), including past reconfigurations and expected future reconfigurations. During analysis, names of interviewees and companies have been anonymized. An overview of these 26 interviews can be found in table 5.2.

TABLE 5.2 Overview of interviewees

No.	Interviewee	Length	Hub (see table 1)
1	Hub employee	0:52 hour	4
2	Hub employee	0:27 hour	4
3	Hub employee	1:38 hour	3
4	Hub employee	1:04 hour	3
5	Hub employee	0:23 hour	1
6	Hub employee	1:41 hour	2
7	Hub employee	0:44 hour	4
8	Hub employee	0:45 hour	4
9	Hub employee	0:29 hour	6
10	Hub employee	0:41 hour	7
11	Hub employee	0:28 hour	6
12	Hub employee	0:48 hour	5
13	Hub employee	0:53 hour	8
14	Hub employee	0:52 hour	4
15	Architect	0:48 hour	
16	Architect	0:37 hour	
17	Architect	0:31 hour	
18	Architect	0:38 hour	
19	Architect	0:22 hour	
20	Architect	0:57 hour	
21	Architect	1:15 hour	
22	Online sales platform employee	0:54 hour	
23	Online sales platform employee	1:00 hour	
24	Non-academic expert	0:53 hour	
25	Non-academic expert	0:37 hour	
26	Supplier	0:55 hour	

As further validation of interview and observation results after phase 2, a focus group with hub employees and non-academic hub experts was organized with a focus on barriers and enablers in the current system, and perspectives for future practice reconfigurations.

Lastly, 2 workshops were organized. The first had 19 participants, consisting of hub employees, architects, public clients, contractors, branch organizations, and academic researchers. It focused on the changing role of demolition companies, and the changes made and needed by other actors. Participants were divided in small groups and asked to think from a different role and describe challenges. Eventually, plenary reflections took place. A report was drafted afterwards which included the most important findings. The second workshop had 29 participants, consisting of hub employees, employees of an online selling platform for secondary materials, public clients, contractors, consultants, and academic researchers. The aim was to understand the current system of reverse supply chains, the envisioned future, and the options and barriers to get there. In small groups participants worked on the system for different specific building components, and reflected on comparisons and differences in a plenary session. Afterwards a report was drafted with the most important notions.

Interviews and focus group discussions were transcribed *ad verbatim* and along with the workshop reports coded in three rounds using Atlas.ti. The first round of coding was deductive, focusing on both past and future reconfigurations of practice elements (i.e. meanings, materials, and skills), enablers, barriers, and transition directions regarding the full system-of-practices. This followed quite directly from interview questions, as they specifically focused on these elements: interviewees often elaborated on the elements that remained the same and the elements that had changed. Then, with these elements, it became important to sort them in different practices. For this, several categorizations were developed, based on emerging themes. Three alternatives were discussed among the authors that grouped the elements differently. The final division in practices was determined on the presence of an inner logic per practice and a total amount of practices that would not be so large that it would obscure overview. We found that this also often, but not always, coincided with personnel, for instance repair personnel often would not sell, and deconstruction personnel often would not repair, though usually CBH employees had had experience in both at certain points in time. This led to the following emerged practice groups: 1) deconstruction, 2) storage, repair, and refurbishment, 3) selling, 4) design, 5) procurement, and 6) supply. Among the authors we discussed in several stages which practices were needed to come to a full system-of-practices for these hubs. We decided on these six, as eliminating some from the results would raise questions, and adding more would add confusion. When these six practice groups were determined, this led to extra interviews in phase 3 (see figure 5.2).

In round 2, practices were inductively coded, categorizing groups of similar reconfigurations per practice group. Results were discussed in consecutive workshops and focus groups, and eventually among the team of researchers to determine the most important results. For past reconfigurations, we divided the results into 1) the reconfigurations themselves that show changes in meanings, materials, and skills, and the enablers that made these reconfigurations possible, and 2) the challenges that hinder further reconfigurations. Further, we divided future reconfigurations into short-term and long-term reconfigurations. All of this relates to the explorative forecasting of practices by practitioners themselves. This has three major limitations: 1) the forecast may be precise and at the same time inaccurate, 2) they cannot be trusted as behaviors that stimulate trends might change, and 3) they are incomplete (Puglisi, 2001). Despite these important limitations, they are an important part of futures studies. During interviews, the interviewers remained critical if the predicted future was too much in the advantage of the person interviewed. But, surprisingly, we found that many practitioners, especially hub employees, were somewhat negative about the prospects of their practice. This, to us, enhanced the trustworthiness of the statements (i.e. that their forecasts were actually what they were thinking was going to happen instead of what they were hoping was going to happen). Further, important to note, these forecasting results should not necessarily be interpreted as a likely future, but more as a better understanding of the practices in the present and the reconfigurations that are happening now. All of this is incorporated in the section below. Note that the results therefore relate to reconfigurations in practices, and do not describe practices themselves. After distinguishing practices and their (potential) reconfigurations, practices were coded on being niche or regime, using the dimensions of Smith (2007), that were translated by Van Uden et al. (2024a), and can be found in table 5.3. Lastly, it was coded which notions of niche protection (shielding, nurturing, and empowerment) were present in both past and notions of potential future reconfigurations. This niche protection can help indicate which parts of the future are thought about, and which are not, which influences the likeliness of those futures. These are discussed in the discussion.

TABLE 5.3 Regime and niche dimensions, based on Smith (2007) and Van Uden et al. (2024)

	Regime	Niche
Principles	Mainstream guiding principles (e.g. profit and loss)	Alternative guiding principles (e.g. minimize ecological footprint, closing loops)
Technologies	Tried and tested technologies and infrastructure (e.g. design with concrete structure)	New technologies and infrastructure (e.g. design with reused concrete)
Industrial structure	Industrial structure *en masse* (e.g. subcontracted labor, volume building)	Alternative industrial structure (e.g. use of secondary building components)
User relations	Traditional user relations and markets (e.g. passive and conservative consumers)	Active user relations and markets (e.g. actively steering clients)
Policy	Following policy and regulations (e.g. MPG[4] minimum is standard)	Challenging policy and regulations (e.g. lowering MPG goals for a project)
Knowledge	Knowledge based on existing competencies and business practice (e.g. standardized designs/ solutions)	Knowledge base for alternative guiding principles (e.g. knowledge of low-impact materials)
Cultural, symbolic meanings	Broadly shared cultural, symbolic meanings (e.g. markets and regulations)	Alternative cultural, symbolic meanings (e.g. circular housing)

5.4 Results

As shown in figure 5.3, components travel through the system-of-practices in several ways. From deconstruction sites, they are collected by CBH employees. Sometimes they are stored and/or repaired or refurbished in the hub, but in most cases components are first sold and later directly transported to 1) virgin component suppliers, 2) middlemen that specialize in specific components, or 3) new construction sites, where they become part of design and/or procurement practices. Components therefore do not always become part of every practice in the system-of-practices. Also, sometimes practices sometimes start working with components without them changing location. For instance, with reuse, it is a common strategy for a new design, to visit buildings that are prepared for deconstruction. Deconstruction and selling teams will then help architects make choices on the use of specific building components. yet, as a result, the design will have been made, while the components are still in an old building. As such, components can become

4 MPG is Milieu Prestatie Gebouwen, the Dutch standard on shadow costs, which are based on Life Cycle Analyses. The current standard is achievable without extensive measures.

part of several practices at the same time while remaining in the same place. Figure 5.3 should therefore not be confused with a linear supply chain, as it helps in giving an overview of which practice(s) work(s) with a component, and not of the location of that component.

After design, components can become part of construction practices, which have been outside the scope of this research. When something goes wrong (e.g. a component gets damaged) it can become part of recycling, recovery, or landfilling practices, which are also outside the scope of this research. Though strictly speaking, CBHs only have to be part of the storage, repair, and refurbish practice, that practice highly influences deconstruction and selling practices, which are usually also performed by employees of that same company. Further, indirectly the other practices of the system-of-practices are also influenced by the CBH.

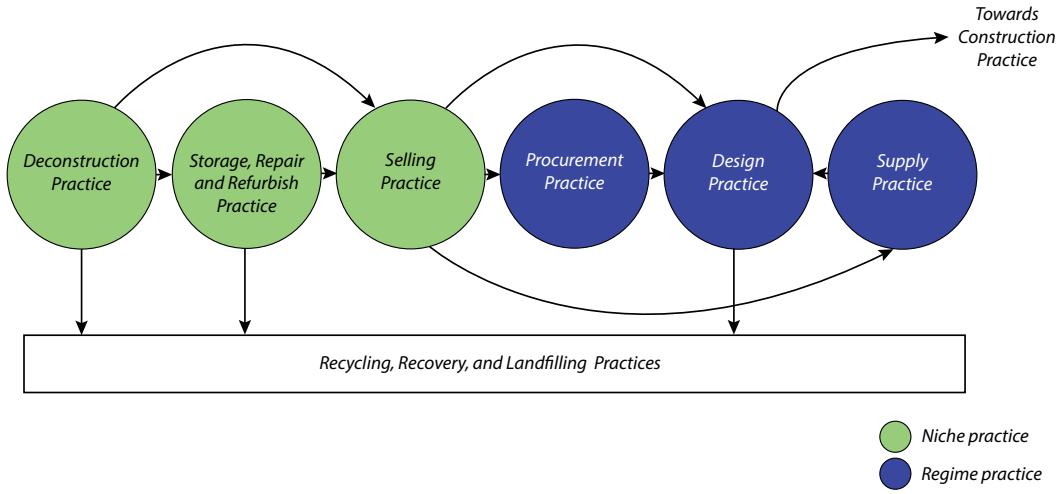

FIG. 5.3 Flow of building components in system-of-practices in which CBH's reside

The result section is divided into two parts. First, we will discuss past practice reconfigurations of the system in which circular hubs reside. This includes current barriers and enablers. Second, we will discuss potential future reconfigurations practitioners deem likely for their practices.

5.4.1 Past reconfigurations

Reconfigurations of practices have taken place throughout the system. This section takes a look at 1) deconstruction, 2) storage, repair and refurbishment, 3) selling, 4) design, 5) procurement, and 6) supply practices and describes the formation, drivers, and challenges of current practices. Deconstruction and storage, repair and refurbishment have undergone major reconfigurations. Selling secondary components is a new practice and poses many challenges. Consequently, design, procurement, and supply practices have undergone only minor reconfigurations so far. This will be discussed in more detail per practice below.

Deconstruction practice

Reconfigurations

Deconstruction, as reconfiguration of demolition, requires new meanings (e.g. mindset), new materials (e.g. tools), and new skills. New meanings for instance regards patience, as deconstruction takes longer, around 30% one interviewee said. One hub employee (#7) said: 'if you lack patience, you just start ramming it until it breaks'. The change of tools can relate to the deconstruction itself, such as use of precision or manual tools compared to for instance a hammer, but also to new storing containers (e.g. crates, carts, sea containers), or even tower cranes. Before deconstruction teams start, material specialists inspect the building using digital tools, to determine a price, what is to be deconstructed, to allow the start of the selling process, and to make material passports. New deconstruction skills for example regard knowledge of old construction standards.

Challenges for further reconfigurations

Driven by the global climate crisis, a growing number of deconstruction tenders asks for specific minimal reuse amounts and stimulates to top that. However, often not enough time is given for deconstruction, as demolition is faster and clients often lack knowledge about this. This often results in a mixture of deconstruction and demolition. Tenders also often demand demolition, as it is cheaper, so the practices exist next to one another, performed by different teams. One hub employee (#3) said 'demolition people were always rough [..] and now we have a role next to that, but we can still be rough if we want to'. Reconfiguration from demolition into deconstruction proves difficult, as demolition has the attraction of 'breaking something hard' (#1). Lastly, existing buildings contain diverse components and connection methods, making it difficult to learn all existing elements. Further, deconstruction is a skill you can get better at, but early disappointing results hinder progress, as demolition workers fail to see the point of deconstruction. Many companies see potential in

employing people with a distance to the labor market, so as to make a social impact, and be able to work cheaper, as this is subsidized. As they are new employees they do not need to unlearn demolition practices, but instead specialize in deconstruction.

Storage, repair, and refurbishment practice

Reconfigurations

After deconstruction, 30% of the components are stored at the hub, but most move to a new client, middlemen, or supplier. Hubs are not new, but a variation on old hubs. Many demolition companies used to have one, but it was 1) a shady business, and 2) not financially capable to challenge the cheap hardware stores that popped up since the early '70s, so many disappeared. To make them valuable again, new meanings had to be connected to the hubs (e.g. making them symbols for a circular economy). Now the number of hubs is growing and they are legal and professionalizing. This practice can therefore be considered a reconfiguration of a 'sleeping' practice.

CBHs are used for storage, which is lengthy compared to logistical hubs, but also for repair and refurbishment, which also happens at social working places, or via middlemen. This concerns a wide variety of materials. This is for instance popular for wooden beams (many hubs have installed saw mills), or even tropical hardwood, which is often used in window frames. An advantage is that many components are (re)standardized. Other often processed components include steel structures, planks, insulation panels, ceiling tiles, doors, kitchens, dividing walls, toilets, and glass. Many other components are either recycled (e.g. concrete crushed for road filling or new concrete) or landfilled.

Skill development was essential in making CBHs function as reasonable alternative for virgin supply chains. It required financial investment and continuous learning, to make a valuable business model for repair and refurbishment (e.g. product development, determining quality, or knowing when to remove nails or cut a beam), so to be able to mass-produce. Further, as employees who deconstruct also had experience in repairing and refurbishing, they created feedback loops.

Challenges for further reconfigurations

Contrastingly, components received from other deconstruction components are often of bad quality and cannot be properly repaired or refurbished. One hub employee (#7) said: 'sometimes we try taking components from others, but then you see the quality is lower and you have to either fight over it or check every component individually. We cannot do that.' This limits growth capacity of CBHs.

Selling practice

Practice development

Selling components became a new practice with the rise of CBHs, often met with unease. This shows the need for further meaning development, for instance in the reluctance to price components. However, it also allowed for new jobs for commercial employees, whose sole purpose is to sell components. Many hubs have lists with standard buyers (business-to-business (B2B)), but this needs constant updating, as different materials start selling. This, in turn, also affects the deconstruction practice. One hub employee (#2) said: 'we are testing all the time', which also shows continuous knowledge development.

Materials for the selling practice relate to building components, selling media, like online marketplaces, but also sometimes to the hubs themselves. Business-to-consumer (B2C) often happens at the hub, but as this is time intensive and does not allow for selling large quantities that come available simultaneously, many CBHs prefer focusing on or shifting to B2B. One hub employee (#1) explained this: 'for us it's often everything or nothing. If we have a project and we know what comes available, we want a client at that point in time for that amount of material and not a part or a week later'. For B2B, selling often goes through external digital marketplaces, such as Marktplaats[5] or non-profit foundation Insert[6], or their own website. Interviewees mention demand is slowly growing, mostly to architects or contractors, wholesale, suppliers, and middlemen that clean, repair, refurbish, and label specific components. Both selling and the design process require time, so CBHs aim to start selling when the components are still in the original building.

Challenges for further practice development

Several challenges hinder further market growth. Selling beforehand does not always work out, as both supply and demand are irregular. Supply is also bigger than demand, so many components stay on the hub and are eventually recycled or landfilled. Further, reuse, especially when repair or refurbishment is needed, is labor intensive and therefore expensive. Hubs cannot demand large enough margins to make a great profit. Lastly, load bearing components often sell badly, because guarantees are difficult to give, although this challenge is slowly being overcome.

5 Marktplaats is a Dutch online market platform, typically used for secondary components between consumers

6 Insert is a Dutch online marketplace for secondary building components, public space components, and greens founded in 2018 as collaboration between private parties. Their core partners cover around 40% of demolition waste.

Recently process norms have been developed for steel, and work started for concrete. Also for other components sometimes quality marks are needed to sell them (e.g. FSC for wood). Sometimes quality marks can be added by the supplier.

Design practice

Reconfigurations

Design practices so far seem to largely remain the same regarding reuse. The 'stickiness' of the practice shows that the practice is a regime practice, at least regarding reuse. Some practice performances might be considered niche, but seem to remain exceptions. Nevertheless, though not large-scale, reconfiguration for reuse have been highlighted in several practice performances. First, as design practices need reconfigurations regarding skills so as to understand how building components can be reused, deconstruction companies increasingly inform the design process with knowledge on deconstruction. However, they are often not accustomed to that role and need to learn the language of the design process. At the same time, sometimes deconstruction companies even become contractors to overcome reuse barriers. Second, two streams for design with reuse have been developed, with each their own reconfigurations regarding meanings, materials, and skills: 1) design-for-disassembly and 2) direct reuse. Some architects have become very active and skilled in searching for secondary components themselves, which also costs time and money. Yet, most reconfigurations seem to relate to the first streams. They are specializing in the ultimate details for deconstruction, influencing future deconstruction practices.

Challenges for further reconfigurations

Several challenges hinder further reconfigurations. First, regarding the second stream, increasingly, architects hand wish lists to CBHs. Yet, many architects still struggle with irregular supplies of components that require flexible designs. Often this results in falling back to traditional design practices. One architect (#16) elaborated: 'along the way, sometimes you know you fall back on traditional ideas or thoughts because of risk or cost or whatever. And then you think we weren't as far as we thought we were'. Further, when searching for components, architects need a lot of information, most of which is often not available on websites, and often they want to see and feel components. Also, quite often reuse is not implemented as it is deemed too expensive. Lastly, reused components can result in new aesthetics, which architects and clients often dislike.

Procurement practice

Reconfigurations

Similar to the design practice, procurement practice also seems difficult to change, showing that this is also a regime practice, at least regarding reuse. Interviewees mention therefore only several small reconfigurations for the procurement practice. First, increasingly public clients tender with criteria regarding deconstruction or reuse for new construction. Tenders sometimes demand a specific percentage to be reused and give discounts if deconstruction companies manage more. This requires a reconfiguration in skills, where clients need to know what they can tender. For this, increasingly clients collaborate with consultancy firms. And what is deemed tenderable is based on what consultancy firms deem likely. More often, tenders now include effort obligation regarding reuse, as knowledge about what can be reused is not developed enough yet.

Challenges for further reconfigurations

Several challenges hinder further reconfigurations. First, clients often still lack knowledge about 1) what can be deconstructed, and 2) how much time this costs. Further, as the market changes quickly, the information that clients gather is often outdated after a short while. Lastly, as tenders often include best effort obligations, and seldom strict demands, initiative often has to be taken through other practices. One architect (#13) elaborated: 'I think in many cases we still need to propose it, because either clients haven't really thought about it or they did think about it, but thought it would be too expensive or that they simply just don't know'.

Supply practice

Reconfigurations

Supply practices. As regime practices have also shown very little reconfigurations, because so far few suppliers take back building components, and the ones that do often make only very few changes in their practices. Nevertheless, in recent years CBHs have developed partnerships with several suppliers for simpler materials such as products as wooden beams, floors, and plasterboards. In these cases the components had diverse origins, and were often originally manufactured by different companies. For these products, the quality has remained similar in the last decades. For instance, secondary plasterboard is now often reused as first layer for new walls, as it still suffices regarding fire safety and acoustics. Without reconfiguration of skills, suppliers can therefore easily add quality marks to these products. However, as the product was not designed for disassembly, the secondary component is cut during deconstruction, and therefore smaller. In the case of wood, CBHs often

remake wooden beams into new standards that suppliers then sell, or in the case of window frames, specialist companies use finger joints to make these into modern standards. This is especially interesting for tropical hardwood, as its quality is now difficult to match with virgin wood.

Challenges for further reconfigurations

Returning components to suppliers has often proved difficult due to legal and financial reasons, and results in collaboration for recycling instead of reuse. Also, so far, the interest for secondary components is inconsistent, and in general relatively low. Therefore, clients for secondary components are actively sought after by suppliers. One plasterboard supplier (#26) said: 'We are contacting all hospitals in the Netherlands […] to tell them this story'.

5.4.2 Future reconfigurations

In general, practitioners see several large elements impact their practices in the future regarding policy, market, and technology. First, policies (e.g. the MPG[7] or EU CO_2 legislation) will stimulate procurement for reuse and allow business model development for this. This will be further secured by norm development and public procurement for (de)construction. This will stimulate 1) design-for-disassembly and standardization, 2) direct reuse, 3) development of circular components, and 4) renovation at the cost of new building. Second, the market plays a pivotal role. There are several market drivers. First, rising prices of virgin materials are expected to stimulate reuse. Second, actors are professionalizing and increasing awareness, which is expected to continue. Third, large and family companies are expected to take a lead as they can afford to make investments. It is expected that this will lead to architects using CBHs more, and hubs to specialize and increase in size and quantity and get more ideal locations. However, long term, hubs are expected to decrease in size and quantity, and become more focused on logistics and move components to either suppliers, or middlemen, specialized in specific components. Third, technology plays an important role. Practitioners see much potential in a digital built environment, as it can provide an overview of components that become available. It is expected that policy is influenced by this information.

7 MPG stands for Milieu Prestatie Gebouwen, which is a Dutch procurement criterion, part of the building law, based on life cycle assessments.

The rest of this section further discusses future practice reconfigurations per practice and the (un)certainty of these based on existing trends. During analysis, we noticed that short-term and long-term change sometimes regarded different transition directions, so we distinguished between them. Short-term change regarded changes foreseen in the next one or two years, and long-term changes regarded changes up to 2050, in line with the Dutch/EU policy agenda. It is noteworthy, that although practitioners see trends happening, for some major ones, it remains unclear for them how these affect their practices directly (e.g. how a digital built environment should be implemented in deconstruction and procurement practices). Lastly, many of these reconfigurations play a role on a large scale, in the system-of-practices, whereas it changes little for individual practices.

Deconstruction practice

Practitioners expect various reconfigurations of deconstruction practices. In comparison to many other practices, a lot and continuous change is expected. In short term, practitioners expect knowledge development regarding deconstruction processes, and technical qualities (e.g. insulation values). The practice is also expected to grow, especially with low-hanging fruit. This would be a continuation of existing trends. Further, as competing demolition companies will become better at deconstruction, they might also provide components to CBHs or suppliers. At the moment, this makes sense for components of which there is always shortage (e.g. wood and plasterboard), but for other components this might also require increased demand.

Long-term reconfigurations are expected to contain more assignments for circular deconstruction, due to increased awareness, procurement skill development, and laws and regulations that stimulate reuse. Realization of this largely depends on political developments that remain highly uncertain. Further, deconstruction is expected to go faster, as more buildings are being designed for disassembly. This makes sense if the trend for design for disassembly continues and grows, which also remains uncertain due to the scepsis involved. Lastly, digitalization and optimization are expected to play an important role. Deconstruction projects will be bundled, made digitally available, and planned as a singular, more efficient assignment. One interviewee (#25) elaborated: 'If you want to make the logistics processes cost efficient, you need a bigger scale for your circular processes. So you have a big scale to do urban mining, which means you have fully loaded transport trips with materials and store them and reuse them again.' Eventually the practice is expected to grow significantly: within large companies, circular parts will merge with traditional parts,

and smaller companies will follow the frontrunners. Noteworthy, although a lot of faith is put in this digital built environment, practitioners offer few details of how this will affect their practice. This development therefore still holds many questions.

Storage, repair, and refurbishment practice

Practitioners expect various reconfiguration regarding storage, repair, and refurbishment practices. In short term, they expect to experiment with materials they have not experimented with before (e.g. new wood products). Further, they expect an increase in CBHs and size of them.

Long term, reconfigurations are expected in opposite direction: CBHs are expected to shrink spatially, and contain less components, because these go directly to suppliers. CBH companies will become more logistical networks than storage, repair, and refurbishment spaces. One hub employee (#14) elaborated: 'Later I see us as an important logistics company: we deconstruct elevators and bring them to the supplier, we bring toilets to the client, wood there. For the future I do not see why we would still need a saw mill.' As a whole, the market is expected to grow. For this, more ideal locations (e.g. connected to water) are necessary to better bundle components and a control system to manage resource flows. Many hubs might have temporary locations, and be specialized in specific building components, or building phases, as combining different types of components becomes inefficient when used large scale. Whether these reconfigurations take on largely depends on supply practices, and the likeliness of suppliers to take on more products, which so far has proven difficult due to laws and regulations, and business models.

Selling practice

Short term, various reconfigurations are expected: what sells probably keeps changing, and knowledge about that and about the price needs to be constantly updated. Also, more awareness about (the need for) guarantees is expected, especially when public clients (e.g. municipalities) are reusing their own components. Further, Insert might incorporate CBH locations, CO_2-impact, more pictures of components, and more available components and details in general. Lastly, sales employees might improve their knowledge on the type of information that different actors need. All of these reconfigurations are likely, as they follow previous reconfiguration trends.

Here, again, long-term reconfigurations are expected in different directions: the online selling platform is expected to first get better accepted and then disappear. One employee (#23) elaborated: 'In my opinion we will not have a digital marketspace in ten years' time. The system will then have changed so much that it will regulate itself without a marketplace […] There will be flows in connecting people and materials. You will have companies who have circular doors, who will have circular sanitary, who will have circular windows. So you will have specialists. […] And secondly, if we digitalize, let's say our cities or our villages, our buildings, public areas, then we will know when materials come out of a building, when they are end-of-life, and what we need to do.' The market for secondary products is expected to grow, especially business-to-business. Eventually, hubs are expected to deliver mostly to suppliers or middlemen that specialize in specific components, and remain to deliver only to the finishing phase of construction projects. Again, the likeliness of these largely depends on 1) overcoming challenges regarding business models, and laws and regulations for suppliers to take on secondary components, and 2) the implementation of a digital built environment, for which there does not seem to be a clear idea for implementation in practices.

Design practice

Various reconfigurations are expected in design practices. Short term, more courage is expected from architects and contractors to start designing with reused materials. This also entails becoming more flexible with the use of specific components. Further, more and earlier involvement of deconstruction companies or other specialists is expected to better understand what design-for-disassembly means ideally. Though this last point seems to be happening already, the likeliness of the rest is debatable, as design with secondary resources is so uncommon, that it is difficult to distinguish trends from existing projects.

Long term, the system is expected to have undergone more fundamental changes. First, better design-for-disassembly will result in standards, and new, wider accepted aesthetics. Second, much of the current system is expected to be part of a digital built environment, allowing knowledge on when components become available. This asks for a new process in which architects are assigned a list of materials – instead of *vice versa* – with which they design a building for longer periods of time. Eventually, architects will take a long responsibility for temporary actions (i.e. the lifespan of a building), making the job more about logistics, and less about construction, similar to the car industry. Although some architects seem to be working in this direction, for a change of the design practice overall much depends on the uncertain implementation of a digital built environment.

Procurement practice

Procurement practices are expected to have various reconfigurations short term. First, they are expected to professionalize regarding realistic budgets and planning, allow visits to the site on time, expect component storage on site, know what can be reused, and better knowledge on how to set up tenders for reuse. This would mean a continuation of current reconfigurations. Also, an increase in tenders for reuse is expected. This still seems to be a larger step, that seems most likely when 'donor' buildings are part of the same project as buildings that would demand these components.

Long term, other reconfigurations are expected. First, rising material costs are expected to lead to more procurement for reuse. Second, laws and regulations on CO_2 or reuse specifically are expected to stimulate procurement for reuse. In the Netherlands, the first would probably entail better testing and sharper demands of the MPG, or (CO_2) taxes. Tenders are expected to shift towards maintenance and renovation, and design-for-disassembly. This is largely due to building law preventing reuse of many components in new buildings. Also here, the likeliness of these reconfigurations depend on uncertain political developments.

Supply practice

Short term, some regulation updates are expected that allow suppliers to give guarantees based on a process. Some of these are new (e.g. steel), and some are in the making. This therefore seems likely.

Long term, more reconfigurations are expected. First, stimulated by laws and regulations many expect that suppliers will take back more components for repair and refurbishment. This would require new business models, as current business models often do not stimulate this. Suppliers would then maybe become the new owners of these components and provide them as a service. So far, this development is highly uncertain.

5.5 Discussion

These results offer interesting points for ongoing academic debates, for which we want to highlight four: 1) the relation of CBHs with logistical hubs, to better understand what a CBH is, 2) CBHs and the practices of reuse, to better understand the effect of CBHs on reuse, and 3) the specific niche protection that allow for development of this niche. Niche protection has proven vital for innovations to be able to compete against regimes and this gives us a better understanding of how CBHs could have emerged (Smith & Raven, 2012). 4) This discussion also highlights why we think that the rise of CBHs is also only limited, as incumbent regime practices remain largely untouched by niche protection.

CBHs might easily be confused with logistical hubs, but this analysis shows that on a practice level there are actually great differences between the two. First, they have very different origins that influence current practices: logistical hubs are usually installed to improve construction processes, whereas CBHs have their foundation in deconstruction and associated practices. Both types of hubs handle building components, but whereas logistical hubs often have clear plans with these, CBHs often do not know when and to whom they sell these components. Consequently, components remain on the hub much longer. Further, what is done with these materials is very different. Whereas logistical hubs are mainly used to overcome logistical challenges, in CBHs components are repaired, refurbished, and actively sold, making CBHs more complex and fundamentally different. However, many interviewees mentioned a future for CBHs with less focus on these extra practices and a larger focus on the logistical processes, meaning that even though these hubs have different origins and are loci for different practices, both hubs might become more similar and co-develop. CBHs can also be confused with material hubs, that mainly recycle, which has proven easier to scale up. This research shows that these processes often go hand in hand, as components that cannot be reused, often can be recycled, and the combination of these help overcome financial strain on CBHs. If CBHs grow, their dependence on recycling might become less. This relates both to reuse being more of an option, and recycling having to serve less as a successful business model while CBHs are being developed. With this distinction, this research contributes to the gap of knowledge on CBHs in supply chain management literature.

Of all circular design strategies, design with secondary resources, and especially direct use of secondary building components, seems especially difficult (van Uden et al., 2024a). Literature has described many barriers for reuse, such as small or absent markets (Munaro et al., 2020), low quality of components (Ababio &

Lu, 2023; Adams et al., 2017), missing data of existing buildings (Koutamanis et al., 2018; van den Berg et al., 2021), difficulty with guarantees (Kooter et al., 2021), a missing logistical structure for secondary components (Nußholz et al., 2019), hesitant procurement behavior (Adams et al., 2017), and lacking design skills (Gerding et al., 2021; van den Berg et al., 2024). This research confirms several of these barriers, but also shows that CBHs can be used to overcome some of these. First, interviewees mentioned the low quality of components if hubs received these from other demolition companies, but as CBH employees were involved in both deconstruction and repair, they noticed a feedback loop that improved component quality after deconstruction. These hubs, especially when connected to a well-established online selling platform such as Insert, or suppliers that can guarantee the quality of components, form a small logistical structure that allows for a growing market of secondary components. Second, this study confirmed that missing data is a large barrier for reuse. We found that practitioners see potential in a digital built environment to help overcome this barrier. However, earlier research highlighted the difficulties in implementation of digital models in routinized practices (van den Berg et al., 2021) and this research shows that so far practitioners do not have a clear vision of how a digital built environment would impact their practices. Third, this research confirms that there is still hesitant behavior regarding procurement for reuse, even though interest is growing. This lack of procurement combined with lacking product information on online marketplaces, hinders architects in developing new design skills for reuse, which is still happening, but slowly. Similarly, this research also confirms hesitant procurement for circular deconstruction, which we found, in line with earlier research, also relates to lacking knowledge and awareness (van den Berg, Hulsbeek, & Voordijk, 2023). Concludingly, CBHs have formed an important factor in overcoming barriers, but this is not enough to overcome all of these and create a fully developed alternative supply chain to virgin components. Especially the second half of the supply chain, relating to design, procurement, and supply needs development to overcome further barriers. This is unsurprising, as regarding reuse, these have proven regime practices. This is an important message for policymakers and managers in these supply chains, as it shows that the positive elements of CBHs do not immediately translate to reuse itself, as other practices should also be considered. With this overview of how CBHs help overcome barriers for reuse, this research contributes to prevailing insights on reuse and a circular economy in construction management literature.

Lastly, this discussion delves deeper into the protection that allows CBHs to develop as a market and logistical niche. Protection can include shielding, nurturing, and empowerment (making niches competitive), all of which can influence each other (Smith & Raven, 2012). First of all, most obviously, many CBHs are shielded as they are part of larger, often also family owned, companies. This allowed for development

of skills, meanings, and materials, without immediately having to make a profit, as the rest of the company could compensate for that. This helps overcome the barrier of large investments for these specific companies (Ababio & Lu, 2023). In many cases, both deconstruction and storage, repair, and refurbishment practices, are therefore shielded demolition practices, and sometimes by other, such as recycling practices. CBHs are further shielded, as they often make use of existing (logistical or material) hubs, which allows smooth growth and shrinkage without large investments. This directly influences deconstruction, storage, repair, and refurbishment, and selling practices, and indirectly the other practices in the system-of-practices. Second, CBHs are nurtured as they make use of subsidized employees with a distance to the labor market. This provides a learning space, but as these people do not need to unlearn practices, it often also saves time and delivers quick wins. Apart from this business perspective, it also creates social impact. This strategy is functional for the current scale of CBHs, but it can only be scaled-up to a certain extent. The impact is mostly on deconstruction, and storage, repair, and refurbishment practices, and influences other practices barely. CBHs are further nurtured on an institutional level with the development of guarantee norms for secondary components based on processes. This currently exists for steel and the norms for other materials are under development. This development highly influences practices throughout the system-of-practices. Third, CBHs are empowered by delivering components to suppliers and therefore aligning with current industrial standards regarding actors, locations, and even quality marks. This minimizes (the need for) practice reconfiguration for architects and contractors and therefore changes storage, repair, and refurbishment, and selling practices, while confirming current design and supply practices. Interviewees complained that typical empowerment through new regulations (Smith & Raven, 2012) is still lacking, but did notice that existing policy goals for a circular economy were enough to already boost interest in secondary components, mostly among private actors. Similarly, in line with earlier research (e.g. Adams et al., 2017), public procurement for reuse is also still largely absent, as public actors are hesitant to demand use of the small secondary component market. This in turn hinders its growth. Concludingly, shielding and nurturing does take place, which has helped initiating this niche development as part of larger companies, but empowerment is still largely absent, even though some traces of it are present. When examining future practices, many interviewees also focus on empowerment in the form of changing laws and regulations, increased procurement, and increased use of existing suppliers that also take over repair and refurbishment. All of this would make the niche less radical and more similar to regime practices of virgin components. Which niche protection is needed for implementing a digital built environment was not brought up by interviewees, showing much uncertainty in this regard.

All in all, shielding, nurturing, and empowering seem to have most influenced deconstruction, storage, repair, and refurbishment, and selling practices, while design, procurement, and supply practices remain largely untouched. As these are, at least regarding reuse, regime practices, this is unsurprising. To further overcome barriers for reuse, it might be necessary to stimulate niche formation for these practices and protect these accordingly. Protection of the new or renewed practices is not enough to force a transition, as changing incumbent practices is needed as well. Whereas some of these practices are helped with niche protection (e.g. design practices change, as training with MPG calculations is subsidized), this still does not affect reuse directly. It is noteworthy that in the forecasts of practitioners, these regime practices will change, stimulated by professionalization of the hubs, and not through niche formation and protection, as would seem likely from this research.

Lastly, this research shows that using concepts of the MLP in a SPT context helps to explain why change is happening, and hints how change in practices can be further stimulated. Perceiving CBHs as a system-of-practices with practices that are either niche or regime, allows to both show which change is happening (i.e. in which practice elements) and in what manner (i.e. slowly and barely (regime), or in general and continuous(niche)). This is especially useful in parts of the system where both niche and regime practices are present, as is the case here. This lens gives transition researchers extra tools to study transitions on both a systemic and a small scale, as is often asked for by scholars (Geels, 2010; Kaufman et al., 2021; van Uden et al., 2024a). So far, this lens is mostly applied for a single practice, or opposing practices (Crivits & Paredis, 2013), but according to a recent systematic literature review (van Uden et al., 2024b), this research is one of the few that uses a crossover between MLP and SPT on a scale where several practices are involved in a system-of-practices. This allows for novel analyses on interactions between niche-practices and regime-practices, and thereby contributes to transition literature that aims to incorporate behavior (Kaufman et al., 2021).

5.6 Conclusion

By conducting interviews, observations, workshops, and a focus group, this research aimed to answer the following research question:

— **Which reconfigurations have taken place in the system-of-practices in which circular building hubs reside regarding reuse of secondary building components and how is it deemed likely to transition in the future?**

We answered this question by analyzing recent reconfigurations in practices and future reconfigurations deemed likely by practitioners in deconstruction, storage, repair and refurbishment, selling, design, procurement, and supply practices. We found that reconfigurations mainly took place in niche practices: deconstruction, storage, repair, and refurbishment, and selling practices. Reconfigurations were stimulated by private companies who used shielding and nurturing, e.g. by giving time to develop a working business model without having to make a profit, or through use of subsidized labor forces. These niche practices reconfigured from demolition practices, changing rapidly and continuously, using 'sleeping' elements such as 'shady' hubs that reconfigured into CBHs. Examples of new elements in existing practices include using saw mills, making new components (e.g. diverse wooden beams) from old components, selling products through online platforms, and patiently deconstructing elements from old buildings. This resulted in overcoming some barriers for reuse mentioned in earlier literature, such as low quality of components, lacking guarantees, and a missing logistical structure. However, some barriers are still present, as fewer reconfigurations take place in design, procurement, and supply practices. Consequently, hesitant procurement behavior and lacking design skills still form an important barrier for further reconfigurations. Nevertheless, also in these regime practices (at least regarding reuse), reconfigurations take place. For instance, some suppliers take simple products back that they sell themselves.

For the future of the system-of-practices in which CBHs reside, we distinguished between short-term and long-term change. Short term, professionalization in practices is expected. This regards for instance better allocated time for deconstruction, selling components with more details (e.g. price, measurements, location, and environmental savings), and skill development for architectural design with reuse, influenced by deconstruction companies. All of this follows current reconfiguration trends. On the scale of the system-of-practices, hubs are expected to grow in size and number. This seems most likely if procurement for reuse grows,

which requires more than merely professionalization of practices. Long term, the expected transition direction is very different, a digital built environment will is expected to inform future procurement and design so that many hubs will shrink or seize to exist. However, there is still little understanding of how a digital built environment should be implemented in practices of construction professionals. Consequently, despite several uncertainties, the market of reuse is expected to grow significantly, but CBHs would only be a driver for this growth, an intermediate step, not the final solution in a circular economy.

Concludingly, CBHs are part of a fast changing alternative niche system that also includes regime practices. This alternative system contrasts the conservative regime of the AEC sector. CBHs and the practices that make up the system-of-practices in which CBHs reside should be perceived as a driving force for reuse, playing an important part in the transition. To make CBHs more successful in the short term, more focus should lie in aligning current regime practices with practices associated with CBHs. Further, contrary to how policymakers seem to adopt the concept of CBHs, they should not be perceived as the ultimate circular solution long term. For this practitioners place hope in a digital circular AEC sector, for which hubs can help pave the way. Visions of implementation of this digital built environment are important to allow these reconfigurations to happen.

There are several limitations to this research. First of all, perhaps most obviously, epistemologically, we cannot know the future for certain. The future practices discussed here should therefore not be perceived as a prediction, but as a starting point for change that can be discussed and critiqued. It should also not be interpreted as a single whole, but as a combination of futures of aspects that will influence each other and result in very different outcomes than the ones discussed in this article. Further, this explorative forecasting should be considered incomplete (e.g. the implementation of a digital built environment). Second, methodologically, the future practices discussed in this article stem from interviewees and participants that play a role in the system itself. They are therefore biased as their answers relate to their own future practices. Interestingly, many hub employees and architects were skeptical about their skills and role in the future. This made us trust the data more. Third, as this research focused on practices, we focused on developed practices we could observe, and not on hubs in development, as several public hubs are. Their different origins might lead to very different results from this research. Fourth, as there are currently few suppliers that deal in reuse of components, this research was limited in gathering data from these sources. Fifth, this research focused on a system-or-practices of CBHs, as it is assumed that this would provide a more sustainable future. However, the used theoretical framework of MLP and SPT is incapable of comparing systems-of-practices on sustainability (e.g. regarding the production of CO_2).

As CBHs can form an important drive for reuse, and much is still unknown about the development of the system-of-practices in which they reside, they form an interesting topic for future research. Future research might particularly focus on hubs in different countries, or public hubs, as their different origins might help overcome some of the current barriers for reuse and result in very different practices. Further, this research might not only focus on the practices on and around the hubs itself, but also on political practices, e.g. regarding space allocation. Also, future research might focus on suppliers that focus or aim to focus on reusing building components. Furthermore, future research might focus on changing regime practices regarding reuse (such as design, procurement, and supply), as this research shows that for the development of CBHs especially those practices are in need of reconfigurations. Lastly, future research might focus on digital technologies for reuse, regarding technique, implementation in practices, and governance.

This research highlights the systemic nature, non-linearity, and uncertainty of the transition towards a circular economy. It shows that change can happen in practices, but for systemic change, the system-of-practices needs to change as a whole in a direction that is still highly uncertain.

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6 Conclusion

This dissertation concerned the change of behaviour and practices in and around construction projects to stimulate speeding up the transition towards a circular economy in the Architecture, Engineering, and Construction (AEC) sector. It concerned four aspects: 1) dynamics in construction projects that help setting and realising circular ambitions (chapter 2), 2) frameworks that can be used to conceptualise and analyse changing practices in transitions (chapter 3), (elements of) practices that help and hinder setting and realising circular ambitions regarding different design strategies (chapter 4), and recent and future changes in circular building hubs and their role in the transition (chapter 5). With a focus on these four aspects this dissertation aimed to answer the overall research question:

— **How do practices within the AEC-sector and its environment influence the setting and realisation of circular ambitions in construction projects and the transition towards a CE in the AEC-sector?**

Whereas originally this research used concepts from organisational science to answer this question, later the research used concepts from Social Practice Theory and Sustainability Transitions Research. Throughout the research interorganisational collaborative behaviour was studied. First, explicitly in chapter 2, and then implicitly in chapters 3, 4, and 5 with the concept of practices. This shift allowed a more systemic take on this transition, which chapter 2 showed was needed.

In this concluding chapter, first the main findings are synthesised, so as to show how the findings relate to each other and are able to answer the main research question. Further, a reflection on implications of the application of crossover frameworks between Sustainability Transitions Research and Social Practice Theory is given. This is still a very new application (see chapter 3) with serious impact on academic practice, upon which, to the author's knowledge, no earlier reflections have been made. Then, this discussion offers a reflection upon the set-up of the research regarding the assumptions behind the NWO call and the collaboration with a consortium of practitioners. The next part goes further into the boundaries and the implications of the research itself, as some research choices were made that go beyond the individual chapters of this dissertation. First, the implication for scholars and practice is discussed. Then, the limitations of this research are discussed, which leads to an agenda for future research. This chapter concludes with a final statement.

6.1 Synthesis of the main findings

6.1.1 Answering the research questions

The answers to research question 1 – 4, of which a summary can be found in table 6.1, all help in answering the main research question behind this research. This next part discusses how these answers are synthesised to form the conclusion of this thesis.

TABLE 6.1 Overview of research questions and main findings

Research question	Most important findings
RQ1. Which dynamics in the execution of interorganisational construction projects are relevant to realise their circular ambitions, and how do these projects contribute to the transition towards a circular economy?	There are 15 dynamics that support realisation of circular ambitions: - Prerequisites: Top-down support, partnership based on increased equality, shared circular goals, involvement of intrinsically motivated people, partnering for circular ambitions - Project dynamics: transparency and trust, flexibility, reciprocal relationships, project team identity, struggle for new roles, pioneering leadership, continuity in staffing, - Contextual influences: sector and organisational cultures, knowledge flows, power and tension In projects niches and regimes can interact, using these 15 dynamics. Most influence of these dynamics is in projects themselves. The influence of niche actors fades further down the chain.
RQ2. How have Social Practice Theory and Sustainability Transitions Research been used together so far and what are the strengths and limitations of the different crossover frameworks?	There are 6 crossover frameworks between Social Practice Theory and Sustainability Transitions Research: - Multi-level practices framework - system of practices and shared elements framework - spatial practices framework - practice-regime interaction points framework - system fractures framework - practices in backcasting framework Different crossover frameworks can be used for diverse applications, such as either simple systems or complex systems, earlier or later change. They are seldom useful to properly capture the element of time.
RQ3. How do practices (mis) align with each other regarding circular design strategies and which practice reconfigurations offer potential to further stimulate the transition towards a circular architecture, construction, and engineering sector?	For 7 circular design strategies the (mis)alignments have been mapped in the system-of-practices around two construction projects. This led to these conclusions: - Construction projects are complex: many diverse aspects influence the realization of circular ambitions in many different ways - Initiation of circular ambition stems from client and municipality - Design with secondary resources has most misalignments of all design strategies - Lack of time is the largest barrier of this moment - There is a limited market for secondary resources - Contrasting ideas on quality, safety, and function hinder uptake of circularity principles - Contracts highly influence alignment. For instance, an early contractor involvement contract allows for overcoming many misalignments for design strategies that are more unlike business-as-usual
RQ4. Which reconfigurations have taken place in the system-of-practices in which circular building hubs reside regarding reuse of secondary building components and how is it deemed likely to transition in the future?	Past and potential future reconfigurations have been mapped for the system-of-practices in which circular building hubs reside. Main findings are: - Reconfigurations are initiated by private demolition companies, stimulated by national and EU policies, not by public procurement. - Reconfigurations have been made possible by use of subsidised labour. - Circular building hubs are a driving force for reuse of building components and help overcome earlier found barriers, such as quality of components, lacking guarantees, and missing industrial structure. - Hesitant procurement behaviour and lacking design skills now form major barriers for further upscaling of circular building hubs. - In the near future, it is expected that the market will grow and professionalise. - In the far future, it is expected that circular building hubs will become redundant in their current form when digital data will inform procurement and design.

This research shows that, although the AEC sector is clearly changing towards a circular economy, transitional change is very difficult to accomplish (chapter 2, 4, and 5). The system is rigid due to path dependencies and as it is fragmented, it proves difficult to change. (The will to) change of one actor is often hindered by the next. The example of Anne in the introduction, a typical story from the conducted interviews, shows the interconnectedness of several major decisions in the process to develop real estate (see chapter 2). She alone was not able to change her practice, as practices around hers, often performed by actors of other organisations, hindered her to diverge from business-as-usual.

This research therefore focused on interorganisational collaborations, first explicitly in the form of dynamics for circularity in construction projects (chapter 2), and later implicitly in the form of systems-of-practices (chapter 3, 4, and 5). The research highlights that and in which ways systemic rigidity inhibits the transition towards a circular economy. Further, by focusing on practices, how they can change (chapter 2, 4, and 5) and their inner logic that inhibits change (chapter 4), this research might form a stepping stone towards developing interventions to further support speeding up the transition towards a circular economy in the AEC sector. This is made explicit in section 6.4.2.

This section discusses changing practices as transition dynamics based on three different archetypes: 1) the system around a business-as-usual project with circular ambitions, 2) a system around a project applying dynamics for circularity and 3) a system around a project applying circular dynamics and using an alternative supply chain (i.e. using circular building hubs). These archetypes follow directly from the previous chapters and show different ways of practice change. In reality, combinations of these archetypes are also likely to exist. Together they form transition dynamics that link project management to supply chain development and transitional system change, as has been asked for by scholars (Geels & Locatelli, 2024). These links are made through crossovers between the multilevel perspective and Social Practice theory. There is not much research on these crossovers yet, and this research adds to this by offering an understanding of change through a complex system-of-practices (see chapter 3,4, and 5). This research also uses new crossovers with project management literature, which helps to understand practice change in projects including its limitations (see chapters 2 and 4). The transition dynamics stemming from these new crossovers and the change they create and fail to create throughout the system are explicated below.

Change in this case always refers to reconfiguration. ‘Reconfiguration’ in the literature is both used for regimes and individual practices (Laakso, Aro, et al., 2021) that change in such a way that parts of the old can be found in the new.

Reconfigurations can be fast and slow, as practices and their systems have different levels of structuration. In extremes, they can be either rigid and heavily structured and show just little change (i.e. regime), or continuously changing and adapting with the intention to implement alternative principles (i.e. niche) (chapter 3), and anything in between (chapter 4). Systems-of-practices and their levels of structuration (i.e. niche or regime) can be mapped with the application of crossover frameworks that apply a combination of Social Practice Theory and Sustainability Transitions Research (chapter 3). Combining Social Practice Theory and Sustainability Transitions Theory in crossover frameworks requires careful definition of concepts to allow for ontological congruence. The implications of the application of these crossover frameworks (chapter 4 and 5) for academic practice will be discussed in section 6.2.

It is common knowledge that it is typical for the AEC sector that the systems-of-practices are unique for every construction project, though there are similarities. The systems-of-practices that have been built up from case studies (chapter 4) show different variations of niche and regime practices.

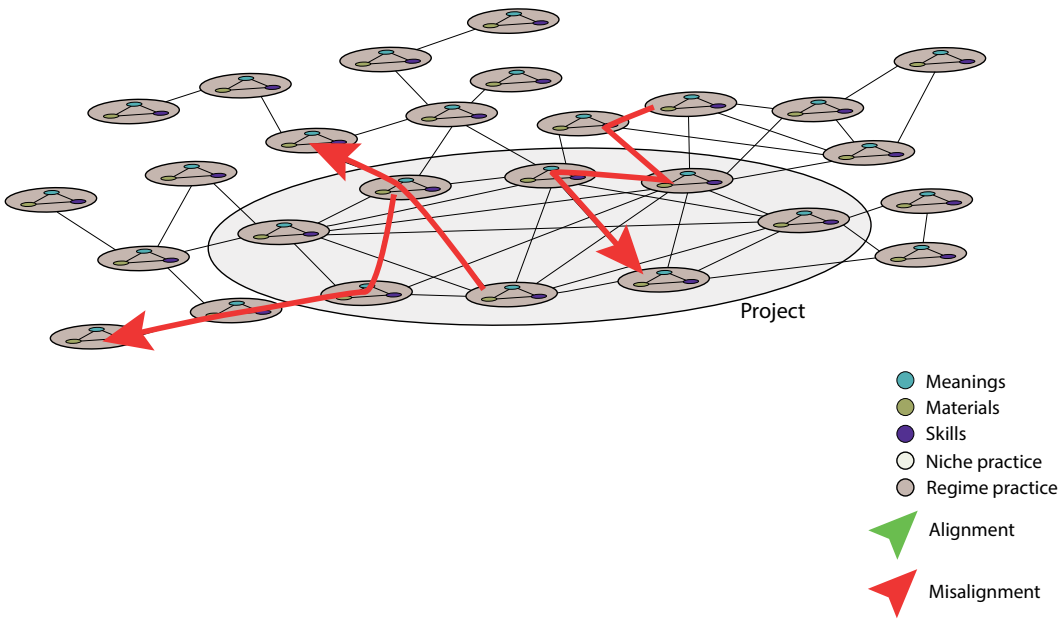

FIG. 6.1 Conceptualisation of system-of-practices of business-as-usual project with circular ambitions (archetype 1)

TOC

Figure 6.1 shows a conceptualisation of the system-of-practices of a business-as-usual project with circular ambitions. The system-of-practices is built up from practices that influence each other, here shown by the connecting lines. Influences can take many forms, such as assignments under contract, or set boundary conditions. As this is a business-as-usual project, all practices within the system are regime. When trying to implement circular design strategies this results in many misalignments between practices. This means that part of a practice is hindered by part of another practice in setting or realising circular design strategies. Misalignments especially occur for design strategies that divert further from business-as-usual, such as design with secondary resources (see chapter 4). An example of such a misalignment is for instance a contractor practice with the value to design solutions as simple as possible as this is often cheaper, easier, and requires less personnel. This misaligns with ambitions (for instance from architecture or client practices) to make components demountable, as this is seldom the simplest solution.

The research of this dissertation shows that an extreme (an archetype if you will) with merely misalignments is unlikely, as some design strategies are relatively close to business-as-usual (see chapter 4). Furthermore, some aligning practice elements have been sleeping, and are becoming extra relevant with the growing interest in a circular economy. An example of this is the love for wood aesthetics that has long been irrelevant due to the high prices of wood, but is now becoming more relevant for design with regenerative resources. Such a sleeping element can in some projects, even largely traditional projects such as in the example, change the balance of design decisions and make design with wood possible.

Within projects, practices can be stimulated to become niche by using dynamics for circularity, modes of behaving that stimulate lasting practice change (chapter 2 and 4), as shown in figure 6.2. Some dynamics are prerequisites. These are top-down support, partnership based on increased equality, shared circular goals, involvement of intrinsically motivated people. Other dynamics for circularity are applied during projects. These are transparency and trust, flexibility, reciprocal relationships, project team identity, struggle for new roles, pioneering leadership, and continuity in staffing. All of these are influenced by contextual dynamics: sector and organisational cultures, knowledge flows, and power and tensions. These dynamics all relate to traditional project partners. However, it was also found that re-partnering is an important dynamic for circularity (chapter 4). This for instance relates to partnering with circular building hubs, or steel suppliers for rollercoasters on fairs who are motivated to limit steel use. Many of these dynamics can simply be considered good project management or common dynamics for change. However, the systemic nature of the needed change, makes these extra relevant. Further, some of these dynamics contradict traditional notions of project management. For

instance, flexibility conflicts with setting strict boundaries on budget, scope, and planning (chapter 2). Others, such as shared circular goals, also highlight how new and broad the concept of circular construction still is. Actors have to carefully discuss their ambitions, as circularity can mean many different things (chapter 2) and even design strategies can be used in many different ways (chapter 4). For example, design for disassembly and reusability can mean that you want to screw a construction together, or it can mean that you clamp it, so as to avoid holes for screws. Carefully coming to shared goals together is essential to set the ambitions fit for the project.

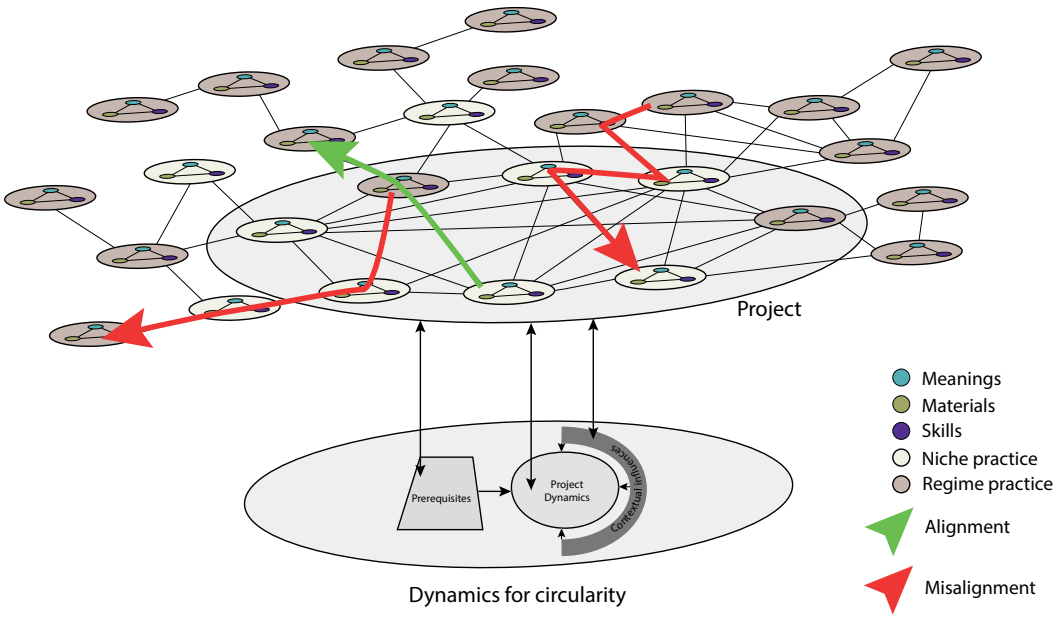

FIG. 6.2 Conceptualisation of system-of-practices of project applying dynamics for circularity (archetype 2)

Conceptually, these dynamics are not separate entities, as Social Practice Theory states that there is nothing outside of practices (Shove et al., 2012). Instead, these dynamics should be interpreted as first reconfigurations that specifically relate to interorganisational collaborations within construction projects. The black arrows between the project and the dynamics in figure 6.2 signify this dialectical relation; practices in construction projects affect the applicability of dynamics for circularity (e.g. early contractor involvement contracts stimulate this), and dynamics for circularity in turn affect practices in projects (e.g. stimulating niche formation) or the system-of-practices (e.g. by re-partnering). Reconfigurations stemming from

dynamics then stimulate further change (chapter 2). Most of this change relates to practices within traditional project boundaries. The influence of these dynamics fades deeper into the supply chains.

It was found that in this stage in the transition towards a circular economy, both niche and regime practices will be found in construction projects where dynamics for circularity are applied (e.g. the researched cases for instance showed that practices related to installations were usually regime). Further, the presence of niche practices can stimulate formation of niche practices in the surrounding part of the system, especially within projects (chapter 4). Similarly, the presence of regime practices often stimulates further regime formation and therefore hinders the potential of practices becoming niche and rigorously change business-as-usual. However, structuring practices that are considered regime (e.g. contract forming practices) can also potentially stimulate the formation of niche practices if they create widely accepted institutional settings that promote change (e.g. by using early contractor involvement contracts).

Although the case studies show that when more dynamics for circularity are present, more niche practices are present, they also show that the presence of niche practices does not automatically result in setting and realising circular outcomes, as many elements throughout the system-of-practices misalign with circular design strategies. Section 6.1.2 delves deeper into the impact of this on the different circular design strategies, as they all have unique (mis)alignments. The systems-of-practices show that transitional change is difficult, as existing structures, lacking skills, and contrasting values hinder it. This is, for instance, shown in contractor practices, where employees are stimulated to minimise physical labour for health reasons. This contradicts the intensive labour needed to repair building components before reusing them.

Figure 6.3 shows the fullest extent to which practices, their hindering and their stimulation of setting and realising circular ambitions, and their reconfigurations have been conceptualised throughout this dissertation. The dynamics for circularity have been discussed. One is re-partnering (chapter 4) which can then lead to making use of an alternative supply chain, such as one involving circular building hubs, for which this research shows several interesting findings. Chapter 5 shows that the supply chain to which these hubs belong is reconfiguring. To start, the practices related to the alternative supply chain of circular building hubs consists of reconfigurations of earlier practices (chapter 5). Circular building hubs themselves often were reconfigurations of existing demolition companies. These hubs therefore did not substitute existing supply chains, but derived from them. Reconfigurations had their origin in national policy that clearly stated that a circular economy that the

Dutch economy should be fully circular in 2050 (NL, 2016). The change is further stimulated by elements such as subsidised labour, long-term investment horizons, norm development for reuse (though this is still a work in progress), use of existing structures (e.g. land from existing material hubs), and starting collaborations with suppliers of virgin components. This last element means that architects and contractors can contact the same organisations for both reused and virgin materials, so their practice is changed barely, while making a major impact for circularity. Further change is hindered by lacking design skills, hesitant procurement behaviour, and lacking business models for suppliers. Therefore, although allowing for more alignments, circular building hubs also make clear that, despite their presence, many misalignments still hinder the uptake of design with secondary resources.

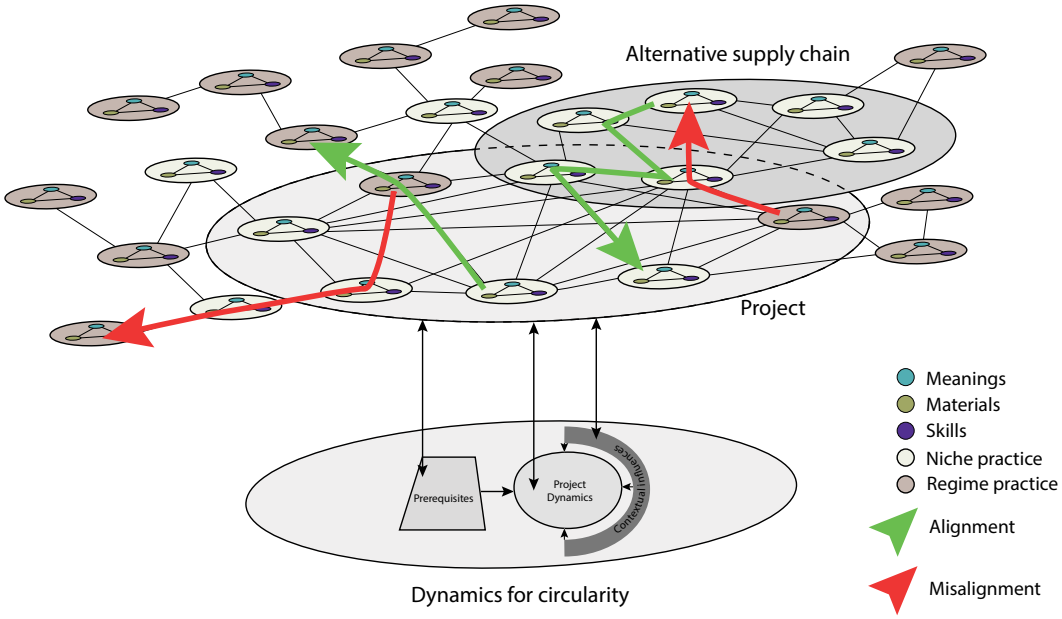

FIG. 6.3 Conceptualisation of system-of-practices of project applying dynamics for circularity and using an alternative supply chain with Circular Building Hubs (archetype 3)

These three archetypes show three different types of reconfiguration that have been researched: 1) reconfigurations of practices within project using dynamics for circularity, 2) reconfigurations throughout the system-of-practices that are stimulated by alignments and hindered by misalignments, and 3) reconfigurations of practices that result in alternative supply chains. Despite their evident different scopes, different stimuli for reconfiguration, and duration (i.e. practices in projects

need more effort to be re-performed than practices in circular building hubs, as these are stimulated by materials, such as sawmills), these three ways of reconfiguration have several things in common. First, reconfigurations of a single practice largely depend on the reconfigurations of other practices. Many practices need to reconfigure around the same time for any reconfigurations to become meaningful (e.g. practices for deconstruction can change to stimulate better quality of secondary materials, but architects also need to be able to design with secondary building components to make that worthwhile). This is why niche formation is helpful; fast, continuous change allows for multiple practices to adjust to one another. Second, these reconfigurations also highlight that more reconfigurations are needed after. The many misalignments throughout the system-of-practices show the difficulties of transitioning. Third, due to both the scope and the depth of the needed change, reconfigurations are and can only be slow. This is often highlighted in literature on transitions in general (e.g. Termeer, Dewulf, & Biesbroek, 2017). And for this specific transition, it explains why the current state of the system is behind on policy goals (Hanemaaijer et al., 2023).

6.1.2 Reconfigurations for seven circular design strategies

There are many ways to interpret what a circular economy is and what transitioning to a circular economy requires. This led to various passionate debates among practitioners during the workshops of this research. To bring order and helpful terminology to this discussion, two construction projects have been researched in their practice-environment and analysed based on the seven design strategies of CB'23 (2023) (chapter 4). Consequently, every circular design strategy has its own alignments and misalignments that in turn all affect each other. Some design strategies require large practice changes, whereas others are closer to business-as-usual. It was found that the design strategies that are close to business-as-usual are design for prevention, design for quality and maintenance, and design for adaptability (chapter 4), which is in line with earlier research (e.g. Rockow et al., 2021). Design for prevention, for instance, often directly reduces costs. On the other side of the spectrum is design with secondary resources, which has many misalignments with both business-as-usual and other circular design strategies.

There are many misalignments to be overcome, many of which concern all circular design strategies. Lack of allocated time in projects seems the most pressing (chapter 4). This has several different origins. Sometimes clients do not allocate enough time for projects. Other times area developments stimulate clients to allocate less time for projects than they would otherwise. This is true for both construction and deconstruction (chapter 4 and 5). Further, what is now usually considered safe, beautiful, and functional often conflicts with circular design strategies, especially

with design with secondary resources (chapter 4). Guarantees for secondary building components can often not be given, the aesthetics of those components are often less appreciated than those of new components, and the (immediate) function of buildings is often prioritised and optimised. Secondary components and existing buildings cannot live up to standards new, customised components and buildings deliver. Consequently, secondary components are seldom used, even if they are available.

Design with secondary resources is the design strategy with most misalignments. There are multiple ways in which design with secondary resources can take place. Of these, the use of circular building hubs is a widely favoured approach (chapter 5). This research shows that circular building hubs are an important driver for reusing building components. The hubs are growing and professionalising, as is the system-of-practices around them. Therefore they are able to help overcome some earlier found misalignments, such as lacking quality of components, and missing infrastructure (chapter 4 and 5). However, some barriers still hinder uptake of secondary building components, such as hesitant procurement behaviour and limited design skills. Further, hubs are not perceived to be the ultimate solution for a circular economy, as they require extra logistics and have limited storage capacity. Many practitioners see a future for a digital built environment, that would allow buildings to be material banks that can be harvested when needed. Circular building hubs could function as both an in-between solution and a driver for the transition towards reuse of secondary building components.

6.2 Reflections on theoretical lens: Transitions and Practices

As mentioned in the introduction, this research answers to the wider academic call to link transitions with behaviour (Dutch Research Council (NWO), n.d.) and projects (Winch, Geels, Locatelli, & Sergeeva, 2023). This research specifically focuses on the mixed uses of concepts from sustainability transitions research and Social Practice Theory. Chapter 2 discussed dynamics that change practices in construction projects. Chapter 3 discussed conceptual frameworks that can be used by academics and policymakers to answer questions that relate to both practice and transitional change. Chapter 4 applies one of these frameworks in a setting of construction projects and their surroundings. And finally, chapter 5 applies one of these frameworks in a setting of circular building hubs and their surroundings.

Despite some scholars voicing concerns about the combination of sustainability transitions research and Social Practice Theory (e.g. Geels, 2010; Schatzki, 2011), chapter 3 shows that both approaches can be combined through crossovers. However, this requires careful definition of concepts, as not every definition allows for crossovers between the two approaches. This section discusses reflections regarding complexity and the answers the crossover frameworks can generate.

6.2.1 Academic practice and conceptually complex frameworks

The resulting crossover frameworks from chapter 3 all lead to increased conceptual complexity. This is unsurprising as one of the basic notions of transitions is that transitions are complex (Köhler et al., 2019), comprising many different aspects (Heurkens & Dąbrowski, 2020) and actors (Geels, 2002), that progress in path-dependent, non-linear ways (Wittmayer & Loorbach, 2016). Consequently, there are no easy answers when analysing transitions in the making: either scholars miss out on essential concepts to study, or they study many, but cannot come to single conclusions (Manson, 2001). There is a value to showing complete, rich pictures of transitions with a multitude of facets, but it is also problematic regarding several aspects, which shall be discussed here for academic practices using Shove et al.'s (2012) three elements of practices (i.e. meanings, skills, and competences).

Regarding meaning, in many scientific (sub)fields, even fields that study complex systems (e.g. information science, organisational science), complexity in research is not appreciated (Dooley, 2004; Horn, 2008; Manson, 2001). It can be a symbol of an imprecise research question, resulting in sloppy, imprecise results. Contrastingly, there are voices that state that approaches that simplify complex systems and their behaviours have limited scope and exaggerated claims of universality (Peter & Swilling, 2014; Sovacool & Hess, 2017). In line with the latter, following from this research, one can conclude that there might be a place for increased conceptual complexity approaches as an addition, not a substitution of more simplified approaches. A function of these more complex approaches can be to give expositions of wide ranges of influencing aspects and opening up academic debates that have become hyper focused. This reasoning is similar to Nicolini's (2009) plea to both zoom in on practices and zoom out on assembled systems-of-practices . However, though multiple examples exist of zoomed-out uses of Social Practice Theory, the vast majority of applications still focuses on a zoomed-in interpretation of the approach (Spaargaren et al., 2016). At this moment, there is still a need for good examples of practice approaches that zoom out, so as to change the meaning of

what good science constitutes under a wider populace of practice performers. The use of crossover frameworks aid in bringing forth these examples.

However, this is not simply a matter of changing meanings, as notions of good science are also maintained by materials, such as articles that serve as standard output of scientific research. As this dissertation is article-based, it is limited by the word counts that scientific journals pose on articles. Unsurprisingly, with their conceptual complexity and the extra word count this requires, the chapters of this research border on the edge of what this medium allows. Both zooming in on practices and zooming out on systems-of-practices already highly increases conceptual complexity (Nicolini, 2009). Many scientific journals do not even allow for articles of the size in this dissertation (e.g. Journal of Cleaner Production, n.d.), making it difficult to use such media for complex outputs. Articles in their current form might not be the best medium to convey conceptually complex narratives. However, articles still form the basis of academic success and conceptual complexity should be incorporated in academic success. This would require a reconfiguration of the medium of articles. This is simpler said than done, as there are many benefits to not increasing word counts of articles, for instance relating to the extra time it would take to read and assess these.

Lastly, conceptually complex frameworks require a reconfiguration of skills. It not only asks for the ability to make sense and create attractive narratives of conceptual complexity, but also to distinguish when conceptual complexity adds to the narrative or concepts become redundant. This is not new; academics have always had to deal with the complexity of the fields they study. However, interdisciplinary research, as is the consequence of using crossover frameworks, makes this skill extra necessary, because researchers have to deal with notions of quality from several fields (Huutoniemi, 2010).

Concludingly, application of crossover frameworks might require a reconfiguration of academic practice. It would not necessarily require a large change, but more an incorporation of an extra format and an extra conceptualisation of good science (one that embraces complexity, as is the case in for instance transition research literature) next to other forms that already exist. This in itself already poses quite some challenges.

6.2.2 Answers from crossover frameworks

As the study on crossover frameworks (chapter 3) and the studies on their application (chapter 4 and 5) show, crossover frameworks can actually show more parts of the puzzle than either approach would be able to do without the other. The combined approaches can therefore help answer many interesting questions. That said, not every application brings as much news to the table. The study on (mis) alignment of practices (chapter 5) for instance uses Sustainability Transitions Research mostly regarding the concepts of niche and regime, that, as they are used here, show many similarities with concepts as 'practice persistence' or 'stickiness of practices' (Shove et al., 2012). However, Smith's (2007) dimensions of niche (STR) and Smith and Raven's (Smith & Raven, 2012) notions of niche protection do bring a lot of useful nuance to this (chapter 5). These conceptual additions can illustrate very well why a practice is niche, or how it is protected as such. There is a lot possible with these kinds of conceptual additions and this dissertation only scratches the surface of the possibilities. Here it is important to keep in mind if the concepts are still ontologically compatible, which, as chapter 3 shows, requires a careful consideration.

There are, however, still many relevant questions crossover frameworks are not able to answer, as is further discussed in the section on limitations (6.4.3).

6.3 Reflections on the research set-up

The way the research of this dissertation was set up, for a large part depended on the set-up of the project TranCiBo with its consortium, and the NWO call of which this research project is a part. This section further reflects on this set-up, the assumptions and implications it brought.

6.3.1 NWO call: Behaviour and Transitions

Within the NWO call for behaviour and transitions lies the assumption that focusing on behaviour can make a meaningful impact on transitions. This assumption has been supported by the research of this dissertation and the TranCiBo research project of which it is part. By concentrating on behaviour and practices, it is possible

to develop targeted interventions, as demonstrated by the intervention toolbox that followed from this research (TranCiBo, 2024). Some of these interventions have already been tested in practice, while others remain to be explored.

However, next to this positively tested assumption, lies a significant theoretical and ontological challenge in the attempt to bridge the different scales and units of analysis of behaviour and systems (Geels et al., 2015; Watson, 2012). This challenge is not just experienced in this research project, but was mentioned by several researchers of various research projects of NWO Transitions and Behaviour programme. Specifically, the complexity lies in integrating individual behavioural change with broader, long-term systemic change in existing theories and frameworks. Addressing this challenge requires moving beyond superficial solutions, or quick fixes, and striving to understand the deeper mechanisms driving systemic transformation. This shift necessitates the development (see chapter 3) and application (see chapter 4 and 5) of robust frameworks that can bridge the gap between short-term behavioural adjustments and the sustained, large-scale changes required for true system evolution.

6.3.2 The consortium

Similar to the NWO call, the set-up of the project with its consortium had several assumptions. First, the assumption that the consortium is a group with whom reflective dialogue can be conducted has proven largely successful, as evidenced by the positive outcomes of various workshops. These sessions facilitated deep engagement and were well-received by participants. Furthermore, it was noticeable that practitioners appreciated the interorganisational take of the workshops. They mentioned their efforts to collaborate with other actors, but through workshops also opened up about their superstitions, that proved to hinder collaboration. Tt also became recurringly clear that everybody plays their own role in the transition, and this for instance became very apparent in a workshop that involved people cleaning secondary toilets in circular building hubs and representatives of branch organisations. Nevertheless, challenges also emerged, particularly in terms of establishing a common understanding of circularity. This was notably observed a during session at a circular building hub, where, despite architects initially expressing confidence in their contributions to circularity, it became clear that none of them truly believed in the use of secondary building components. This scepticism towards the hub's narrative only softened after the session, when they began sharing business cards, indicating a delayed shift in openness to circular practices. This also showed that the transition is not long underway and there is still a need to discuss definitions and trajectories, which have to precede clearcut solutions.

Similarly, the assumption that this group would be useful basis for intervention was validated to some extent, especially through reflective sessions and workshops. However, for further interventions and reflections thereupon, some important difficulties were encountered. First, projects within the group tend to have long time horizons, often extending beyond or interfering with the duration of the research itself. This is also true for organisational transformation. Second, while some projects were brought to the table by members of the consortium, none of them had clear project lineage, as this is rare in the AEC sector. Initiatives like SUPERLOCAL (n.d.), that explicitly focus on learning continuously from projects and taking those lessons to new projects are notable exceptions. Third, there are not that many projects that truly embrace circular ambitions and the ones that are there, often attract many researchers, which leads to research fatigue among practitioners. The lack of circular projects points to the fact that circularity is still in its early stages, leaving limited opportunities for direct intervention. Fourth, as this is truly a transition with a systemic scale, interventions within individual projects tend to have limited impact (see chapter 2). This underscores the complexity of achieving meaningful change for the transition towards a circular economy in the AEC sector. Lastly, the needed change is multi-aspectual and requires multiple, ever changing actors, which hinder clearcut solutions for intervention. This means, for instance, that even when dynamics for circularity are adopted successfully in a construction project, there can always be different, unexpected aspects that hinder realisation of circular ambitions.

6.4 Reflections on the research

This section dives deeper into the implications of the research, first highlighting implications for academic research and then for practitioners. Thereafter, the limitations of this research are explicated, from which recommendations for future research follow.

6.4.1 Scholarly implications

This dissertation offers insights into the transition towards a circular construction economy by examining construction projects and circular hubs through the lens of Social Practice Theory and Sustainability Transitions Research, while also using concepts from organisational studies. The existing construction regime is

increasingly under pressure from global environmental concerns, that in turn are translated into European, and national sustainability agendas, policies, and laws and regulations. However, the fragmented nature of the AEC sector presents a substantial barrier for change and perpetuates the existing construction regime. This section delves deeper into the scholarly implications regarding the following themes: dynamics for circularity, (mis)alignment of practices for different circular design strategies and the stages of the transition for different design strategies, and particularly design with secondary resources in the form of circular building hubs and the system-of-practices in which they reside.

This research shows that better collaboration within interorganisational projects, in the form of dynamics for circularity, can stimulate circular decision-making. These dynamics help actors to alter their practices, so as to better stimulate circular design. However, the influence of these dynamics often diminishes further down the supply chain. This research highlights that it is difficult to change practices, as construction projects lack the protected space that is typically available to niches. Furthermore, the locked-in structures and processes of the current regime inhibit the flexibility needed to distribute resources differently, alter plans during construction processes, and the opportunity for actors to assume new roles. Consequently, if interventions are solely aimed at changing practices within construction projects, the realisation of circular ambitions will remain limited.

Furthermore, this research identifies key (mis)alignments within and around circular construction projects that hinder the setting and realisation of circular goals (chapter 4). These (mis)alignments highlight the systemic nature of the transition towards a circular economy. The study reveals that while some circular design strategies, such as design for prevention and design for adaptability, align more closely with business-as-usual practices, others, like design with secondary resources, face significant challenges. These challenges include the availability of secondary materials, the limited time allocated to actors to source these materials, and the money it costs clients to get a building that is largely second hand. This makes it unlikely that some of these strategies will be widely adopted in the near future without substantial systemic reconfigurations. This dissertation also reinforces the notion that standards, knowledge, and tools for circular construction are still in their early stages of development. While progress is being made, for instance in areas like fire safety standards for wooden constructions and the use of digital tools for circularity assessments, significant gaps remain. Knowledge, skills, and tools for designing with secondary resources are particularly lacking, which impedes the adoption of this circular strategy in daily practice.

Lastly, the study provides a detailed analysis of Circular Building Hubs (CBHs), emphasizing their distinct role within the construction sector. While CBH's and logistical hubs might appear similar, they differ fundamentally in their origins, practices, and objectives. CBH's are primarily focused on deconstruction and the repair, refurbishment, and sale of building components, whereas logistical hubs are designed to streamline construction processes. However, the study suggests that these hubs may evolve towards greater similarity in the future, particularly if CBH's shift towards emphasising logistical processes over their current (e.g. repair) practices. The research confirms several barriers to the reuse of building components identified in the literature, such as low quality, missing data, and hesitant procurement behaviour. However, it also shows that CBH's can help overcome some of these barriers by improving the quality of components through involvement in deconstruction and repair and by creating small logistical structures that support the growing market for secondary components. Despite these advances, significant barriers remain, particularly in terms of hesitant public procurement behaviour and lacking design skills.

In conclusion, this dissertation contributes to a better understanding of the transition towards a circular construction economy by providing a nuanced analysis of practice (mis)alignments and the potential of interorganisational projects to foster meaningful niche-regime interactions. It showed how change for circularity can develop in projects, which forces allow and hinder this change, and how an alternative supply chain around circular building hubs can develop. Above all, this research highlights the interconnectedness of practices. It is not simply a project implementation of a new technique, but a systemic change that can be stimulated but not created by good project management.

6.4.2 Implications and recommendations for practice

This research underscores the critical roles that various practitioners play in advancing the transition towards a circular construction economy. The societal relevance of this transition cannot be understated, as it directly contributes to the reduction of CO_2 emissions, resource use, and waste production. To achieve these goals, practitioners are advised to engage in both learning from and experimenting with circular construction projects. National and local governments, as well as other organisations in the construction sector, must prioritize these efforts, as they are essential to fostering the necessary collaboration and redefining organisational roles and responsibilities within the construction chain. This section further dives into the implications of this research for practice and provides recommendations, stepping stones for interventions, for

practitioners to stimulate speed up the transition towards a circular economy in the AEC sector. This section discusses implications regarding dynamics for circularity in construction projects, systemic implications, and circular building hubs.

A key takeaway for practitioners is the importance of recognising and managing the temporal dynamics that are inherent in interorganisational projects. Circular construction projects, given their uncertainty, require a degree of flexibility in planning, budgeting, and scope to accommodate the inevitable setbacks and opportunities for innovation that arise. This research suggests that explicitly appointing someone within the project team to be responsible for keeping circular ambitions on the agenda during project meetings is a practical step that can help go the extra mile for circularity and change the business-as-usual. Additionally, public clients are advised to take a proactive approach in working with architects and contractors to develop a shared vision in the early stages of construction projects. This collaborative process ensures that the expertise of all parties is fully leveraged, leading to more integrated, circular project outcomes. Public clients are further advised to show more ambition in procurement, as hesitant procurement behaviour is one of the most hindering factors in reuse of building components through circular building hubs. Possible interventions to stimulate this might include setting up seminars so actors can learn what this requires for procurement (chapter 2 and 4), or, especially concerning design with secondary resources, partnering with circular building hubs or secondary component selling platforms to recurringly understand better what the market has to offer, or even what public clients have to offer themselves from their own assets (chapter 5).

The research also sheds light on several ongoing reconfigurations within the AEC sector that align with circular design strategies. For example, there is a growing familiarity with wooden constructions and an increasing initiation of circular ambitions via Environmental, Social, and Governance (ESG) ratings in policy-making. These shifts are encouraging, but also underscore the need for practitioners to be aware of the systemic nature of the transition and its barriers that continue to hinder the adoption of circular design strategies. Barriers related to safety, quality, and function are not merely technical challenges but relate to deeply rooted understandings of contrasting ambitions that many practitioners also want to see accomplished in construction projects. For instance, safety concerns extend beyond regulatory compliance. Notions regarding safety influence decisions about which suppliers are preferred by contractors, which therefore affects who is participating in construction projects and which ambitions (here, that is safety standards) are undisputed. Practitioners are advised to take a systemic perspective for this transitional change, as this research shows circular ambitions cannot be achieved by changes in construction projects alone.

In practical terms a systemic perspective means that practitioners are advised to first meticulously trace the origins of their decisions and understand the broader consequences of those decisions and the impact they make on other actors. Then, all actors involved can be held accountable for aligning their practices with circularity goals and interventions can be set up to stimulate this alignment. An example of a practice with far reaching impact is area development. Area developers should make timely decisions to allow clients of construction projects to effectively allocate resources, such as time and money, so as to achieve circular ambitions. Similarly, clients must ensure that sufficient time is allocated to projects with circular ambitions. Further, contractors in projects should not only aim to meet ambitions set by the client but also involve their procurement departments in re-evaluating preferred suppliers to better align with circular principles. A possible intervention to bring to light what the impact is of design decisions is setting up radical pilot projects that show where the current system cannot function for circularity (see chapter 4).

Another crucial implication for practitioners is the need to engage in open and explicit discussions about underlying values. The transition to a circular economy often brings conflicting values to the surface, particularly concerning safety, quality, and function. Practitioners are encouraged to reassess whether their original values should continue to hold the same interpretation and priority they have traditionally held. Furthermore, practitioners should be clear and precise in articulating their interpretation of circularity. This research indicates that misalignments between practices can heavily depend on individual perspectives and the organisational contexts that help produce these. This highlights the necessity for all parties to come to a shared understanding of what circularity entails within any given project. Interventions might include setting up meetings at the start of the project to come to a shared understanding of circularity and the contrasting values that might hinder that specific interpretation.

Finally, the research highlights the evolving role of Circular Building Hubs (CBH's) within the construction sector. CBH's have emerged as important driver for the reuse of building components, as they help overcome existing barriers such as the low quality of secondary materials and the lack of logistical structures. They should, however, not be perceived as the ultimate solution for achieving a circular economy. Instead, CBHs should be seen as part of a rapidly changing alternative niche system that contrasts with the more conservative regime of the Architecture, Engineering, and Construction (AEC) sector. In the short term, the market structure around CBH's is expected to grow and professionalize, with improvements in areas such as time allocation for deconstruction, the increase of use of secondary building components, and the development of design skills for reuse. However, in the long term, the role

of CBH's may shift as digital data on the built environment becomes more prevalent, potentially transforming these hubs from repair and refurbishment centres into logistical companies that support a digital circular AEC sector. Practitioners are advised to make use of this developing phenomenon and sustain its development. Policy makers are advised to take the changing roles of CBH's into account. This is also relevant for land allocation for circular building hubs. Concludingly, while CBH's are an important component in the current transition towards a circular construction economy, they should be perceived as a stepping stone rather than the final destination. Practitioners are advised to recognise the potential of a digital circular AEC sector and see CBH's as a vital part of paving the way for this future, rather than as the end goal in themselves. By embracing these insights and recommendations, practitioners can contribute meaningfully to the ongoing transition of the AEC sector towards a circular economy.

6.4.3 Limitations

No research ever encompasses everything. This is also true for this research. Previous chapters already describe limitations for every individual study. Here limitations that relate to the research of the whole dissertation will be discussed. These are divided into methodological, scope, and theoretical limitations.

Methodologically, as described in the previous chapters, this research has several limitations. First, maybe most fundamental, all of the empirical studies of this research are qualitative. The reasoning behind this was the explorative nature of the research and the search for dynamics of how change comes about was given priority over the numbers relating to change. As a result, this study provides answers relating to the dynamics of transitional change, but not to the amount of change (i.e. the amount of changing practices), nor the extent to which practice change results in more circular outcomes. Quantitative studies on circular change results (e.g. material throughput) are common (e.g. Hanemaaijer et al., 2023; Sileryte et al., 2022), but linking change results directly to practices remains a research gap. Second, as is common in case study research, there is a limited number of case studies in this dissertation. This limitation was dealt with by combining a wider range of cases (i.e. construction projects and circular building hubs) in chapter 2 and 5, with two in-depth cases (i.e. construction projects) in chapter 4. However, despite this strategy to overcome this limitation, the end result still relies on a limited number of cases, meaning that despite perceived saturation of results, more, and even contrasting results could follow from additional case study research.

Regarding scope, this research holds limitations on different levels. The intended scope of the research was continuously updated, based on findings. Conscious choices were made about aspects that were to be researched and aspects that were not given priority. Consequently, systemically, some parts have not been intensively researched in this dissertation. This, for instance, relates to practice changes deeper into organisations, especially regarding client practices, policymaking practices on a national level, including law and regulation making practices. Further, also quite fundamental, all of this research is based on work in the Netherlands and lessons cannot simply be transferred to other settings of other countries. In this transition, the Netherlands is often regarded as a frontrunner with many formal, bottom-up initiatives (see for instance chapter 5). Research in countries with other characteristics (e.g. the People's Republic of China with strong top-down initiatives, South Africa with many informal initiatives, or countries that can be considered laggards) might provide very different results.

Theoretically, this research focused on the combination of practices and transitions. Chapter 2 also used concepts from interorganisational behaviour, and the findings have been tested again in chapter 4. However, theoretical triangulation (Fusch, Fusch, & Ness, 2018), analysing the same topic through different theories, to research whether this leads to different outcomes, has not really been part of this dissertation. That is because this dissertation focused on an in-depth study of one theoretical framework, which did not allow for theoretical triangulation. Many other approaches to study behaviour or transitions could also have been applied, possibly resulting in different outcomes.

6.4.4 Future research

Following from these limitations, future researchers might take several research directions, which we shall again divide in the categories methodology, scope, and theory.

Methodologically, researchers may take a more qualitative approach. This might entail practice changes following from this research, using project dynamics (see chapter 2), practice (mis)alignments (see chapter 4), or reconfigurations in the system in which circular building hubs reside (see chapter 5). This research might take into account the amount of practices that change, focusing on for instance differences of the practice within the system (e.g. practice connections, practice performer) or organisational differences (e.g. regarding size, structure, function). This would be a quantitative study using sustainability transitions research and

social practice theory. Within both approaches there is already a call for such quantitative studies or studies that combine qualitative with quantitative elements in general (Köhler et al., 2019; Spaargaren et al., 2016) and this research confirms and highlights this gap for this specific transition towards a circular economy in the AEC sector. A mixed method might also be applied to measure how changing practices affect circular results. This is a known gap of both sustainability transitions research and practice theory research and is not solved by combining the approaches (see chapter 3), but requires a new, quantitative input. Future researchers might further focus on conducting extra case studies. This is helpful in general, as extra case studies might provide extra questions and answers. Extra case studies might also focus on specific design strategies. Many of the researched cases had a wide range of circular ambitions, focusing on different design strategies at the same time. Some failing ambitions were therefore compensated by highlighting other, more successful ambitions. When (predominantly) focusing on one design strategy, the narrative of interviewees might highlight new alignments and misalignments for specific design strategies. Further, as the transition progresses, (mis)alignments will continuously change, and so should priorities for intervention, which would require more case studies. Lastly, chapter 3 highlighted the difficulty of capturing an element of time in crossovers between Social Practice Theory and Sustainability Transitions Research. Future researchers might develop a framework that captures time, so as to make it easier to research change, or preferably 'changing', instead of a current state of a system.

Regarding scope, future researchers might dive deeper into organisations and the practices that affect practices in projects. Based on this research, it is recommended that extra research would be conducted to practices within client organisations, as well as policymaker practices, and norm, law, and regulation setting practices. Especially the politics behind the transition will provide an interesting topic for research. Further, future researchers might focus on contexts of different nationalities to better understand which results from this research pertain to the specific context of the Netherlands, and which are universal.

Lastly, regarding theory, future researchers might focus on developing different crossover frameworks between Social Practice Theory and Sustainability Transitions Research. This research found particular useful frameworks for reconfiguration, whereas other transition paths (e.g. substitution) remain uncovered. Future researchers might develop these for different transitions. Further, different interpretations of both transitions and behaviour, as these might provide fundamentally different results than the use of sustainability transitions research (especially the MLP) and Social Practice Theory in this research. Alternative approaches might be found for instance in neo-institutional economics, behavioural

economics, theory of planned behaviour, theory of small wins, actor-network theory, agent-based modelling. Comparing results from these future studies with the results of this thesis might provide an extra theoretical triangulation (Fusch et al., 2018).

6.5 Final statement

This research has had a formal driver, stemming from an NWO call (Dutch Research Council (NWO), n.d.) and the response to this call in the form of the TranCiBo project (van Marrewijk, 2022). Next to this formal driver, this research has had informal drivers, stemming from personal ideals and fascinations. That means that this research was not conducted simply to join the latest academic hype regarding the circular economy, but to stimulate a heartfelt needed change in our society that benefits our direct environment, climate, and social justice.

From this heartfelt need to change stems my desire to discuss one final, important term. This dissertation mentions the term 'radical change' several times as important characteristic of the transition towards a circular economy in the AEC sector. This is often easily mentioned in reports and articles, but during the conducted interviews it was often mentioned that circularity 'was not that difficult' and one just needed to 'use common sense'. Circularity would just be a minor addition to highly complex construction projects, with various ambitions. To me this also highlights that there is a mismatch between formal statements and perceived needed change in the field. Radical change, to the extent that I believe is necessary for this transition, means that other ambitions might be severely hindered. Some architectural ambitions (e.g. sculptural architecture), or ambitions regarding area development (e.g. quick action) might prove difficult to accomplish in a circular economy. Also, regarding the transition agenda of the EU (i.e. being fully circular in 2050), organisations need to change faster to keep up (Hanemaaijer et al., 2023). If not, the needed change will not be achieved. And even if this radical change is being achieved, some organisations might not benefit from it. The radicality of the change would create new economic and institutional structures and therefore distribute power differently. Some will benefit from this, but some (incumbent) actors will not and lose their current positions. This is true both in the Netherlands itself, and in other places in the world that form part of the supply chains.

Even in the early stages of the transition towards a circular economy, the complications do not seem to lie with technological change, but with social change (see chapter 2, 4, and 5). The moment that the transition moves towards the stages that new power distributions will become evident, this will be even clearer. This will become even more evident when the circular economy makes a more dominant claim on already contested space, for instance for circular building hubs or new factories. These factors also make this transition highly political, or at least it should make it highly political. Yet, so far, the Dutch government has been limited in giving direction for this transition. This dissertation stresses the need to speed up the transition and continuously and consciously move forward. Actors should not be overwhelmed by the systemic challenges, nor underwhelmed by the perceived 'common sense' the transition requires, but continuously reconfigure their practices through discussion and collaboration, so as to continuously learn and overcome misalignments. As the opening quote of this dissertation says: "Great things happen not by impulse, but by a series of small things brought together" (Van Gogh, 1882). In the letter to Theo van Gogh from which this famous quote is taken, Vincent also mentions that he cares not for abstract principles if they do not lead to action. For the transition towards a circular economy in the AEC sector, above all, more action is needed to move forward. This can be a continuation of small steps, in line with the recommendations of this dissertation. But it is in the combination of all these tiny reconfigurations throughout the system-of-practices, and continuous reconfigurations that follows after, that this transition can happen. There are many potential ways forward, and it matters, above all for the actors involved, that we go, which way we go, and how fast we go.

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Appendices

APPENDIX A

Publications that use both Sustainability Transitions Research and Social Practice Theory

Related to chapter 3

Articles from search in Scopus and Web of Science			
1	Svennevik E.M.C., Dijk M., Arnfalk P.	How do new mobility practices emerge? A comparative analysis of car-sharing in cities in Norway, Sweden and the Netherlands	2021
2	Mickwitz P., Neij L., Johansson M., Benner M., Sandin S.	A theory-based approach to evaluations intended to inform transitions toward sustainability	2021
3	Huttunen S., Kaljonen M., Lonkila A., Rantala S., Rekola A., Paloniemi R.	Pluralising agency to understand behaviour change in sustainability transitions	2021
4	Pérez-Sindín X.S., Van Assche K.	"Coal [from Colombia] is our life". Bourdieu, the miners (after they are miners) and resistance in As Pontes	2021

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Articles from search in Scopus and Web of Science			
5	Sovacool B.K., Hess D.J., Cantoni R.	Energy transitions from the cradle to the grave: A meta-theoretical framework integrating responsible innovation, social practices, and energy justice	2021
6	Mathai M.V., Isenhour C., Stevis D., Vergragt P., Bengtsson M., Lorek S., Mortensen L.F., Coscieme L., Scott D., Waheed A., Alfredsson E.	The Political Economy of (Un)Sustainable Production and Consumption: A Multidisciplinary Synthesis for Research and Action	2021
7	Kivimaa P., Laakso S., Lonkila A., Kaljonen M.	Moving beyond disruptive innovation: A review of disruption in sustainability transitions	2021
8	Svennevik E.M.C.	Providers and practices: How suppliers shape car-sharing practices	2021
9	Kokko S., Fischer K.	A practice approach to understanding the multilevel dynamics of sanitation innovation	2021
10	Nogueira L.A., Wigger K.A., Jolly S.	Common-pool resources and governance in sustainability transitions	2021
11	Laakso S., Aro R., Heiskanen E., Kaljonen M.	Reconfigurations in sustainability transitions: a systematic and critical review	2021
12	Svennevik E.M.C., Julsrud T.E., Farstad E.	From novelty to normality: reproducing car-sharing practices in transitions to sustainable mobility	2020
13	Koretsky Z., van Lente H.	Technology phase-out as unravelling of socio-technical configurations: Cloud seeding case	2020
14	Labanca N., Pereira Â.G., Watson M., Krieger K., Padovan D., Watts L., Moezzi M., Wallenborn G., Wright R., Laes E., Fath B.D., Ruzzenenti F., De Moor T., Bauwens T., Mehta L.	Transforming innovation for decarbonisation? Insights from combining complex systems and social practice perspectives	2020
15	El Bilali H.	Transition heuristic frameworks in research on agro-food sustainability transitions	2020
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APPENDIX B

Alignments and misalignments

Related to chapter 4

The paper (chapter 4) elaborates on several off the (mis)alignments found in project X and Y. As the main body of the paper is not deemed the right medium to present all (mis)alignments, but we wanted to be open about our findings so to a) be transparent, and b) better contribute to the body of knowledge regarding these transitions, an overview of the results is presented in this appendix. The results are presented similarly to the findings section in the main body of the paper. First, project X is presented regarding circularity in general (ambitions and realisation), design for prevention, design for quality and maintenance, design for adaptability, design for disassembly and reusability, design with existing building (parts), design with secondary resources, and design with renewable resources. Then, project Y is presented with the same order of design strategies.

Alignments are presented in green and misalignments are presented in red.

This appendix might help researchers and policymakers who are studying the transition(s) to a circular economy in the AEC sector and aim to further speed up the transition(s). This overview is more complete than the overview of the main body. However, by no means should this be considered a complete set. Researching more construction projects might highlight new (mis)alignments. According to interviewees and workshop participants these should contain the most important ones though.

Project X

Below all found (mis)alignments can be found for project X. The system-of-practices in which this takes place can be found in figure 1. This figure also shows the distinction between regime practices and niche practices. These are not portrayed as binary states, but as gradients, as is more common in transitions that follow reconfiguration paths.

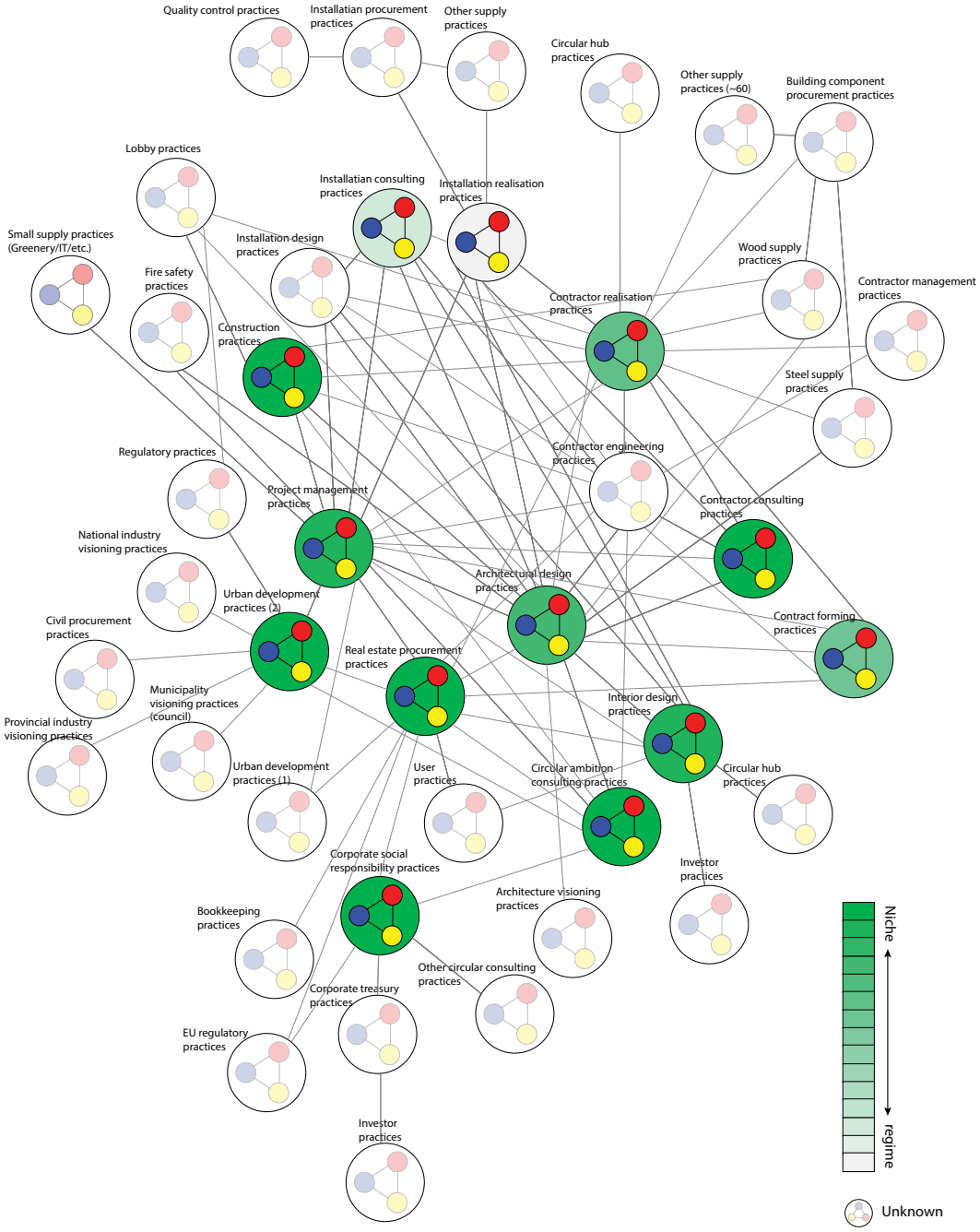

FIG. APP.B.1 System-of-practices project X with distinctions between regime and niche

TOC

Circularity in general
Ambitions
High circular bar (agency municipality visioning practice) – agency on circularity (material-functional structure urban development practice (2). The municipality has set circular goals so high, employees do not feel the urge to challenge them to set goals even higher.
Setting high circular goals (agency municipality visioning practice) – employee belonging (agency urban development practice (2)). The high circular goals of the municipality make employees proud to belong to the organisation.
Circular goals (agency contractor consulting practice) – parenthood (agency contractor consulting practice). A common story seems to be that realising circular goals is so important, because parents want to make a better world for their children. (also mentioned by real estate procurer)
Lacking circular knowledge (agency real estate procurement practice) – finances (material-functional structure real estate procurement practice). Change costs money. Gaining new knowledge, setting up sustainability matrices, requires money for advisors, at 120,- per hour. It helps to know beforehand if change will lead to something, otherwise these are expensive tasks.
Unwillingness to compromise on function (agency architectural design practice) – circular ambitions (agency real estate procurement practice). Functional concessions are not considered for large buildings. Whereas a single house can have a functional concession for the sake of circular ambitions, in large buildings these are considered not-done. This shows here for instance in terms of acoustics (also mentioned by constructor (9)). Although there are no laws or regulations on acoustics for offices, extra concrete was added to the wooden floors to deal with this. Circular ambitions are considered as an addition to the (also unwritten) ambitions already there. (also mentioned by installation consultant)
Finances through ESG ratings (material-functional structure interior design management practice) – Circular ambitions (material-functional structure interior design practice). ESG ratings push companies through finances to set circular policies. These ESG ratings do not push for very ambitious policies (yet). This was also noticeable for the client (8).
Dividing responsibilities (agency real estate procurement practice) – circular goals (agency architectural design practice, construction practice, contractor engineering practice, contractor realisation practice). As responsibilities were very well discussed, this allowed actors to take responsibility for circular goals in their newly defined roles.
Building as face of the company (agency corporate social responsibility practice) – fundable circular ambitions (material-functional structure real estate procurement practice). Buildings are the face of a company. Especially when a company does many different (more expensive) things than building buildings, a building can be a way to showcase the circular principles of a company, resulting in extra money for circularity measures.
Functional demands (agency real estate procurement practice) – circular solutions (material-functional structure construction practice). The function of specific parts of the building already dictates the loadbearing structure of these parts, e.g. a working hall would have to be made with a steel structure, and a parking garage from concrete. Options to choose materials with lower CO_2 impacts are limited, but reuse (especially for steel structures) is still on the table at this point. The project manager (13) also mentioned this limitation in choosing for an empty plot, instead of reusing an old building.
Land lease (material-functional structure urban development practice (2) and real estate procurement practice) – circular ambitions (agency urban development practice (2)). Because the land was leased from the municipality, the municipality got the option to set extralegal demands, which functioned here as back-up system for the circular ambitions stemming from the client.
Realisation
Specialisation (material-functional structure contractor realisation practice and contractor engineering practice) – circular idea continuation (agency contractor realisation practice). A circular portfolio is one of the few things contractors can use to win, as prices between different parties seldom truly differ.
Old agreements and contracts (material-functional structure contractor realisation practice and other supply practices) – circular goals (agency real estate procurement practice). Earlier agreements and contracts between contractors and suppliers make realising some circular goals impossible. Also partnering options may be limited, as not every supplier is a previously defined preferred supplier. Similarly, this is true for installations (11) where preferred suppliers seem mainly chosen because of their use of safety and quality measures and finances, at the cost of sustainable (e.g. with no or limited packaging) or local suppliers.

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Circularity in general
Hiring a consultant (material-functional structure contractor consulting practice) – circular idea continuation (material-functional structure contractor realisation practice and contractor engineering practice). Hiring a consultant for the contractor resulted in (partly) bridging the specialisation gap (see 2.2), as the consultant remained in the project for a longer time with a more general focus.
Lack of ready knowledge (agency contractor engineering practice) – time for design process (material-functional structure project management practice). Time for the design process in the project was limited for reasons regarding urban development. Lacking ready knowledge cost a lot of limited time.
Flexibility (agency contractor consulting practice) – circular goals (agency real estate procurement practice). It takes a lot of flexibility to change current practices. A consultant always needs to find new ways to change the minds of people.
Specialisation (agency contractor realisation practice) – circular system thinking (agency contractor consulting practice). As a generalist (consultant) it is difficult to change the mind of a specialist (contractor specialists). (Ready) knowledge is lacking and time is too limited to find it.
Circular goals (agency real estate procurement practice) – tragedy of the commons (agency architectural design practice, project management practice, contractor engineering practice, contractor realisation practice, construction practice). As circular goals concern all, no one is specifically likely to take responsibility on them.
Market pressure (material-functional structure contractor realisation practice, installation realisation practice, construction practice) – circular goals (real estate procurement practice). As market pressure grows and one or more parties of a team are under time pressure, it is unlikely that they are willing/able to change their practice to achieve circular goals.
People skills (agency architectural design practice) – circular change (agency real estate procurement practice). Setting up alliances are deemed necessary to realise circular goals. This means actors have to find each other on a personal level as well as on a content level.
Changing practice for circular ambitions (agency architectural design practice) – financial risks (agency and material-functional structure contractor realisation practice practice). Changing outcomes always involves taking risks, especially regarding circular ambitions where new techniques (wood) and uncertainties (reuse) are in play. As contractors have to take these risks, they often veto them beforehand. (also mentioned by real estate procurer (4), and constructor (9))
Conflict escalation (agency real estate procurement) – circular dynamics (agency architectural design practice, construction practice, contractor engineering practice, contractor realisation practice). Conflicts were immediately escalated to direction level, allowing the project team to keep working through the established dynamics for circularity (in line with Kooter et al., 2021).
Financial pressure (material-functional structure contractor realisation practice) – circular dynamics (agency architectural design practice, construction practice, contractor engineering practice, contractor realisation practice). As soon as financial pressure hits the project - in later stages, when it becomes difficult to stay within budget – actors tend to stop their circular dynamics (see previous)
Problem plurality (material-functional structure architectural design practice, construction practice, contractor engineering practice, contractor realisation practice, project management practice) – Circular leadership (agency project management practice). There are many problems that have to be solved in a construction project. There is a tendency to let these problems 'hang' until they have to be solved. Usually this ends in the client paying. This problem plurality makes it difficult to be a proactive leader for circular ambitions.
Circular certifying (agency interior design practice) – Finances (material-functional structure real estate procurement practice). Certifying is expensive and the costs could also be used to spend on circular measures, as is also mentioned by the CSR manager (8) . This tension leads to a lack of practical circular knowledge, but does result in many circular practices.
Functional segregation (agency architectural design practice) – circular solutions (material-functional structure construction practice). By segregating the design into separate design questions with unique functions, circularity solutions could be sought for specific problems, without them conflicting with each other, e.g. the office could be made out of wood, which would not work for the working hall. However, the working hall could be made from reused steel, which would not have worked for the office.

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Circularity in general
Costs for advisors (material-functional structure and socio-cultural structure project management practice) – Major circular design choices (agency construction practice). Constructors are often brought in around the preliminary design phase to save costs. Several important design decisions have already been made by then. This is also mentioned by the installation engineer (11). Further, these cost reductions can also be found as constructors are seldom asked to make variant studies or extensive calculations.
Procurement regulation culture (socio-cultural structure real estate procurement practice) – open communication (agency real estate procurement practice). EU regulations define procurement for public parties. These regulations are taken more strictly than prescribed, which hinders open communication between client and contractor, which would be especially useful for new methods, techniques, and processes such as regarding circularity.
Dividing design and realisation (material-functional structure project management practice) – circular goals (material-functional structure contractor realisation practice). As the project was clearly divided into design and realisation, not all goals of the design found there way as easily in the realisation phase. Here people with different concrete assignments (realisation of the design within time and budget) were working, who had very little incentive to contribute to circularity. Also knowledge transfer often did not take place.
Specialisation (agency contractor realisation practice) – circular system thinking (agency contractor consulting practice). As a generalist (consultant) it is difficult to change the mind of a specialist (contractor specialists). (Ready) knowledge is lacking and time is too limited to find it.
Early contractor involvement contract (agency contract forming practice) – circular change mindset (agency architectural design practice, construction practice, contractor engineering practice, contractor realisation practice). Dealing with change is deemed very difficult for private parties in the construction sector. The early contractor involvement contract allows for a change mindset, allowing actors involved to try new things and experiment.

Design for prevention
Population density (agency urban development practice (2) - travel distances (material functional structure user practice). The municipality aimed for a high FSI for the business park. This allowed a location close to the city centre for the users who travel in and out often.
Energy neutrality (agency real estate procurement practice) – Reduce (agency real estate procurement practice). Energy neutrality requires a lot of insulation and solar panels, contrasting reduce ambitions. Solar panels especially also contain critical and toxic materials.
Doing everything to get the job (agency other supply practice) – reducing waste (agency contractor realisation practice). Suppliers often lie about not producing any waste on the building site in order to get the job. It requires hard work to get the truth on the table and active management from the contractor to keep suppliers to their promises. This is also true for other sustainability issues, such as reuse that remains implicit and does not happen when push comes to shove.
Design are never considered done (socio-cultural structure interior design practice) – Reduce (agency project management practice). Whereas most of the actors work with strict deadlines adjusted to production times, the interior architect has more time. This means a design change from the interior architect might result in double production, here for instance due to a change in departmentalization.
Measuring environmental impact (material-functional structure EU policy practice) – reuse and reduce (agency corporate social responsibility practice and agency real estate procurement practice). The EU is launching new laws and legislation on measurement of environmental impact. Knowing that this is to come, CSR managers are stimulated to already take action on measuring, which in itself stimulates managers to take action on their findings. Similarly, this effect also takes place when the client asks suppliers which materials they use.
Engineering assignment (socio-cultural structure architectural design practice) – Reduce (agency corporate social responsibility practice). Asking an engineer to create a solution in general results to creating something more, opposite to reducing goals.
Energy neutrality (agency municipality visioning practice) – financial benefits (material-functional structure (real estate procurement practice). Some goals of the municipality are more easily taken over than others. Especially energy neutrality (or movement towards that) is popular as it aligns with reducing high energy costs.
Energy neutrality (agency real estate procurement practice) – Bookkeeping tradition (material-functional structure bookkeeping practice). The building was designed energy neutral while in use, with the exception of charging electric vehicles, a major part of energy use, as these costs were paid by another department of the client.
Wood detailing skills (agency architecture practice) – environmental impact (material-functional structure contractor realisation practice). Detailing in wood is a new process for many architects. The way in which this is done, highly impacts the environmental impact of a project. Coating steel has a very negative impact. If the steel elements that connect the wood can be detailed in the wood itself, the impact is minimized.
Hidden lobby work (agency lobby practice) – Distrust national database (agency architectural design practice). As the NMD (national environmental database) is still being regularly updated, LCA information changes often, also with influences on the MPG (LCA based scores for houses and large offices). There is a distrust if these LCA scores are correct, or the result of active lobbying.

Design for quality and maintenance
Life cycle of materials (material-functional structure other supply practice) – existing perceptions of what a good building is (agency architectural design practice). Wood was not seriously considered for the façade, as it would not withstand the harsh environment of the building. Instead steel cladding was chosen. This notion of the life cycle of materials relates to old practice meanings of what a good building is.

Design for adaptability
Design for flexibility (agency interior design practice) – Easy function continuation (agency users practice). Every year 10% of the work spaces need to change. By designing for flexibility, this is easily achievable.

Design for disassembly and reusability
Interesting job activity (agency construction practice) – Design for disassembly (agency real estate procurement practice). Constructors like the design for disassembly, as this gives them a) a challenge they often lack, and b) extra hours and therefore money.

Design with existing building (parts)
Hyperfocus on function (agency project management practice) – Design with existing buildings (agency real estate procurement practice). None of the existing buildings were considered able to house the intended function (interviewee 13); design logic stemmed from function, not availability.

Design with secondary resources
Rapid decision making process (agency urban development practice (1)) – Reuse (material-functional structure contractor realisation practice). Time restrictions stemming from urban development goals (here: urban functions for new neighbourhood) misalign with time needed for finding, calculating, and labouring on secondary materials (such as steel structures). This was also mentioned by the architect (3), real estate procurer (4), installation consultant (5), constructor (9) and project manager (13)). To a lesser extent this is also a misalignment for new techniques, e.g. wood. Details with wood need to overcome technical issues regarding fire safety (mostly to do with the steel connecting elements) and acoustics (mostly to do with floors being thin in specific places). In concrete detailing this would be very easy. The limited time also resulted in mistakes, that might have been overcome if there was more time for controlling, according to the project manager. Renegotiating about the time constraints was never on the table, as 1) there is no culture to do so, and 2) extra time is not considered to lead to a better project necessarily. Sticking to the deadlines is considered beneficial.
Functional design limitations (agency/material-functional structure architectural design practice) – reuse (agency real estate procurement practice). The plot was oddly shaped, so the architect chose to first focus on finding options to fit the program functionally on the plot, before circular goals were seriously considered. This diminished options for reuse. This was also mentioned by architect (3) and project manager (13).
Reuse (agency real estate procurement practice) – Lacking a 'blue' personality (agency contractor consulting practice). Dealing with reuse is considered a 'blue' task, requiring making lists, working neatly, strict planning, follow-through, etc. Here this was largely lacking.
Reuse (agency real estate procurement practice) – hub size (material-functional structure circular hub practice). The new hubs are limited in size, making reuse in large quantities impossible.
Reuse conceptions (agency architectural design practice) – Budget setting (material-functional structure real estate procurement practice). There are ideas that reuse should always be cheaper. Due to labour costs, this is often not the case. Questions rise whether more expensive reuse is a decent option in itself. Often reuse is discarded as alternative. This is also mentioned by installation consultant (5),contractor (6), constructor (9), and installation engineer (11). The latter argues transport to other countries with lower labour costs should be considered as alternative (and calculated if it is still sustainable). Contrastingly, for furniture reuse often is 85-90% cheaper, according to the interior architect (7).

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Design with secondary resources
Reuse (agency real estate procurement practice) – giving guarantees (material-functional structure contractor realisation practice). As there is no norm regarding reuse, it is not possible to give guarantees like you can with new building components, resulting in huge risks for the contractor. This is also mentioned by installation consultant (5), contractor (6), and constructor (9). However, the contractor did mention that new standards have been set, but this has not led to the possibility to give guarantees yet as they are not official norms. The constructor mentioned you are subjected to the whims of the specific civil servant you're are encountering. Further, changing the norms costs money, which the government seems hesitant to spend.
European tender procedures (material-functional structure real estate procurement practice) – Time for reuse (material-functional contractor realisation practice). European tender procedures take up a lot of time. When time is limited, the time spent on tender procedures cannot be spent on finding secondary materials. (also mentioned by installation consultant)
Lacking knowledge on circularity for installations (agency and socio-cultural structure installation consulting practice) – reuse (agency real estate procurement practice). Whereas most parts of the building could be designed according to circular principles, most of these principles cannot be used for installations yet, as there is no knowledge in the sector on how to implement this. Design for disassembly is one of the most important realisable principles. Apart from knowledge, a limited drive is also perceived. There are no agents of change.
Conservative sector (socio-cultural structure installation engineering practice) – reuse (agency installation engineering practice). The installation sector is very conservative. Circular principles are not top-of-mind and it seems people do not want to change. A lack of change agents is perceived compared to other parts of the building sector. This is also mentioned by the installation engineer (11).
Soft demands for reuse (agency real estate procurement practice) – Reuse (agency contractor realisation practice). Reuse demands are 'soft'; they are mentioned as effort obligation. This means that less time is spent to actually realise reuse ambitions.
Penalties in contracts for lacking material qualities (agency real estate procurement practice) – Reuse (agency contractor realisation practice). Reuse is made less attractive because of the contractual penalties for material qualities.
Existence of hubs (material-functional structure circular hub practice) – Tendency to look for demolition projects for reusable materials (agency contractor realisation practice). Circular hubs function very similarly as suppliers; they can be contacted with questions on material supply. This hinders starting new practices regarding finding secondary building components from demolition projects. At the same time, these hubs cannot properly provide for buildings materials, as also mentioned by the contract lawyer (12), which is why reuse is not demanded through contract, but merely encouraged.
Reuse (material-functional structure contractor realisation practice) – aesthetic qualities (agency real estate procurement practice). Clients have aesthetic demands about their new buildings. Reusing building components do not always match with those.
Repetition of circular message (agency contractor realisation practice) – reuse on small scales (material-functional structure contractor realisation practice). Many actors say that repetition of circular thinking is needed to make the transition happen (see Kooter et al. 2021). Because it is so important to repeat, reusing on a small (unsignificant) scale, is therefore still considered worthwhile to stimulate the transition. The contractor even mentioned that it is even worthwhile to do something relatively expensive on a small scale, just to get the practice, without having high absolute costs.
Reuse (agency real estate procurement practice) – reducing labour hours (agency contractor realisation practice). Reusing materials often requires maintenance. This maintenance often comprises highly repetitive work, resulting in mistakes, illness, and tired employees. Contractors have been actively trying to reduce labour hours for several years already. Reuse misaligns with that. For them the conscious choice here is between humans and environment.
Circular mindset (agency user practice) – Reuse (material-functional structure interior design practice). The culture of the client company is highly focused on circularity. The direct assignments the interior architect gets from the users therefore reflect this, which actively leads to reuse. This might be difficult to accomplish in other settings. The Corporate social responsibility manager (8) says it is a delicate procedure, where polarisation can heavily slow down the transition.

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Design with secondary resources
Design primarily for function (agency interior design practice) – Reuse (material-functional structure circular hub practice). Designers tend to design from the needs of the user, from function. As they only then search for reused materials, they are unable to find them at circular hubs, due to the limited stock. Designing the other way around would open doors there. This is also true for architects (3) and mentioned by the CSR manager (8).
Measuring environmental impact (material-functional structure EU policy practice) – reuse and reduce (agency corporate social responsibility practice and agency real estate procurement practice). The EU is launching new laws and legislation on measurement of environmental impact. Knowing that this is to come, CSR managers are stimulated to already take action on measuring, which in itself stimulates managers to take action on their findings. Similarly, this effect also takes place when the client asks suppliers which materials they use.
Perceived public-private dichotomy (socio-cultural structure construction practice) – changing laws and regulation on reuse (agency law making practice). There is a lack of norms and legislation concerning reuse. Branch organisations are used to change this. However, these branch organisations are either made up from private parties, or from public parties, whereas changing these laws would affect both. This culture diminishes power from practice.
Quality assurance (material-functional structure and socio-cultural structure construction practice and agency regulatory practice) – Reuse (agency real estate procurement practice). New (to come) laws on quality assurance demand proof that building components perform in a certain way. This will make it more difficult to start reusing. Also the culture to focus on guaranteed quality hinders innovation.
Building aesthetics (agency real estate procurement practice) – reuse (material-functional structure installation realisation practice). When installations are visible, it becomes less attractive to reuse them because of the aesthetics.
Changing practice for circular ambitions (agency architectural design practice) – financial risks (agency and material-functional structure contractor realisation practice practice). Changing outcomes always involves taking risks, especially regarding circular ambitions where new techniques (wood) and uncertainties (reuse) are in play. As contractors have to take these risks, they often veto them beforehand. (also mentioned by real estate procurer (4), and constructor (9))

Design with renewable resources
Traditional budgeting (agency real estate procurement practice) – using biobased materials (material-functional structure contractor realisation practice). Setting budgets is a capacity based on calculations from experience. As biobased materials can be more expensive, this changes the budget. Here this money might have been made available, if this knowledge would have been present beforehand.
Wood aesthetics (agency architectural design practice) – biobased construction (agency real estate procurement). Wood is perceived to be a very beautiful material. These arguments for aesthetics align with the given assignment to build more circular (here with biobased materials). It also results in less material use for the interior (7).
Wood detailing skills (agency architecture practice) – environmental impact (material-functional structure contractor realisation practice). Detailing in wood is a new process for many architects. The way in which this is done, highly impacts the environmental impact of a project. Coating steel has a very negative impact. If the steel elements that connect the wood can be detailed in the wood itself, the impact is minimized.
Construction calculations (socio-cultural structure construction practice) – Building costs (material-functional structure real estate procurement practice). The costs of design decisions on loadbearing structures cannot be compared one on one, as the choice for one material has a huge impact on other elements, e.g. wood is more expensive than concrete, but it saves money on elements like the interior or foundations. This requires detailed (and therefore more expensive) calculations, which require more time, and often a lot of assumptions.

Project Y

Below all found (mis)alignments can be found for project Y, represented in the same category order as the (mis)alignments of project X. An overview of the system-of-practices can be found in figure 2. This figure also shows the distinction between regime practices and niche practices.

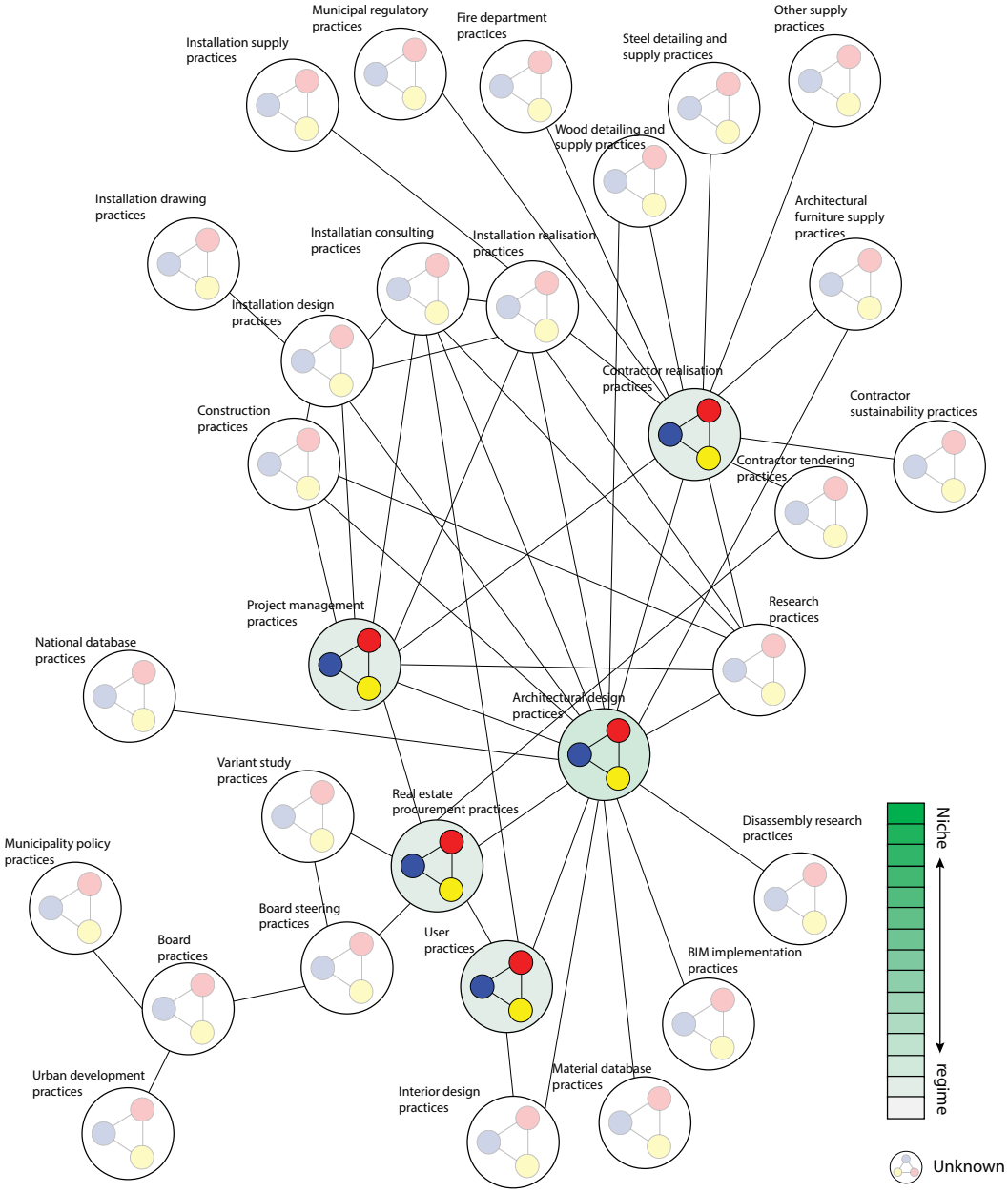

FIG. APP.B.2 System-of-practices project Y with distinctions between regime and niche

TOC

Circular goals (broad)
Ambitions
Lack of mandate to set ambitions for non-clients (material-functional structure and socio-cultural structure architectural design practice and contractor realisation practice) – Circularity ambitions in general (agency board practice). When the client is not challenging the other actors regarding circularity, other actors have very few moments to put this on the table, and if they do, these ambitions are not taken seriously. The window of opportunity is usually around the time of the quotation/ tender (mentioned by architect and contractor). Here you have to be very precise what you want to achieve. After that moment is gone, very little is likely to happen. This is also difficult, as it requires constant awareness of circularity, which is now often lacking. Similarly to the mandate argument regarding clients, architects have very little wiggle space to take over the perceived role of others, as this is not why they are hired.
Different notions of who is responsible for systemic change (agency architectural design practice and contractor realisation practice) – stimulating the circularity transition (municipality policy practice). Actors tend to point to each other to assign responsibility for systemic change: here architects point to suppliers, contractors point to the client, the client points to the market in general.
The notion to better stick to your strengths (agency architectural design practice) – stimulating the circularity transition, especially regarding reuse (municipality policy practice). Architects mention that they find it hard to change their practice and do something else (especially reuse of building components), because they are not good at that, whereas they are good at some circular aspects, such as future proofing. Consultants are to be added to the project to make this happen. This also relates to architects not wanting to be frontrunners, but rather early adapters (which is also a common theme in the frontrunner project). This is also mentioned by the project manager.
Public responsibility (socio-cultural structure board practice) – circular ambitions (matrrial-functional structure architectural design practice and contractor realisation practice). There is a general understanding that public clients (have to) steer the circularity transition, making private companies follow. However, here the board of this public client largely follows societal trends; they would not dare to be a frontrunner, only an early adapter. The project manager and real estate procurer also mentioned the leading role of public clients. However, they also mentioned that money for sustainability cannot be spent on their core business (i.e. education). The user also mentioned that they were influenced by this societal trend, but to a lesser extent.
Uncertainty for future area development (material-functional structure urban development practice) – Setting limited ambitions (agency real estate procurement practice). Because it was uncertain what the future of the area would bring, it was uncertain what the client wanted with the future of the building. This was also mentioned by the user. The client therefore decided to keep the building open for 10 years, allowing for smaller amount of ambitions to be financially viable. It was a given that investments had to be pay themselves back.
Preference to keep the building open (agency user practice) – Setting limited ambitions (agency real estate procurement practice). Because the user did not want to close for too long, so not to lose their market position, their was very limited time in the realisation phase, so the ambitions could not be set too ambitious. Also, as construction had to take place during summer, this gave pressure for the design phase, making innovation largely impossible. This is also mentioned by the project manager, who mentions actors have to get used to each other, especially if they go beyond business-as-usual. It was also mentioned buy the user, who mentioned they had no space to move to a different location and wanted to keep working to stay in business.
Small size of the building project (Material-functional structure real estate procurement practice) – Setting limited ambitions (agency real estate procurement practice). As the project size was small, the client fell little reason to make an explicit choice of demands, wasting a chance to set circular goals, which would have been in line with the vision of the board regarding the portfolio in general. This is also mentioned by the contractor.
Traditional contracting (material-functional structure real estate procurement practice) – Lack of tendency to change business-as-usual (socio-cultural structure contractor realisation practice). The traditional contract technically allows for innovation, but culturally this option often is not taken on by the contractor. More traditional personnel is attracted and they often do not feel any tendency or mandate to change business as usual, instead they follow the ambitions the client sets. For instance, donor steel was not even considered.

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Circular goals (broad)
Only doing the necessary (socio-cultural structure project management practice) – investing in circularity (agency board practice). Even though the board wanted a project that was as sustainable as possible, many ambitions were not even set, as they would not pay themselves back after ten years (the time the building was definitely owned by the client), even though these ambitions would probably raise the value.
Perceived dichotomy between theoretically educated and practically educated people (socio-cultural structure user practice) – Setting circular goals (agency user practice). Theoretically educated people were not deemed to live 'in the real world'. Sustainability and circularity were not taken seriously, as it did not fit many of the other worldviews present among staff members, e.g. showing off if you managed to earn something, such as air travel or a new car. Further, staff members did not have the money to care for aspects as sustainability.
Perceived customer preference (agency user practice) – Setting circular goals (agency user practice). Customers of the facility were deemed to not care about sustainability, but about quality, which were deemed to be conflicting values.
Realisation
Aiming for circularity in general (agency architectural design practice) – conservative culture of companies (socio-cultural structure installation realisation practice and architectural design practice). Concepts of circularity are still largely absent within installation companies. It is very difficult for other actors (e.g. architects) to influence them therein. It is already difficult for an individual to break from the culture of the own firm itself.
Bottom-up management (agency project management practice) – Possibility to influence circularity ambitions (agency architectural design practice). When assignments are divided into parts, relying on the expertise of the responsible actors, it becomes difficult, if not impossible, to steer the project to common circularity goals.
Limited time to plan (material-functional structure real estate procurement practice) – Lack of possibility to change business-as-usual (material-functional structure contractor realisation practice). Changing ways of doing requires extra time in the project. Pressure from the user (that only wanted to close for a short period in summer) and the installations that were running out of date limited available time. Here you see a difference in the various circular solutions, e.g. wood has become so common, that it can culturally be used in a traditional contract, whereas reuse is too niche. This lack of time is also mentioned by the Project manager.
Bonding over common goals (agency contractor realisation practice) – go the extra mile for circularity (agency contractor realisation practice). Good partnership is extremely valued. This starts with a common goal and is maintained by aiming to overcome problems that arise along the way. If a partner ignores the, this destroys that bond. Accountability seems more important than time and money. This culture is also mentioned by the project manager.

Design for prevention
Time to fill in circularity measuring tools (material-functional structure user practice) – learning about circularity in general (agency architectural design practice). Circular measurement tools (e.g. BCI) are very time-consuming to fill in, making it unattractive in general, especially for smaller (e.g. renovation) projects, where available time is limited while still involving many materials. Then using these tools become a relatively bigger part of the project.
Shortage of personnel (material-functional structure installation drawing practice) – minimizing materials (agency board practice). Shortage of personnel caused that drawings were not ready before production. Therefore, many mistakes were made that negatively compensated for anything done positively regarding circularity.
Energy generation and efficiency (agency board practice) – Money making (agency real estate procurement practice). As solutions regarding energy use often pay themselves back within 10 years, many of these type of solutions were used in the project.

Design for quality and maintenance
Reasonable scope (time/size) for which to make a project (socio-cultural structure variant study practice) – prolonging loops (agency architectural design practice). There is a culture present that dictates for how long a building should suffice. Some solutions that would make the building workable for 5 years were discarded because it would not be long enough, whereas other solutions were not deemed financially viable, nor would the impact of it be foreseeable (e.g. regarding the time that components could be harvested).
Life cycle of materials (material-functional structure other supply practice) – existing perceptions of what a good building is (agency architectural design practice). The notion of the life cycle of materials relates to old practice meanings of what a good building is.

Design for disassembly and reusability
Making things as simple as possible (agency contractor realisation practice) – Making elements demountable (agency architectural design practice). The contractor is used to making things as simple as possible, this is often cheap, easier to make, and requires less (stress on) personnel. Creating demountable building components seldom is the simplest option, especially when the goal is to clamp the elements together to avoid making holes.
Life expectancy of buildings (material-functional structure real estate procurement practice) – abstractness of design for disassembly ambitions (agency contractor realisation practice). Because the expected life expectancy of buildings is so long, it remains uncertain what will happen with building components in the future, i.e. if they these components are needed and will actually be harvested from buildings. This hinders going the extra mile for designing for disassembly. This is also mentioned by the project manager.

Design with existing building (parts)
Different notions of what circularity means (agency architectural design practice) – reuse of building components (agency board practice). There are different notions of circularity going round. Many relate to traditional ways of doing things (e.g. making sure a building is adaptable). These notions stimulate some forms of circularity (e.g. design for adaptability, minimizing materials and the impact thereof), but make it impossible to find each other regarding others (e.g. regarding reuse of building components).
The notion to better stick to your strengths (agency architectural design practice) – stimulating the circularity transition, especially regarding reuse (municipality policy practice). Architects mention that they find it hard to change their practice and do something else (especially reuse of building components), because they are not good at that, whereas they are good at some circular aspects, such as future proofing. Consultants are to be added to the project to make this happen. This also relates to architects not wanting to be frontrunners, but rather early adapters (which is also a common theme in the frontrunner project). This is also mentioned by the project manager.
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Traditional contracting (material-functional structure real estate procurement practice) – Lack of tendency to change business-as-usual (socio-cultural structure contractor realisation practice). The traditional contract technically allows for innovation, but culturally this option often is not taken on by the contractor. More traditional personnel is attracted and they often do not feel any tendency or mandate to change business as usual, instead they follow the ambitions the client sets. For instance, donor steel was not even considered.

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Design with existing building (parts)
Small market for secondary building components (material-functional structure other supplier practice) – prolonging loops (agency architectural design practice). The lack of secondary building components on the market makes it unlikely for them to be used in a project (also mentioned by architect and real estate procurer).
Sense of aesthetic standard (socio-cultural structure project management practice) – reuse (agency board practice). There is a sense of consensus for what is aesthetically acceptable. Rehanging ceiling of 25 years old does not fit that description.
Lack of ability to give guarantees (material-functional structure contractor practice) – reuse (agency real estate procurement practice). As contractors cannot give guarantees for secondary building components, reuse becomes very difficult to achieve.

Design with secondary resources
Different notions of what circularity means (agency architectural design practice) – reuse of building components (agency board practice). There are different notions of circularity going round. Many relate to traditional ways of doing things (e.g. making sure a building is future proof). These notions stimulate some forms of circularity (e.g. future proofing, minimizing materials and the impact thereof), but make it impossible to find each other regarding others (e.g. regarding reuse of building components).
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Lack of ability to give guarantees (material-functional structure contractor practice) – reuse (agency board practice). As contractors cannot give guarantees for secondary building components, reuse becomes very difficult to achieve.

Design with renewable resources
Material prices (material-functional structure architectural design practice) – using biobased materials (agency project management practice). A combination of crises highly affected materials costs. The price of wood seems to be affected less, making it increasingly a more attractive alternative to more traditional materials (i.e. steel and concrete).
Energy generation and efficiency (agency board practice) – Money making (agency real estate procurement practice). As solutions regarding energy use often pay themselves back within 10 years, many of these type of solutions were used in the project.

Curriculum Vitae

Mart van Uden was born on 9 March 1990 in Breda, the Netherlands. He followed his high school education at the Stedelijk Gymnasium Breda between 2002 and 2008, with a nature & technology profile. He continued his studies at the Architecture and the Built environment faculty in Delft, where he received both his BSc and his MSc, following the architecture track of the Masters Architecture, Urbanism and Building Sciences. He graduated on the architectural translation of Habermasian public sphere, so as to stimulate politically meaningful encounters between strangers in public space. After working as a freelance consultant on improving building processes regarding sustainability, finance, and planning, Mart started his PhD in 2020, again in the Architecture and the Built Environment faculty at the Delft University of Technology.

His PhD focused on changing interorganisational collaborative behaviour so as to stimulate the transition towards a circular economy in the architecture, engineering, and construction sector. This topic relates to dynamics in construction projects, (mis)alignments of routinised practices throughout the sector, development of supply chains around circular building hubs, and conceptual frameworks to study both practices and transitions. The research was part of the TranCiBo research group, led by Alfons van Marrewijk, and the PhD research was supervised by Hans Wamelink, Ellen van Bueren, and Erwin Heurkens.

Mart has been part of various national and international networks that collaborate in knowledge dissemination around the transition towards a circular economy in the architecture, engineering, and construction sector, such as practitioners knowledge platform Cirkelstad, academic platform Circular Built Environment hub, which is centred in the faculty of Architecture in the Built Environment at Delft, and the Dutch Canadian Circular Alliance that fosters exchange of knowledge between Dutch and Canadian actors in both academia and industry.

Research results have continuously been communicated with the consortium associated with the TranCiBo project, which consists of architects, contractors, public clients, branch organisations, and the knowledge platform Cirkelstad. Cirkelstad itself offered various stages to share results on both national and local level. Results have been further disseminated through practitioner's conference Building Holland, and expert panels, such as in Pakhuis de Zwijger. Mart has

also been interviewed for TU Delft stories and Cirkelstad Magazine. Lastly, Mart has presented his results in at academic conferences relating to construction, transitions, and organisational sciences.

Mart has also been involved in education, teaching courses on academic writing and collaborative city development in the Bachelors of Architecture and the Built Environment and a living lab at the MADE Master programme of the AMS Institute. Mart has also been involved in tutoring Master graduation students from Architecture in the Built Environment, MADE, and Industrial Ecology.

Parallel to his academic work, Mart has worked as a consultant to help organisations in their transformation for a circular economy and as a singing tutor.

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25#14

Reconfiguration of Practices towards a Circular Economy in the Architecture, Engineering, and Construction sector

Change throughout a Persistent System

Mart van Uden

The Architecture, Engineering, and Construction (AEC) sector is a major contributor to CO_2 emissions and resource consumption. In response, the Netherlands aims to make the sector 50% circular by 2030 and fully circular by 2050. However, the transition from a linear to a circular economy is complex due to technical, organisational, and cultural barriers. This dissertation explores how interorganisational behaviour and routinised practices within and beyond construction projects influence the realisation of circular ambitions. This research highlights the importance of top-down support, equal partnerships, shared goals, and intrinsically motivated individuals in construction projects. Trust, transparency, flexibility, and a shared team identity further foster the redefinition of traditional roles so as to drive innovation. However, factors such as focus on short-term cost and risk aversion often hinder progress. The dissertation further combines Sustainability Transitions Research (STR) and Social Practice Theory (SPT) into crossover frameworks that capture both systemic change and everyday practices. These are used to analyse (mis)alignments in the system-of-practices around construction projects. It was found that using secondary materials often clashes with notions of quality, safety, and aesthetics. Increasingly, Circular Building Hubs (CBHs) are brought forward as answer to this problem. This research shows that these hubs can be accelerators in the transition, though they are seen as temporary rather than permanent solutions. Ultimately, no single intervention will enable the shift to circularity. Instead, multiple coordinated changes in practices are needed. This dissertation provides tools for researchers and practitioners to navigate this complexity and encourages learning, experimentation, and a systemic approach to support sector-wide transitioning.

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