Branching out: Timber adoption in multi-storey construction through the Diffusion of Innovations framework

A qualitative study of adoption dynamics, barriers, and enablers for multi-storey timber in the Netherlands through a Diffusion of Innovations lens

Master Thesis

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by

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To obtain the degree of Master of Science
at the Delft University of Technology

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Preface

As my academic journey comes to an end, so does the completion of this master's thesis. Looking back, the past seven years have passed in what feels like a heartbeat. Especially during the final years of my master's, I have been fortunate to experience opportunities that had a huge impact on me, both personally and academically – and I would not have chosen a different path.

I began studying Architecture, Urbanism, and Building Sciences at Eindhoven University of Technology in 2018. During my bachelor's, I gravitated towards structural engineering but eventually realised I was missing collaboration and the broader social aspects of the built environment. Wanting a broader perspective, I moved to Delft to begin my master's in Construction Management and Engineering. Coming from a technical background, the transition was not easy. Yet I soon realised that the broad toolbox this master's provided was exactly what I had been looking for.

My exchange at KTH in Stockholm will always stand out as one of the best semesters of my life. After returning, I joined the multidisciplinary project in Vietnam and South Korea, where I spent ten weeks with fellow students working on a resilience design project in the Mekong Delta. There, I witnessed first-hand the immense impact of climate change and the urgency of sustainable and adaptable solutions. At the same time, Stockholm had already shown me how urban environments can embrace sustainability through mass timber construction. Together, these experiences deepened my fascination with sustainable building and ultimately guided me towards the topic of this master's thesis.

I would first like to express my sincere gratitude to my supervisors, Dr.ir. J. Ninan, Dr. E.J. Houweling, and Dr.ir. Straub, for their guidance and especially for their shared enthusiasm for timber construction. Johan, thank you for being there every week to help me navigate this process and for constantly challenging me to dig deeper into the academic possibilities of my work. Erik-Jan, I am extremely grateful for our one-on-one sessions; your energy and confidence gave me an extra boost of motivation every time we spoke. Ad, thank you for your guidance during the presentations and your encouragement, which made me feel supported throughout this journey. I also want to thank Pierre Jennen for his help and enthusiasm at the start of this project. Pierre, your passion for timber is truly inspiring, and I hope it continues to drive and motivate many students in their own journeys.

I would also like to sincerely thank my supervisor at Arcadis, ir. W. L. G. H. Slotman. Wouter, thank you for giving me this opportunity to write my thesis at a company of your scale. I am especially grateful for your weekly guidance – your practical knowledge was far beyond what I had imagined and helped me enormously. But what will stay with me most is the enthusiasm you brought to work every day. It was contagious, and it made me truly excited to end this academic journey and to begin my professional one. The combined enthusiasm of all four of my supervisors has been the driving force behind me these past months. I cannot express enough how powerful and motivating that has been.

The two buildings I was able to investigate for my thesis have been incredibly inspiring, and the interviews with the people involved were truly a highlight. The drive and passion they showed for these projects has given me so much energy and excitement to work on such projects in the future myself. So, to the participants, thank you for your time and passion.

To my family, thank you for your unwavering support throughout all these years. In stressful moments, I always knew that I could come home and talk about it. Mum, especially, you have been amazing in guiding me. Even though the subjects were not your field, your knowledge about academic work and your constant willingness to help have been invaluable.

Lastly, I wish you, the reader of this document, an enjoyable read. I hope you find this thesis interesting and that it brings you the excitement it has given me. Most of all, I hope this research can contribute in some way to advancing the adoption of timber in construction and ultimately to building a more sustainable future.

Sjors Hooijmaijers
Delft, January 2026

Summary

The construction sector is one of the largest contributors to global greenhouse gas emissions, resource consumption, and waste generation. At the same time, rapid urbanisation and limited land availability in high-density contexts such as the Netherlands create a growing need for multi-storey housing solutions. Together, these pressures drive demand for sustainable alternatives to conventional construction materials. Timber has emerged as a promising option, offering advantages in carbon storage, prefabrication efficiency, and biophilic qualities. While timber as a material has a long history, its use in multi-storey construction in the Netherlands is still perceived as new by project coalitions since it introduces engineered systems and disrupts established routines, making it a genuine innovation in this context. However, despite its potential, the adoption of multi-storey timber buildings remains limited. This research addresses the central question: *How can the adoption of timber in multi-storey construction projects be accelerated by identifying key barriers and enablers using the Diffusion of Innovations framework?*

Although the technical and ecological benefits of timber are increasingly well understood, the dynamics of adoption at the project level remain underexplored. Most existing research emphasises aspects such as technical feasibility, cost comparisons, or broad industry trends while paying less attention to the roles of stakeholder motivation, collaboration, and project dynamics in shaping material decisions. To address this gap, this research applies Rogers' Diffusion of Innovations (DOI) theory as an analytical lens, adapting its stages and attributes to the fragmented, project-based context of construction projects.

The research design combined a structured literature review with two case studies: a fully timber project and a hybrid timber project. In total, 15 semi-structured interviews were conducted with stakeholders on both case study projects, including developers, clients, architects, engineers, and advisors. The empirical data were analysed using the Gioia method, which enabled systematic coding from first-order statements to higher-order themes and aggregate dimensions.

The findings indicate that although timber's innovation attributes – relative advantage, compatibility, complexity, trialability, and observability – play an important role, they do not determine adoption on their own. Adoption was often slowed by perceived cost disadvantages, industry fragmentation, and a culture that favoured familiar practices. These factors reinforced perceptions of risk and uncertainty, limiting the translation of timber's advantages into practice. At the same time, clear enablers were present, such as timber's environmental performance, market distinctiveness, and the potential for faster prefabrication. These strengthened timber's perceived relative advantage. Project dynamics strongly shaped how these key attributes were perceived and embedded into practice. Early integration of timber specialists, the use of integral design processes, and blurring of traditional stakeholder boundaries enabled smoother collaboration across disciplines and reduced uncertainty, making adoption more feasible. Where such approaches were absent, ambitions weakened and decisions reverted to conventional solutions.

Findings further highlight the importance of maintaining ambition consistently throughout the project, as sustainability ambitions, although strong, tended to decline once cost pressures or perceived risks came into play. Motivated stakeholders played a decisive role in countering this dilution. Developers, architects, and advisors who positioned themselves as champions managed to keep timber ambitions alive, framing the material not only as a sustainable choice but also as a symbol of innovation and market advantage. Their efforts were particularly effective when supported by decision-making authority or specialist expertise.

From these insights, the research develops an adapted DOI framework for project-based multi-stakeholder contexts such as the construction industry. Unlike the linear model of adoption within a single organisation, timber adoption is shown to be a dynamic negotiation within temporary project coalitions. Motiva-

tion acts as the gatekeeping condition for timber to be seriously considered, after which persuasion and project shaping unfold concurrently, shaped by early integration of specialised expertise and collaborative structures. Progression and decisions are rarely linear as teams cycle back to earlier decisions to resolve emerging constraints, while ambitions must be actively reinforced to withstand cost or risk pressures. Finally, diffusion beyond individual projects depends on deliberate methods of inter-project knowledge transfer, ensuring that lessons and performance data become shared rather than remaining locked within isolated pioneering projects.

Key recommendations from this research include:

1. *Integrate supplier and specialist expertise early*, as this will reduce risks due to uncertainty and lack of knowledge while ensuring detailing, grid layouts, and prefabrication plans are optimised for timber from the start.
2. *Encourage integral, multidisciplinary design processes from the outset* to align interdependent decisions across project actors, thereby reducing uncertainty, strengthening feasibility and optimising both cost and time.
3. *Lock shared project ambitions early and sustain them* by defining clear sustainability and performance goals upfront and actively reinforcing them against cost and risk pressures.
4. *Frame timber as both a sustainability and market advantage* by positioning it not only as an environmental solution but also as a source of added value through extra floors, faster construction, and distinctiveness.
5. *Strengthen cross-project knowledge transfer* through systematic sharing of lessons, databases, and experiences across projects and disciplines to reduce uncertainty and accelerate industry learning.

Theoretically, this research contributes by extending Rogers' Diffusion of Innovations framework to the fragmented, project-based construction sector. By placing motivation, project dynamics, and inter-project learning at the centre of adoption, the framework captures how material choices are negotiated within temporary coalitions rather than within single organisations.

In conclusion, adoption can be accelerated when motivation drives serious consideration, when project structures enable integration and iteration, and when knowledge is systematically transferred across projects. Together, these extensions to the DOI framework turn timber from an experimental material into a credible mainstream choice, enabling the transition from isolated pioneering projects to sector-wide diffusion. They ultimately provide a pathway for the construction sector to meet its climate goals while breaking away from longstanding reliance on conventional materials.

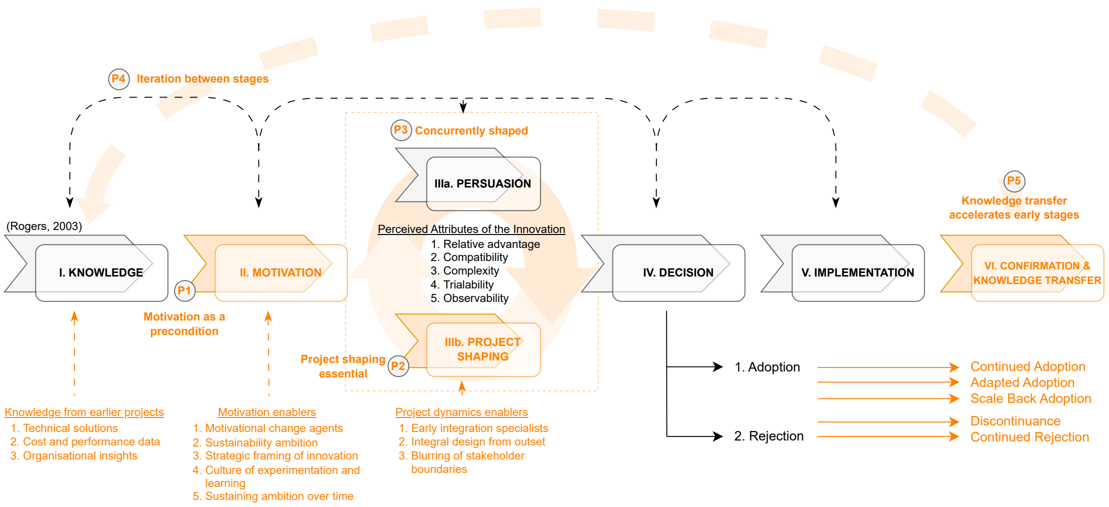

Figure 1: Adapted innovation-decision process for timber adoption (adapted from Rogers (2003))

Samenvatting

De bouwsector is wereldwijd verantwoordelijk voor een groot deel van de CO_2-uitstoot, het grondstoffengebruik en de afvalproductie. Tegelijkertijd groeit in Nederland, door verstedelijking en schaarse ruimte, de vraag naar meerlaagse woningbouw. Dit zet de sector onder druk om sneller duurzame alternatieven voor beton en staal toe te passen. Houtbouw komt daarbij steeds nadrukkelijker in beeld: het materiaal slaat CO_2 op, maakt snelle en nauwkeurige prefabricatie mogelijk en draagt bij aan een gezonde leefomgeving. Toch blijft de toepassing van hout in meerlaagse gebouwen in Nederland beperkt. Dit onderzoek stelt daarom de vraag: Hoe kan de toepassing van hout in meerlaagse bouwprojecten in Nederland worden versneld door barrières en drijfveren in kaart te brengen met behulp van het Diffusion of Innovations (DOI) model?

Hoewel hout als materiaal al eeuwen bestaat, wordt de toepassing in hogere gebouwen nog steeds gezien als een innovatie. Het gebruik van kruislaaghout (CLT) en gelamineerd hout (GLT) vraagt namelijk om nieuwe ontwerpprocessen, andere berekenings- en kwaliteitsprocedures en een herinrichting van het bouwproces. Hierdoor ervaren projectcoalities hout niet als een simpele materiaalvervanging, maar als een vervanging die bestaande routines en rollen verstoort.

Dit onderzoek laat zien dat de technische en ecologische voordelen van hout, zoals lage milieubelasting en snelle bouwtijd, op zichzelf niet genoeg zijn om adoptie te versnellen. Belemmeringen liggen vooral in de kostenperceptie, de versnipperde sectorstructuur en de onzekerheden rond techniek en regelgeving. Belangrijke succesfactoren zijn daarentegen vroege betrokkenheid van leveranciers en specialisten, integrale samenwerking in het ontwerp en het zichtbaar maken van de meerwaarde van hout in de markt.

Een cruciale uitkomst is dat motivatie van actoren bepalend is voor de vraag of hout überhaupt serieus wordt overwogen. Wanneer opdrachtgevers of ontwerpers zich als champions opstellen en een duidelijke duurzaamheids- of innovatiedoelstelling uitdragen, blijft hout gedurende het project op tafel. Daarnaast blijkt besluitvorming in projecten geen eenmalig moment, maar een doorlopend traject waarin teams regelmatig teruggrijpen op eerdere keuzes om nieuwe uitdagingen op te lossen.

Op basis van deze inzichten is het Diffusion of Innovations (DOI)-model aangepast voor de Nederlandse bouwpraktijk. Het model benadrukt motivatie als startpunt, projectshaping en samenwerking als samenhangende dynamieken, een beslissingsfase die herbeoordeeld kan worden, en kennisdeling tussen projecten als voorwaarde voor brede opschaling.

Praktische aanbevelingen zijn:

1. *Betrek leveranciers en specialisten zo vroeg mogelijk*, zodat risico's door onzekerheid en gebrek aan kennis worden verminderd en detaillering, indeling van het grid en prefabricageplannen vanaf het begin worden geoptimaliseerd voor hout.
2. *Werk vanaf de start integraal en multidisciplinair* om onderlinge afhankelijkheden tussen projectfactoren goed af te stemmen. Dit vermindert onzekerheid, versterkt de haalbaarheid en optimaliseert zowel kosten als doorlooptijd.
3. *Leg gezamenlijke ambities vroeg vast en bewaak deze* door duidelijke duurzaamheids- en prestatiedoelen vooraf te definiëren en ze actief te bewaken tegen kosten- en risicodruk.
4. *Positioneer hout zowel vanuit duurzaamheid als vanuit marktvoordeel* door het niet alleen neer te zetten als een milieuvriendelijke keuze, maar ook als een bron van meerwaarde door extra verdiepingen, snellere bouw en marktonderscheidend vermogen.
5. *Versterk structurele kennisdeling tussen projecten* door systematisch ervaringen en data te delen en zo onzekerheid te verkleinen en sectorbrede leerprocessen te versnellen.

Als conclusie: meerlaagse houtbouw kan alleen versnellen als gemotiveerde actoren het initiatief nemen, projecten vanaf de start integraal worden ingericht en ervaringen actief worden gedeeld. Onder die voorwaarden kan hout zich ontwikkelen van pioniersmateriaal tot een volwaardig mainstream alternatief voor de Nederlandse bouwsector.

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1 Introduction to the topic

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The global construction industry faces growing pressure to provide high-density, sustainable housing solutions in urban areas. In densely populated countries like the Netherlands, this demand is driven by limited land availability. Vertical expansion through multi-storey buildings, therefore, is increasingly seen as a necessary way to maximise space efficiency and accommodate the growing population. However, conventional building materials like concrete and steel significantly contribute to global carbon emissions, making the construction sector one of the largest greenhouse gas emitters (Quesada et al., 2018).

The Netherlands aims to reduce emissions from the built environment by requiring energy-efficient buildings and circular materials, supported by policy incentives like the National Climate Agreement (Government of the Netherlands, 2019). These national goals align with global commitments such as the Paris Agreement, which aims to keep global warming well below 2 degrees Celsius by achieving net-zero emissions by 2050. Countries must create and follow plans to reduce carbon emissions under this agreement, and the construction industry is seen as an important area to improve (Global Buildings Performance Network, 2023). In order to address both environmental and housing concerns, finding scalable, sustainable alternatives to conventional building materials has become a critical priority. However, the transition to more climate-friendly building materials has been gradual.

Timber construction is emerging as a promising alternative to traditional building materials. Its feasibility has been demonstrated in low-rise residential buildings due to, for instance, its energy efficiency, carbon sequestration benefits, and prefabrication potential (Haisma et al., 2023). Innovations such as cross-laminated timber (CLT) and glued laminated timber (GLT) have shown that tall timber structures are feasible, offering both strength and sustainability benefits (Quesada et al., 2018). However, despite these well-documented benefits, timber remains underutilised in large-scale, multi-storey developments in the Netherlands, where its potential is recognised but its adoption in the built environment remains relatively low.

1.1. Motivation

The construction industry is at a crucial point as it faces increasing pressure to provide sustainable, high-density housing solutions in urban areas while reducing its environmental impact. As climate change accelerates, rising temperatures and more frequent extreme weather events create new challenges for the built environment, highlighting the need for materials that improve building resilience while minimising carbon footprints (PlanRadar, 2022). Timber construction is particularly promising due to its low carbon footprint, circular economy potential, and scalability for multi-storey applications (Haisma et al., 2023).

Furthermore, timber's ability to sequester carbon and its efficiency in prefabrication make it an attractive option for sustainable urban development. In the broader context of decarbonisation, timber plays a key role in reducing emissions in construction by contributing to three core decarbonisation strategies: improving energy efficiency, transitioning to renewable energy sources, and utilising sustainable construction materials (PlanRadar, 2022). Among these strategies, reducing embodied carbon is especially important, as material production remains one of the largest contributors to CO_2 emissions in the sector.

Despite its recognised potential, the full benefits of timber construction remain underexplored in multi-storey urban developments. Understanding the barriers that prevent firms from choosing timber and the enablers that could promote broader implementation, particularly within the fragmented project-based structure of the construction industry, is necessary to ensure timber construction can be more widely integrated into mainstream projects. By addressing these aspects, timber construction can contribute to both sustainability goals and the urgent demand for high-density urban housing.

1.2. Research gap

To meet climate goals and improve sustainability in the built environment, the adoption of alternative building materials must accelerate. Timber construction offers a promising way to reduce carbon emissions and enhance circularity in the building industry. However, despite the recognised potential of timber as a sustainable material, its adoption in multi-storey construction in the Netherlands remains slow, hindered by various barriers and adoption challenges. Understanding these barriers and the role of stakeholder motivation and project dynamics in reinforcing or overcoming them is critical to ensuring that timber can be effectively integrated into mainstream construction practices. The research gap comprises a practical problem and a literature gap, both of which are explained in the next sections.

1.2.1. Practical problem

Compared to low-rise timber buildings, which have been more widely accepted, multi-storey timber construction faces more challenges. These challenges are not only technical, such as concerns about structural stability, fire safety, and sound insulation, but also involve broader uncertainties related to market acceptance, regulatory stability and financial feasibility.

A primary reason for this reluctance is that multi-storey timber functions as a project-level innovation in Dutch practice. It is perceived as new by the temporary coalition that decides on the structural concept, and it reconfigures established routines and roles. At this scale, engineered timber introduces unfamiliar structural systems and requires performance verification for fire, acoustics and moisture. Furthermore, there is little local precedent to benchmark against, and it relies on procurement and assurance processes that many stakeholders have not yet institutionalised (Santana-Sosa & Kovacic, 2022). As a result, project teams do not see it as a straightforward material replacement but as a new approach to delivering a building, which increases perceived uncertainty and reinforces reliance on established solutions. Cost expectations often amplify this caution, as benchmarks are not yet established and learning effects are uneven across the market (Jones et al., 2016). Taken together, this perceived newness helps explain why uptake remains cautious despite widely acknowledged sustainability benefits (Hossain & Ng, 2018).

Effective stakeholder cooperation is particularly crucial for multi-storey timber construction because it requires decision-making and alignment among multiple actors. The prefabricated nature of timber components demands integrated design processes that influence the entire project lifecycle. However, current construction processes in the Netherlands face difficulties in promoting effective collaboration among stakeholders, hindering the integration of timber.

To facilitate the transition to timber construction, it is essential to understand the specific project-level barriers and enablers, and how stakeholder influence and project dynamics shape alignment, influence financial feasibility, and interact with regulatory adaptation. These barriers create uncertainty in decision-making, influencing the willingness of stakeholders to adopt timber and affecting the scaling of multi-storey timber projects. Addressing these challenges is necessary for realising timber's potential as a sustainable solution for high-density urban development.

1.2.2. Literature gap

Much of the existing literature on sustainable material adoption in construction has primarily examined the technical feasibility of timber construction and the regulatory landscape shaping its adoption. These include technical aspects like fire safety, structural stability, and acoustic performance. However, these studies do not sufficiently explore how timber is adopted in multi-storey buildings and the role of the different stakeholders in these decisions. In particular, there is limited work that examines project-level adoption within temporary coalitions and explains why adoption often stalls in early phases in multi-storey contexts.

A notable contribution to this field is the research by Law (2023), who examined the socio-technical and enabling processes in timber construction using the Technological Innovation System (TIS) framework. Her study identified key factors and market actors that influence large-scale timber adoption, focusing primarily on publicly led, low-rise timber housing projects in the Netherlands. The work by Law confirms that transition theory is useful for studying how timber is being adopted and highlights the different stakeholders and enabling environments in timber innovation within the public housing domain. This research, however, takes a different approach in both its theoretical and empirical scope. It uses the Diffusion of Innovations (DOI) as the primary framework to examine project-level adoption decisions, barriers, and enablers. Law's research provides a key point of reference, but this research develops a distinct analytical approach with different tools, case types, and research questions. Specifically, it addresses a gap by examining how adoption unfolds within projects—how temporary coalitions progress, or fail to progress, from initial awareness to persuasion and decision —and by comparing full and hybrid structural concepts within the same analytical framework.

Unlike the TIS framework, which is mainly used to study the emergence and structure of innovation systems over time, this research uses a more focused approach to understand timber adoption within construction projects. TIS is well-suited for analysing how an innovation develops and how it is shaped by broader system functions such as market formation and institutional support. However, as also noted by Law (2023), the TIS framework does not capture well the practical organisational processes, including how project- and firm-specific decisions are made and their influence. Moreover, the TIS framework does not allow for easy comparison between different structural systems, like full timber and hybrid timber, because of its focus on the system rather than the decision-making contexts. For this reason, this research adopts the Diffusion of Innovations (DOI) framework as a primary framework to study how timber adoption occurs within construction projects, focusing on the project-level decisions that shape material use. DOI is, therefore, positioned here as a project-focused process lens suited to temporary, multi-stakeholder decision-making. It complements, rather than replaces, system-level views.

This research uses the Diffusion of Innovations (DOI) framework to both trace how adoption unfolds across stages—knowledge, persuasion, decision, implementation, and confirmation —and to structure the identification of adoption barriers and enablers for multi-storey timber construction projects (Rogers, 2003). In practice, DOI is applied in two complementary ways: (1) its five perceived attributes (relative advantage, compatibility, complexity, trialability, and observability) help explain how stakeholders evaluate timber; and (2) its stage-based innovation-decision process clarifies when and why adoption in projects progresses or stalls (Rogers, 2003). This dual lens is operationalised in a comparative case study (full-timber and hybrid-timber) to clarify the mechanisms that advance or hinder adoption.

The use of DOI as the framework brings clarity and analytical depth. At the same time, this research explicitly adapts the framework to the fragmented, project-based, multi-stakeholder context of the construction industry. This ensures that the analysis captures how adoption unfolds in practice while remaining focused on project-based decisions, stakeholder influence and motivation, and the identification and comparison of barriers and enablers.

1.3. Research goal

The primary goal of this research is to analyse how stakeholders adopt multi-storey timber construction, what factors influence their adoption decisions, and how adoption barriers and enablers shape their choices. By focusing on a comparative analysis of a full timber project and a hybrid timber project, this research aims to gain insights into the practical and strategic considerations project teams face when implementing multi-storey timber construction in the Netherlands.

This research will explore the key factors that either accelerate or hinder timber adoption at the project level, such as assessing its relative advantage over traditional materials and its compatibility with industry regulations. Special attention is given to how stakeholder motivations and project dynamics reinforce or overcome these barriers and enablers. By analysing the interplay between these factors, this research aims to uncover the mechanisms that drive or hinder the shift from traditional building materials to timber.

The outcome of this research will offer practical recommendations to support the wider adoption of multi-storey timber in the Netherlands. By structuring the key barriers and enablers and linking them to relevant stakeholders where applicable, this research will guide industry professionals on overcoming adoption challenges and facilitating the integration of timber into mainstream construction practices.

1.4. Research questions

For this thesis, the following main research question is proposed:

How can the adoption of timber in multi-storey construction projects be accelerated by identifying key barriers and enablers using the Diffusion of Innovations framework?

To answer the research question, several sub-questions will be answered. Each of these will address a different aspect of the research question, ensuring a clear understanding to answer the main research question fully:

1. *What are the current barriers and enablers influencing the adoption of timber in multi-storey construction?*

   The first question provides a descriptive overview of the current state by identifying the key barriers and enablers shaping the adoption of full timber and hybrid timber construction. This question provides the basis for determining the conditions that support or hinder adoption.

2. *How do stakeholder roles and project dynamics influence the presence of barriers and enablers in full timber and hybrid timber projects?*

   The goal of the second question is to examine how stakeholder roles and project dynamics influence the presence of barriers and enablers in full timber and hybrid timber projects. It explores how project structures, collaboration models, and the timing of actor involvement affect the way timber's innovation attributes are experienced in practice.

3. *What role does stakeholder motivation play in initiating and sustaining the adoption of timber in multi-storey construction?*

   This final sub-question investigates the possible role of stakeholder motivation in the adoption of multi-storey timber, exploring how different levels and sources of motivation affect the consideration of timber as a material choice and influence the progression of adoption within projects.

1.5. Research design

The following research design, as shown in Figure 1.1, provides a structured approach to answering the main research question. The figure shows how the research goal, the research questions, and the data relate to each other in this research, integrating secondary data from the literature review with primary data obtained through the case study and semi-structured interviews. The research questions guide the data collection process, ensuring a thorough analysis of the barriers and enablers shaping multi-storey timber adoption. Based on the findings, strategic recommendations are developed to help accelerate multi-storey timber adoption, which in turn will support the research goals. The different research methods and data collection are explained in depth in chapter 2.

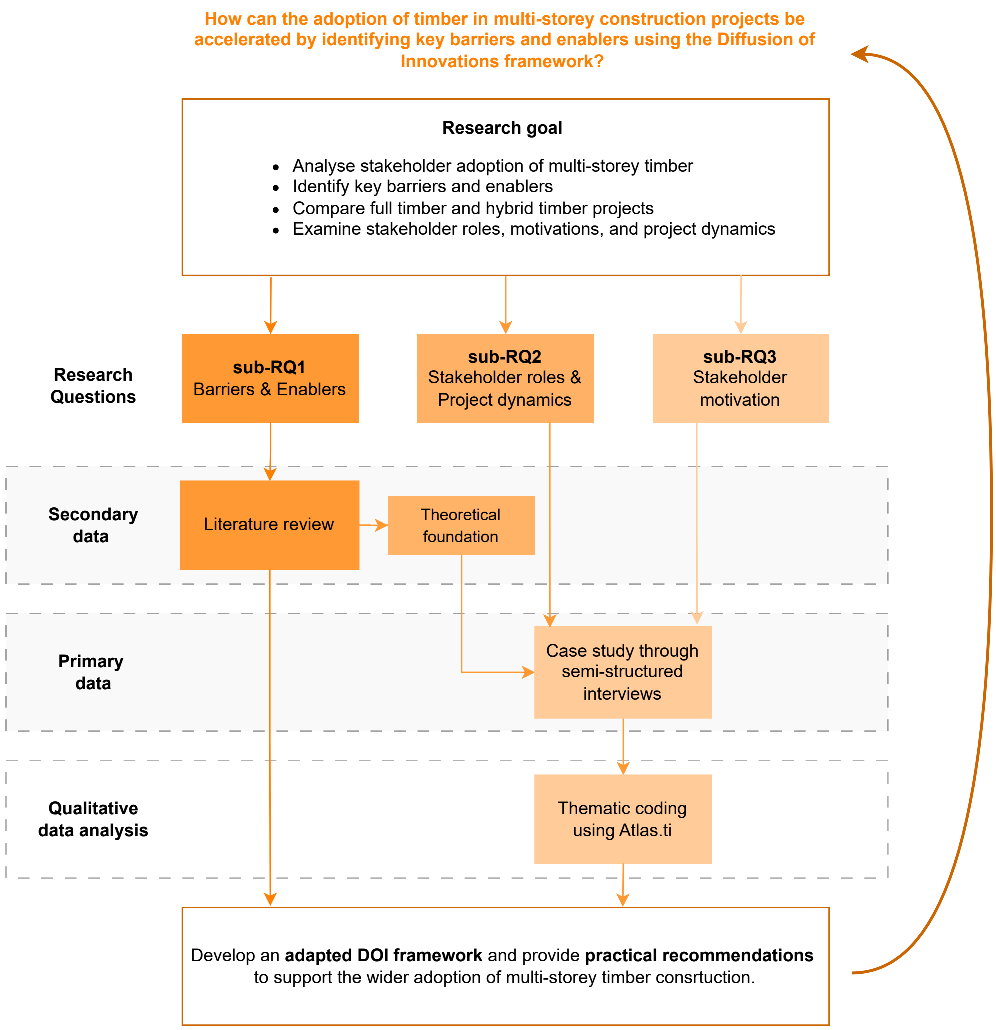

Figure 1.1: Overview of the research design

1.6. Research scope

The aim of this research is to analyse the adoption dynamics of multi-storey timber construction in the Netherlands by comparing full timber and hybrid timber projects. The scope of this research is defined by the following limitations:

- **Focus on adoption and project-based insights**: This research examines the adoption of multi-storey timber construction through a literature review and a comparative analysis of a full timber project and a hybrid timber project. By using the Diffusion of Innovations (DOI) framework, this research tries to understand decision-making and adoption at the project level, shaped by stakeholder roles, motivations, and project dynamics.
- **Definition of innovation**: In this research, "innovation" follows Rogers (2003): a practice perceived as new by the adopting unit. The focus is not on timber as a generic material but on engineered timber systems (e.g., CLT/GLT) in multi-storey construction in the Dutch context. For project decision-making units with limited prior experience and references, these systems are

perceived as new and uncertain, thereby fitting the DOI lens used in this study.

- **Geographical and sectoral focus**: This research focuses on two multi-storey projects in the Netherlands. This scope ensures consistency and access to detailed project data. Furthermore, low-rise projects will be excluded from the scope to ensure a focused examination of adoption challenges in multi-storey timber projects.
- **Focus on engineered timber**: This research specifically examines the use of engineered timber in structural applications such as cross-laminated timber (CLT) and glued laminated timber (GLT). It excludes traditional solid wood construction methods, such as light-frame or raw lumber. The word 'timber' used in this research applies to modern engineered wood products with increased strength and structural properties and possibilities.
- **Methodology and data collection**: This research adopts a qualitative approach, relying on a case study analysis and semi-structured interviews. Insights from the case study are compared with insights from the literature to contextualise and enrich the analysis of adoption barriers and enablers. No large-scale surveys or quantitative modelling will be conducted as part of this research.

2 Research Methodology

2 Research Methodology

2.1. Introduction

This chapter outlines the methodological structure used by describing the main research approach, the use of qualitative methods, and the use of the Double Diamond approach to guide the process. The methodology combines insights from literature and a case study, where semi-structured interviews are used to understand how decisions about timber adoption are made in practice. Furthermore, it outlines the measures implemented to ensure data quality and reliability.

2.2. Research design

2.2.1. Research approach

This research adopts a qualitative approach to analyse how multi-storey timber is adopted in the Netherlands through the lens of project-based stakeholder adoption and influence. A qualitative method is useful to get new theoretical insights while also allowing for the interpretation of the theory (Harrison et al., 2007, as cited in Fellows and Liu (2015, p. 9)). Furthermore, qualitative research is not only descriptive, but it also aims to understand why things happen by looking at stakeholder experiences and existing literature, not just at the number-supported hard facts (Fellows & Liu, 2015, p. 9) (Baarda, 2013, p. 24).

2.2.2. The Double Diamond

A design-based approach is applied to structure the research process, which is based on the Double Diamond model by Design Council (2023), to move from a problem towards a solution. This model supports iterative learning by going through four stages: Discover, Define, Develop, and Deliver. By diverging and converging through these phases, the model allows for broad exploration but also a focused refinement (Humble, 2023). The Discover and Define stages are about understanding the problem through the use of a literature review and stakeholder mapping. The Develop and Deliver stages are about collecting empirical data, analysing project dynamics, constructing the adapted framework, and formulating strategic recommendations. By using this approach, the research has a more open structure and is flexible at the beginning while eventually narrowing towards concrete outcomes.

A visualisation of this approach is shown in Figure 2.1, linking the research phases with the data collection methods.

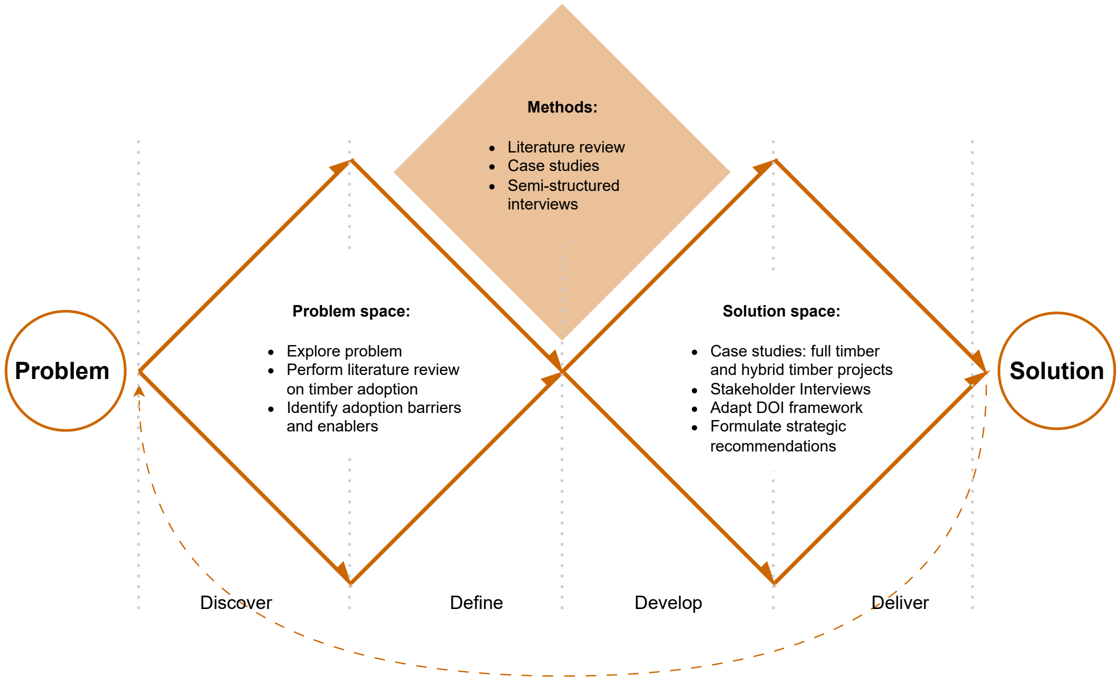

Figure 2.1: Double diamond research design (adapted from Design Council (2023))

The design approach fits well with the research objective, which requires both theoretical interpretation and practical insights. Because the Double Diamond model is structured and supports an iterative process, later findings from interviews and the case study can refine earlier assumptions from the literature review. The next section will explain how data is collected across the different phases of the Double Diamond.

2.3. Data collection methods

The research is structured in alignment with the Double Diamond model. Each phase has its own data sources and focus. In this section, the data collection methods used in this research are discussed through the two main stages of data: Discover & Define and Develop & Deliver.

This research uses both primary and secondary data sources:

1. *Primary data*: Information that is collected first-hand specifically for the research. This information was obtained through semi-structured interviews with key stakeholders and a comparative case study of two multi-storey timber projects. This data is original and specific to the research context, ensuring relevance and accuracy (Benedictine University Library, 2024).
2. *Secondary data*: This refers to pre-existing information that was collected for other purposes but is relevant to the current research. This data includes academic literature, industry reports, policy documents, and databases.

Discover & Define phases

The first phase, the Discover phase, of the research focuses on exploring the current state of timber construction in the Netherlands. This phase represents the problem space in the Double Diamond model, and it is aimed at understanding the industry context, the barriers and enablers within the industry, the different stakeholders involved, and the guiding theories for this research through secondary data gathering.

2.3.1. Literature review

The literature in this phase is aimed at building a strong theoretical foundation and answering the first sub-question of this research, which is: *What are the current barriers and enablers influencing the adoption of timber in multi-storey construction?* It starts by looking at the environmental impact of the construction industry and the growing pressure for more high-density and sustainable housing options in the Netherlands, which together help highlight the relevance of timber as an alternative material. The review, furthermore, includes an examination of the roles of different stakeholders involved in construction projects and how they influence adoption decisions. The Circle of Influence model is later applied to structure the stakeholder landscape in the literature framework. Key themes such as barriers and enablers of multi-storey timber were also identified and synthesised from the literature.

Academic search engines were used to gather the data for the literature review. These include Google Scholar and Scopus, but also cross-referencing through papers was used. To find the literature on barriers and enablers, keywords used included, but were not limited to, the following: ”multi-storey timber” OR ”mid-rise timber” OR ”high-rise timber” AND ”challenge*” OR ”barrier*” AND ”driver*” OR ”enabler*” AND NOT ”low-rise” OR ”single-storey”. Furthermore, searches were limited to research published in the last 10 years, and languages included English and Dutch to broaden the searches.

The searches initially produced over a hundred results, many of which were screened for relevance based on title or abstract. After removing duplicates and studies outside the scope of multi-storey construction, around 40 core publications were retained for in-depth review. These include both peer-reviewed journal articles and reports, supplemented by cross-referenced sources frequently cited in the field.

Additionally, literature on the Diffusion of Innovations (DOI) theory is reviewed (Rogers, 2003). Here, DOI is used as the primary analytical lens for this research. Introducing DOI early in the research process provided a framework for linking theory to real-world adoption choices, identifying and categorising adoption barriers and enablers, and informing the coding structure later applied in the case study analysis.

The following Define phase involves structuring the outcomes of the literature review to build the analytical framework of the study. Key barriers and enablers, along with insights into stakeholder roles and interactions, are narrowed down, and where possible, aligned with relevant aspects of the Diffusion of Innovations theory. These structured insights informed the development of the interview guide and served as the theoretical foundation for the case study analysis while remaining open to refinement in later phases.

Develop & Deliver phases

Building on the theoretical foundation established in the first part of the research, the second phase of the research focuses on collecting primary data through a qualitative case study. Data in this case study is collected through semi-structured interviews and, when necessary, relevant documents (Yin, 2014). This stage aligns with the Develop and Deliver phases of the Double Diamond model, where insights from the earlier phases are applied to two real-life cases and used to come up with practical recommendations.

This part of the research mainly focuses on answering the second sub-question: ”*How do stakeholder roles and project dynamics influence the presence of barriers and enablers in full timber and hybrid timber projects?* and the third sub-question of this research: *What role does stakeholder motivation play in initiating and sustaining the adoption of timber in multi-storey construction?*

2.3.2. Case study research and selection

The two case studies were selected for this research because they reflect different approaches to the adoption of timber in multi-storey construction, with both being situated in the Dutch context, making them accessible for data collection. Both are privately led developments, yet their organisational setups and adoption trajectories differ in analytically valuable ways.

Full timber project

The first case concerns a full-timber residential development. From the very beginning, the client, who also acted as the lead architect, set out with a clear sustainability ambition and positioned timber as the defining principle of the project, utilising it throughout all storeys of the building. This ambition resulted in a heavy front-loaded project setup. The building is located in a Dutch city, on the edge of a residential neighbourhood and adjacent to a major roadway and green space. This location, between dense urban fabric and a natural landscape, was deliberately chosen so that the building could symbolically embody a bridge between city and nature, integrating greenery into its design. The building rises ten storeys high, making it one of the tallest residential timber towers in the Netherlands, constructed with a timber core. It contains around 100 rental apartments, ranging from compact studios to larger family units. The building also offers flexible, subscription-based living, allowing occupants to use services such as guest rooms, workspaces, and mobility options through a digital platform.

The structure above ground is realised entirely in timber, including the core and lift shaft, with only the foundations in concrete. Prefabricated CLT wall and floor panels were assembled on site and supported by a glued-laminated timber column-and-beam system, with engineered joints ensuring structural continuity. Because the building does not rely on a conventional concrete core, overall stability is provided through prominent diagonal timber elements integrated into the facade. Architecturally, the design makes timber visible in both interior spaces and external elements. Outdoor amenity space is added through over 100 balconies supported by lightweight, ultra-high-performance concrete. Finally, vegetation is integrated into the facade and rooftop gardens, contributing to biodiversity and improving the microclimate.

In addition to offering housing, the building showcases biobased and circular design. The panel system uses recycled wood, such as reclaimed pallets, in some parts, while natural insulation materials reduce embodied impacts. Other innovations include the use of sensor technology to monitor building performance, solar panels, and smart water systems that are designed to achieve significant reductions in consumption. Together, these technical strategies support the project's broader ambition to operate as a net-zero, future-proof residential building. In this sense, the project is a clear example of a client-led pathway, where timber was established as a guiding principle before other design or commercial considerations came into play.

Hybrid timber project

The second case concerns a hybrid timber-concrete development. Unlike the first case, timber was not part of the initial brief but entered the process after a preliminary concept in conventional materials had already been developed. The project is located in a high-density Dutch business district, adjacent to a major mobility hub. The project is designed as a thirteen-storey office tower with a total floor area of approximately 16,000 square metres. The programme combines office floors with a large bicycle parking facility and a semi-public plinth. Furthermore, the office has roof gardens and three intermediate ”breath spaces” that provide indoor-outdoor zones to enhance comfort and well-being. The development is positioned as a next-generation office space, as it aims to meet Paris Proof standards, WELL Gold certification, and BREEAM Excellent ratings.

The building is realised through a ”table-construction” system: a concrete foundation and first level form the base, above which twelve storeys are built using a glued-laminated timber column-and-beam frame combined with prefabricated CLT floor panels. Together, the timber elements account for roughly three-quarters of the building's structural material. Stability and height are ensured by a central concrete core, two steel bracing levels, and steel facade diagonals, while engineered steel connectors integrate the timber and concrete systems. This hybrid approach reflects an effort to merge lightweight timber with conventional construction techniques to achieve a high-rise scale. The building also incorporates multiple sustainability measures, including rooftop solar panels, greywater and rainwater recycling systems, and features to encourage biodiversity.

The project was initiated by a private developer, but its direction was strongly influenced by the multi-tenant coalition that was formed together with two large international firms and the private developer before a plot was chosen. One of these tenants, the engineering firm, had a lease on its existing headquarters that was due to expire, creating urgency to secure a new location. At the same time, both tenants positioned themselves as organisations with high sustainability ambitions and sought a new office that would reflect this identity. The search for a suitable site took over seven years before an appropriate plot close to a mobility hub was secured. An internationally renowned architect was appointed to design the building. As the architect had no prior experience with timber, the initial design did not anticipate timber as a structural material, and this continues to be reflected in the outcome, where the facades conceal rather than express the building's timber elements. The organisational setup also included a contractor from the developer's wider holding group, ensuring a direct link to realisation. This combination of actors, with tenants playing an unusually prominent role as both future users and technical contributors, makes the project a distinct example of a tenant- and supply-driven adoption pathway, in which timber was added to an ongoing commercial development.

These contextual contrasts provide a strong basis for comparison, enabling an exploration of how barriers, enablers, stakeholder roles, and motivational factors differ between projects and how these dynamics shape decisions on timber adoption in practice.

2.3.3. Qualitative data analysis

The main data collection method of the two selected cases is through semi-structured interviews. These are done to gather primary, in-depth data on stakeholder perspectives and decision-making processes within the projects and to explore how adoption unfolds in practice. This method balances having a consistent structure in the interviews but also has the flexibility to explore important themes as the interview unfolds (Baarda, 2013). Participants are selected based on their involvement in either the full timber or the hybrid timber project. It is further ensured that a wide range of perspectives from the construction industry in these two projects were included. The Circle of Influence model was used as a guiding lens to ensure that different categories of stakeholders were represented in the interviews.

The semi-structured interviews were conducted either in person or via Microsoft Teams, with all sessions being recorded and transcribed using transcription functions. Each recording was reviewed and corrected manually to improve accuracy, as automated transcription tools often contain errors. All participants have explicitly consented to the recordings and transcriptions, with their data anonymised as outlined in the data management plan.

To analyse the data gathered from the interviews, a thematic analysis is done using ATLAS.ti, a website that offers specialised software for qualitative data analysis that helps apply codes to the unstructured interview data to uncover patterns and insights. This method was used in the research to find recurring themes and patterns regarding the adoption process of multi-storey timber construction.

To structure the qualitative analysis, the Gioia method was used (Magnani & Gioia, 2023). The Gioia method follows three phases:

- **First-order concepts**: Initial 'raw' data captured during the interviews, expressed in participants' own language to preserve authenticity and perspective.
- **Second-order themes**: Broader analytical themes developed from the first-order data, highlighting patterns and differences across stakeholder views.
- **Aggregate dimensions**: Synthesised categories that align the second-order themes with the DOI attributes and adoption process.

The use of the GIOIA method in this research ensures a structured and transparent connection between the empirical data and the theoretical outcomes by showing the different coding steps taken. Furthermore, keeping the first-order concepts close to participants' voices allowed for strong empirical grounding. The coding, through ATLAS.ti, began with organising and tagging the interview data, followed by grouping recurring concepts into second-order themes. These themes not only reflected the barriers and enablers identified in the literature but also the project dynamics and stakeholder motivation as key factors shaping adoption. The themes were then synthesised into broader dimensions that connected the empirical results to the DOI framework.

The Deliver phase of this research focuses on synthesising insights from the interviews to identify key patterns and to connect these findings with the earlier explored literature into a comprehensive framework. Here, the empirical findings of timber adoption are reflected in the innovation-decision process of the DOI theory. In this adapted framework, the DOI model was extended to account for stakeholder motivation and project dynamics, providing a more accurate reflection of how adoption unfolds in project-based, multi-stakeholder construction contexts. From this framework, strategic recommendations were derived to support the wider adoption of multi-storey timber construction.

2.4. Data management and limitations

2.4.1. Limitations and drawbacks

Even though the chosen methods offer a good way to answer the research questions, some limitations and drawbacks are recognised:

- *Time constraints*: The goal is to finish this research within 6 months; this might restrict how detailed the literature review can be and how many interviews can be done.
- *Small sample size*: As the number of interviews is limited, these will provide a certain depth, but do not represent the entire construction industry. The analysis focuses on detail rather than statistical representation.
- *Limited generalisability*: Findings from the case study may not apply to other multi-storey projects. Therefore, conclusions from these case studies need careful consideration.
- *Response and interpretation bias*: Both the interview responses and the researchers' interpretation of these responses may introduce bias, therefore also necessitating careful consideration.
- *Geographic context*: As both of the cases are in the Netherlands, findings from this research might be less applicable to countries with a different context.

2.4.2. Data management plan

This research followed the FAIR principles, meaning they are findable, accessible, interoperable, and reusable. This ensures effective data management and long-term usability (Barker et al., 2022). All data, collected through interviews, case studies, and literature reviews, was clearly documented and consistently named for easy discovery and reuse. Anonymisation protocols were applied to protect participant privacy, and consent was obtained before data sharing. Furthermore, digital data on the different case studies was securely stored on password-protected servers, while physical records of these case studies were stored in secure locations at the company.

2.4.3. Human participation

This research involves human participation through semi-structured interviews with key stakeholders, including architects, engineers, project managers, and others involved in multi-storey timber adoption. Ethical approval was obtained from the Human Research Ethics Committee (HREC) to ensure that they comply with the ethical guidelines and participant protection. Informed consent was secured from the participants, the purpose of the research was detailed to the participants, and they had the right to withdraw at any time. Data were anonymised to protect participant identities and stored safely on a secure online server.

2.4.4. Confidentiality

Maintaining the confidentiality of the participants is of high importance to this research. All data collected was handled in strict confidence, ensuring that personal identifiers were removed to protect participant identities. Access to sensitive data will be restricted to only authorised people.

3 Literature review

3 Literature review

3.1. Introduction

In this chapter, the literature relevant to this research is reviewed to provide a theoretical foundation for understanding the adoption of timber in multi-storey construction. It starts with outlining the environmental impact of the construction sector, followed by the current environmental and policy pressures and timber as an alternative material. Then, the stakeholder landscape is given, after which the theoretical framework, the Diffusion of Innovation (DOI), is discussed. Finally, the adoption barriers and enablers are provided and structured using the DOI key attributes to innovation uptake.

3.2. Climate change in the construction industry

3.2.1. Urbanisation and high-density housing

The global construction industry is at an important point where it faces growing pressure to deliver high-density, sustainable housing solutions in rapidly urbanising cities. As urban populations grow, the demand for large-scale, high-rise construction rises, driven by housing shortages and the need for efficient land use (Bajaj, 2023). This trend is especially evident in densely populated countries like the Netherlands, where limited land availability requires vertical growth in urban areas to enhance spatial efficiency (Korteweg, 2021). Research by Evers et al. (2024) supports this, as the Netherlands shows an above-average population growth and a below-average urban fabric expansion. Urbanisation per capita reinforces this contrast, as nearly 1.7 million people have been added to the population of the Netherlands over the past years, showing the need for more efficient, denser forms of urban development (Evers et al., 2024).

The Netherlands currently faces a housing shortage of more than 370,000 homes (Langen, 2025), a figure projected to grow if building rates remain unchanged (Collins, 2024). As most of the land in the Netherlands is already used for agriculture, nature, or existing urban use, meeting the growing housing demand within the current area is becoming more and more challenging (Collins, 2024). This densification trend means that more people live within the same amount of space, which helps limit the need for new land development (Bajaj, 2023). However, it also creates major challenges, like more traffic, poorer air quality, and stronger effects from climate change (European Commission, 2022). In response to these issues, strategic urban development policies in the Netherlands are increasingly focused on integrating high-rise buildings into urban transport hubs and underutilised areas to promote more sustainable, compact cities (Government of the Netherlands, 2019).

3.2.2. Environmental impact of the construction industry

The construction industry has traditionally relied on materials such as concrete and steel to meet the rising demand for high-density housing due to their scalability, structural reliability, and cost-effectiveness. However, these materials significantly contribute to global carbon emissions and resource depletion. The construction sector is responsible for approximately 37% of global greenhouse gas emissions, as shown in Figure 3.1, making it one of the largest emitting industries worldwide (United Nations Environment Programme, 2023). From this total, about 27% comes from building operations, while around 10% is related to the materials and processes involved in the actual construction, known as embodied energy (UNEP, 2022). Embodied energy refers to the total energy used throughout the entire production process of a material or building component. This includes extraction, manufacturing, transport, and delivery, which together represent the upstream environmental impact of the building's life cycle (Asdrubali et al., 2017). As societal and governmental pressure to meet global climate commitments grows, transitioning towards low-carbon materials is crucial for the construction industry to reduce its environmental impact while ensuring structural integrity (Quesada et al., 2018).

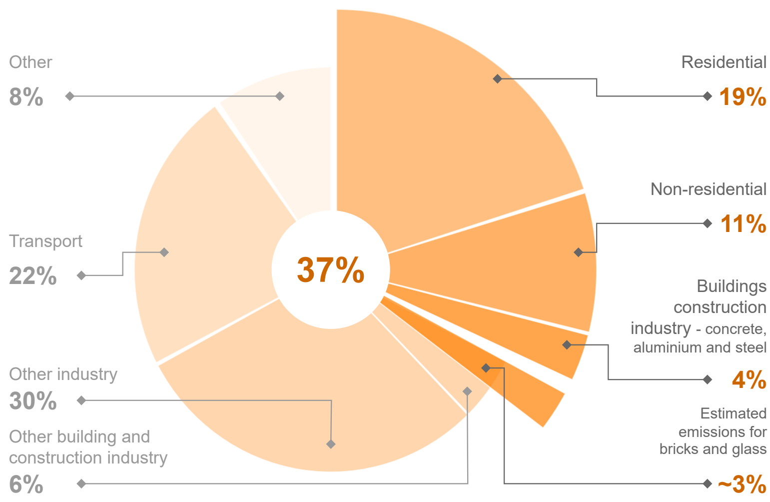

Figure 3.1: Total annual global CO_2 emissions (adapted from UNEP (2022))

In addition to being a major contributor to global greenhouse gas emissions, the construction sector places a heavy burden on energy resources and raw material reserves. Construction consumes about one-third of global final energy, and construction materials dominate resource consumption (UNEP, 2022). These impacts are largely due to the widespread use of high-carbon materials like concrete and steel, which dominate both structural and infrastructural developments. Moreover, construction and demolition account for around 35% of the total waste generation in the European Union, with much of it ending up in landfills because reuse and recycling are limited. This highlights the sector's inefficiency in resource recovery.

Although there has been a growing interest in the design of low-carbon buildings, many existing strategies still fail to address the entire construction life cycle, from material selection to demolition. This is relevant for this research, as the adoption of timber construction helps in reducing the embodied carbon of the building, an often overlooked part of lifecycle emissions. This gap is especially clear in the way that most policies and practices still focus primarily on reducing operational carbon while often overlooking the embodied emissions of material production, construction and demolition (Pomponi & Moncaster, 2016). Operational carbon refers to the emissions caused by heating, lighting, air conditioning and powering the building during its lifetime and has recently been reduced due to building regulations (Santana-Sosa & Kovacic, 2022). Embodied emissions, however, are locked into the building from the beginning and therefore difficult to mitigate once construction is complete. This makes it important to choose materials carefully in the early stages (Pomponi & Moncaster, 2016). Choices made in the design phase are especially important, as in this stage up to 80% of the product's environmental impacts are determined (European Commission (2012), as cited in European Commission (2020)). In this research, the use of timber as an alternative material that addresses the problem of embodied carbon in the building lifecycle compared to conventional materials like concrete and steel is investigated.

Apart from existing strategies failing to address the entire construction life cycle, Pomponi and Moncaster (2016) highlight that most life cycle assessments are also incomplete. 90% of the LCAs focus only on manufacturing, and they fail to also address the end-of-life stages. This can, furthermore, lead to misleading conclusions and insufficient strategies in relation to the building life cycle and circular design.

The building life cycle is a broad subject, which has many definitions in the literature. In the context of this research, the building life cycle, as defined by the European Standards in the EN 15804, is used. Therefore, the building life cycle includes 5 stages: the product stage, the construction process stage, the use stage, and the end-of-life stage, as shown in Figure 3.2. The building life cycle, therefore, starts with the raw material supply and ends with the disposal of the building materials (BRE Global, 2018). After the disposal, there is potential for reuse, recovery, and recycling.

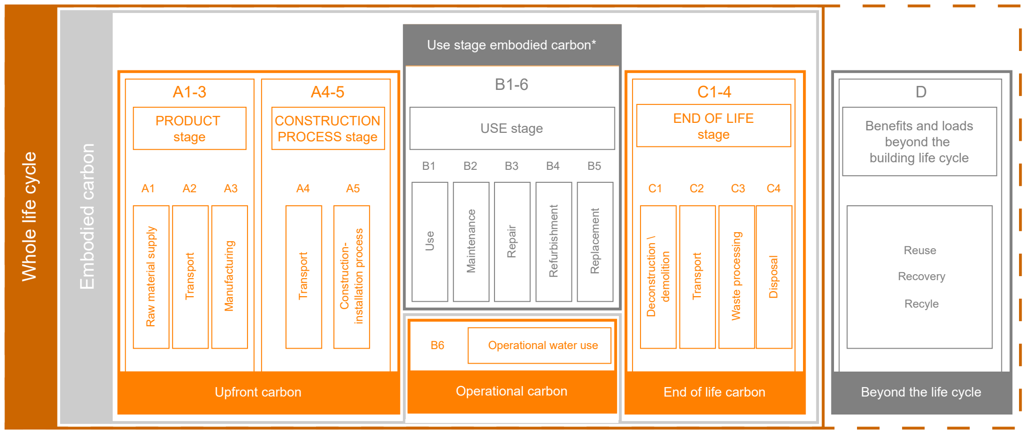

Figure 3.2: Life cycle stages, as described in EN 15804 (adapted from GRESB (2022))

While operational carbon is primarily emitted during the use stage of the building, embodied carbon is generated through all earlier and later life cycle stages, including material production, construction, and end-of-life processing. However, as mentioned above, it is challenging to reduce embodied emissions once construction has begun; therefore, circular design is crucial. This entails extending the useful life of materials and components through reuse, adaptability, and ease of disassembly. According to the EU Circular Economy Action Plan, this helps reduce waste production and encourages the recovery of high-quality materials while also reducing the need for virgin materials, all of which help decrease the environmental impact of the building (European Commission, 2020). This research focuses on reducing embodied carbon by looking at the adoption of engineered timber as an alternative building material to promote circularity and low-carbon building goals.

As the industry seeks to address both environmental and housing concerns, finding scalable, sustainable alternatives to conventional building materials has become a critical priority. However, the transition to more climate-friendly building materials has been gradual, as mentioned by Mewomo et al. (2023). In their paper, they highlight that a lack of awareness and knowledge about sustainable materials among industry stakeholders negatively influences this transition (Mewomo et al., 2023).

One of the solutions to achieve sustainability in construction is the use of bio-based and low-carbon materials, which provide alternatives to carbon-intensive options like concrete and steel, which dominate the construction industry. These alternatives, such as engineered timber, are getting more recognised for their potential to lower embodied emissions, promote a circular economy, and enable faster, lower-waste construction methods (Giacomello et al., 2024).

3.2.3. Policy and regulatory pressures

Following the environmental challenges in the construction industry, several national and international policies have been introduced to pressure the construction sector to adopt more sustainable practices.

At the global level, several important policy frameworks have set the direction for reducing carbon emissions, including the construction sector. One of the most important is the Paris Agreement, adopted in 2015, which requires all participating countries to keep global warming below 2 °C. While the agreement does not explicitly target the construction industry, it requires countries to submit and regularly update their nationally determined contributions (NDCs), and around 60% of the countries have cited decreasing building-related emissions as part of efforts to cut emissions (UNEP, 2022).

To support this, at the European level, the European Union introduced the European Green Deal, which outlines the goal of achieving climate neutrality by 2050. A key part of this plan is the Circular Economy Action Plan, which promotes actions like longer building lifespans, designing for disassembly, and a revision of material recovery targets set in EU legislation for construction and demolition waste (European Commission, 2020). These EU-level ambitions directly inform national climate policy in member states.

As one of the leading contributors to emissions, the construction sector has been a key focus of these international agreements. In response to these global and European efforts, the Netherlands has also introduced policy incentives and frameworks, such as the National Climate Agreement (Government of the Netherlands, 2019), which serves as the main national plan for reducing carbon emissions in the built environment. Within this framework, the construction sector is expected to reduce CO_2 emissions by 3.4 megatons by 2030 (Government of the Netherlands, 2019). This reduction is linked to actions such as phasing out natural gas, improving energy performance, and using sustainable materials. Furthermore, the agreement sets a target of a 50% reduction in primary raw material use by 2030, as part of the transition to largely circular and sustainable value chains by 2050.

Complementing the Climate Agreement, the Circular Construction Economy Programme translates EU goals into practical measures for the Netherlands. This programme seeks to embed lifecycle thinking into building practices. Key instruments include mandatory environmental performance assessments (MPG) for new buildings, encouragement of biobased and modular construction, and the development of building components designed for reuse (Rijksoverheid, 2023). The MPG threshold, which applies to both public and private sector developments, has been gradually tightened since 2021, creating a clear incentive to use materials with lower embodied carbon, such as timber and other natural biobased resources. Moreover, the Netherlands is advancing its national agenda on biobased construction through programmes like the ”Nationale Aanpak Biobased Bouwen”, which has the goal to increase biobased materials like timber within the built environment, trying to promote innovation and market scaling through collaboration between government and industry stakeholders (Rijksoverheid, 2023).

The international and national frameworks discussed above show a growing alignment between climate goals and material innovation in the construction sector. Biobased materials, furthermore, receive increasing policy attention as viable alternatives for carbon-intensive materials. Regulations like the MPG and programmes like the Nationale Aanpak Biobased Bouwen show a push for natural, renewable materials, where low-embodied-carbon solutions are favoured.

3.2.4. Timber as a response to climate change

As the construction sector seeks to reduce its environmental footprint and align with circular economy goals, biobased materials are gaining significant attention as a means to meet structural demands while reducing emissions. Among biobased materials, timber construction is emerging as a promising alternative to traditional building materials. Its feasibility has been demonstrated in low-rise residential buildings due to, for instance, its energy efficiency, carbon sequestration benefits, and prefabrication potential. These features make timber a strong option for sustainable development, especially for larger-scale projects.

Innovations such as cross-laminated timber (CLT) and glued laminated timber (GLT) have shown that tall timber structures are feasible, offering both strength and sustainability benefits (Quesada et al., 2018). These structural innovations make it possible to use engineered timber in more types of buildings, combining good ecological performance and structural integrity.

Timber construction offers several environmental benefits, including reduced greenhouse gas emissions, improved energy efficiency, and long-term carbon sequestration. A recent study, on a high-ambition scenario, projected that by shifting 50% of residential construction to bio-based materials such as CLT, the European sector could achieve an 18% reduction in carbon emissions by 2030 (Haisma et al., 2023). Other research suggests that up to 60% of the embodied CO_2 emissions could be reduced by shifting to timber as the primary material because 45% of the buildings’ embodied carbon comes from its superstructure (Santana-Sosa & Kovacic, 2022). This shows how much can be achieved in emission reductions by switching to low-carbon building materials. In addition, the prefabricated nature of engineered timber elements reduces construction waste and site disturbances, promoting circular economy practices. This makes timber a material that is well-suited for climate-responsive construction, as it offers both environmental and practical advantages across the building process (Gosselin et al., 2018) (Quesada et al., 2018).

Looking back at the construction life cycle, according to industry benchmarks, the materials and construction phase alone can be responsible for more than 60% of a building's overall carbon emissions, with end-of-life impacts contributing another 12% (GRESB, 2022), as shown in Table 3.1. This shows how important it is to consider embodied carbon when choosing materials. In these early and late life cycle stages, when emissions are frequently fixed before the building is even used, engineered timber offers a great opportunity to cut emissions.

Table 3.1: Estimated Carbon Emissions per Life Cycle Stage in Office Construction (in kg CO_2 eq/m^2 GFA) (adapted from GRESB (2022))

Life Cycle Stage	% of Total Impacts	Detail Description	Code	eToolLCD Benchmark
Materials & Construction	64%	Product Stage	A1–A3	600
		Transport of Equipment & Materials	A4	120
		Construction	A5	58
Use (B6, B7 excluded)	24%	Use of Products	B1	298
		Maintenance	B2	
		Repair	B3	
		Replacement	B4	
		Refurbishment	B5	
End of Life	12%	Deconstruction / Demolition	C1	150
		Transport of Waste Off-site	C2	
		Waste Processing	C3	
		Disposal	C4	
Total	**100%**			**1220**

In addition to its environmental value, timber is becoming more important in the context of urbanisation and housing demand. As highlighted earlier, the Netherlands has limited space and a growing housing shortage, leading to more dense, multi-storey buildings. Timber is well-suited for this because it can be prefabricated and built in a relatively short amount of time, which is an important advantage when both time and space are limited.

However, despite these well-documented benefits, timber remains underutilised in large-scale, multi-storey construction. Like many other European countries, the Netherlands has recognised the potential of timber, but its adoption in the built environment remains relatively low. While technical feasibility and sustainability advantages are known in the industry, the actual market uptake of timber in urban contexts is still slow. This gap between potential and practice is shaped by many factors, like institutional practices, project-level decisions, and industry norms. Furthermore, the complex stakeholder landscape plays a critical part in shaping how, where, and whether timber is adopted.

3.3. Stakeholder landscape in multi-storey timber

Adopting timber in multi-storey construction is not just about what is technically possible or what policies allow, but also about the actors who make or influence these decisions throughout the building process. Especially in the Dutch context, where the construction industry is very fragmented, understanding which stakeholders are involved is essential for understanding why the implementation of timber construction is still slow (van de Rijt et al., 2010). Recent research has emphasised that stakeholder dynamics play an important role in driving innovation within sustainable construction, especially regarding novel materials like engineered timber (Law, 2023). Law's examination of residential timber projects shows how institutional support and collaboration between stakeholders can drive wider system change. To further understand timber adoption at the project level, where the material choices are made, further stakeholder mapping is therefore necessary to explore which stakeholders are involved and how.

This analysis builds on the approach taken by Law (2023), who examined residential timber construction by distinguishing between inner and outer layer stakeholders, with a focus on stakeholder dynamics from the contractor's point of view. While her work offers a useful starting point for identifying key actors, this research adopts a more project-focused perspective by using the circle of influence model to classify stakeholders based on how closely they are involved in decision-making within multi-storey timber construction projects. This will allow for a more precise mapping of influence while also looking at some of their roles in enabling or hindering adoption.

This section maps the key stakeholders involved in shaping conditions for timber adoption. As this research studies the adoption of timber by firms, particular attention is given to stakeholders who directly influence material choices and the adoption of innovation within construction projects. To structure this stakeholder analysis, the circle of influence approach by Covey is applied (Learning Loop, 2022). Covey's model distinguishes between three circles of influence:

- The **circle of control**, which includes actors that have direct decision-making power over a project.
- The **circle of influence** includes those who do not make final decisions but are able to (strongly) shape the direction of a project.
- The **circle of concern** covers the wider actors that affect the overall context but are not directly involved in specific projects.

This framework, shown in Figure 3.3, helps to map out the network of actors based on their proximity to key decisions and how much they can influence the use of new innovations. It separates those stakeholders who directly impact project decisions, such as material choices, from those in more indirect, supporting roles. Although this section does not yet analyse specific impacts, this stakeholder mapping will later help with understanding how the different actors relate to the identified barriers and drivers.

In the fragmented Dutch construction sector, where responsibilities are divided among many actors, the layered structure of influence, as shown in this framework, helps clarify which stakeholders affect the adoption of timber and how directly they are involved in project-level decisions.

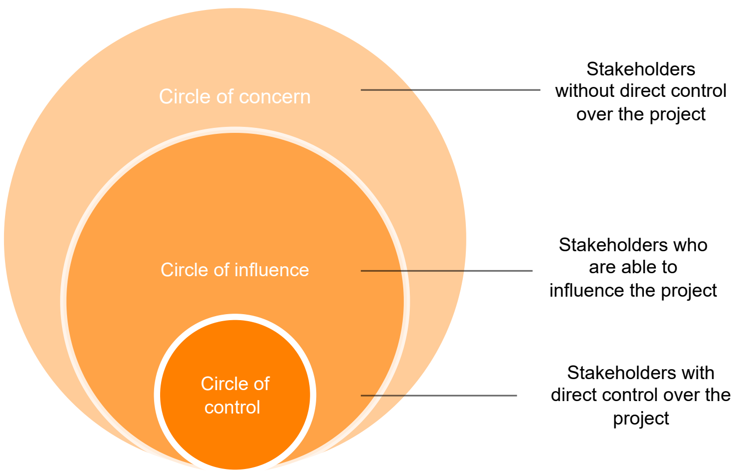

Figure 3.3: Circle of influence (adapted from Learning Loop (2022))

3.3.1. Circle of control

The stakeholders who, in multi-storey timber construction, play a central role in the project are placed in the circle of control. They shape project goals, influence early design and technical choices, and define material choices. Their involvement is crucial in steering the project's direction.

Client

The client typically initiates the construction process and sets its overall direction. They are responsible for setting project objectives, securing financing, and appointing competent designers and contractors (NFU Mutual, 2021). In contrast to the stakeholder analysis by Law (2023), the two case studies in this research are privately led developments, meaning government clients are excluded from these two cases and, therefore, excluded here in the stakeholder mapping. However, even within private-sector projects, the term ”client” includes various types of actors, each with its own goals and time horizons. Key types of clients include:

- **Project developers**, who typically operate with a short-term profit model and focus on maximising return on investment. Because of this, they often base decisions on what is financially safe and follows market trends, which makes them less likely to choose new or unfamiliar materials.
- **Investors**, such as pension funds or asset managers, who prioritise long-term returns and risk mitigation. These clients are usually more willing to use sustainable materials if they fit their long-term goals.
- **Building owners**, such as commercial firms or housing associations, who develop projects for their use. They have a direct involvement in the construction process and often set performance and durability goals.

Each of these client types influences the design choices and the potential for innovation in different ways. What they have in common, though, is their early involvement and central role in the project, where their support, or lack of support, for innovative design solutions has a major impact on how the project develops. This is why clients are considered among the most influential stakeholders. Clients are responsible for commissioning construction work, setting key project requirements, and appointing principal project partners. Clients typically have a significant financial influence and control over project commissioning. They can also place specific requirements into the procurement process, shaping design outcomes like the choice of materials (NFU Mutual, 2021).

From a project perspective, clients influence timber adoption through how much risk they’re willing to take, procurement preferences, and how strongly they value sustainability. In large-scale housing projects, their priorities, such as return on investment or their commitments to ESG goals, decide whether innovative materials are even considered during the design phase. Law (2023) notes that early adopters among clients can accelerate adoption by backing pilots or by explicitly requesting bio-based materials in tender documents.

Clients play an important role in determining whether timber is considered at all. As highlighted by both Gosselin et al. (2018) and Salvadori (2021), the adoption of timber in multi-storey construction often depends on early support from the client; without their initiative, it is unlikely that timber will be seen as a realistic option later in the project. For this reason, the client is positioned centrally in the circle of control, playing a pivotal role in shaping project direction and materialisation.

3.3.2. Circle of influence

In multi-storey timber construction, those who play an important role in shaping project outcomes without being the leading decision-makers are positioned in the circle of influence. They contribute throughout the design and building process, influencing how timber is evaluated and either implemented or not, even though they do not set the main objectives.

Architect

Architects are responsible for turning client ambitions into concrete spatial and material designs. They are usually engaged from the early design stages and are responsible for defining the building’s concept, aesthetics, and functional layout. Through this role, they often lead conversations around sustainability, innovation, and material choices.

As Gosselin et al. (2018) points out, architects have the potential to advocate for timber by including it in the early design concept, especially when the project has sustainability as a central focus. Their design and material choices can shape how other stakeholders, like clients, engineers, and contractors, view timber.

When architects are positive towards timber, they can play a key role in shaping how and whether it is integrated into the project. Even though they do not make the final decision on the material choice, their design decisions heavily shape the construction method, structural layout, and spatial organisation of the building, all of which can either support or limit the use of timber (Gosselin et al., 2018). Their influence lies in initiating and framing timber within the early design phase, but they often still do not have the final say on whether timber is selected. Their early design choices are, however, impactful, which results in architects being placed at the front of the circle of influence.

Structural engineer

Engineers are responsible for ensuring the structural integrity and technical feasibility of the building. Contrary to the stakeholder analysis by Law (2023), who looked at low-rise housing and did not specifically include structural engineers, this research does. Structural engineers play an important role in the feasibility of multi-storey timber buildings due to stricter rules for fire safety, stability, and overall performance.

As noted by Gosselin et al. (2018) and Salvadori (2021), their involvement, alongside other stakeholders, is important for shaping the viability and design confidence of timber structures, especially in navigating technical and regulatory uncertainties that characterise early timber designs. Together with architects, they help assess if a timber design is technically feasible and practical. Therefore, when structural engineers are brought in early, their input plays an important role in determining whether timber is considered a viable structural option. Though Roos et al. (2010) did find that some engineers are often still cautious of timber. This conservatism can act as a barrier to adoption unless engineers are experienced or actively engaged in innovative projects.

Structural engineers, like architects, are positioned in the circle of influence in this research. They do not have the decision-making authority about material selection. However, their influence lies in supporting or limiting the use of timber, helping to define what can and cannot be done within the project. Therefore, structural engineers use their knowledge of interpreting building codes and standards to shape how others see the technical risks or possibilities of using timber.

Suppliers

Suppliers are used as an umbrella term to include the group of actors directly involved in the realisation of timber elements. They primarily include timber suppliers and fabricators, who are responsible for transforming raw timber materials into project-specific components through industrialised and often prefabricated processes. As Orozco et al. (2023) point out, they play a prominent role in multi-storey timber construction, particularly in the construction and manufacturing categories, and frequently act as innovative practitioners.

These actors often work across multiple projects, allowing them to refine construction methods and share their knowledge across the industry. In the Netherlands, where only a small group have experience with timber construction, this repeated involvement makes suppliers important drivers for innovation (Orozco et al., 2023). Unlike Law (2023), who grouped timber contractors and suppliers as producers, this research builds on the stakeholder distinctions outlined by Roos et al. (2010) to more clearly separate their roles. This way, the suppliers' relation to innovation and technical feasibility becomes clearer.

While suppliers do not typically hold direct decision-making power within the project, they influence timber adoption primarily through their ability to deliver timber systems that meet both regulatory and structural standards. Their technical input during the early design phase can improve collaboration with architects and engineers, helping make timber choices feel less risky and more feasible and buildable solutions (Gosselin et al., 2018).

For this research, therefore, suppliers are especially important because they both carry out the work and help drive innovation. As stakeholders in the circle of influence, they play an important role in translating timber ambition into buildable outcomes. Their role goes beyond timber production, as they also help reduce risks by using their experience, improving design details for efficiency, and giving advice on what is possible within the project's time and budget. However, as highlighted by Roos et al. (2010), suppliers are often perceived as passive and fragmented, which can limit their influence on material choices unless they build strong collaborations with designers or contractors. Especially in the Netherlands, because timber is produced at smaller scales and at higher costs than conventional materials like concrete, which are more widely available and standardised.

Contractor

The contractor is responsible for the execution of the building plans on-site. They are tasked with coordinating construction activities, managing subcontractors, and ensuring that the building is delivered according to specifications, time, and budget, which are specified together with the project manager. Contractors hold an ambiguous position in timber adoption, with their influence depending largely on the project delivery model. In the Netherlands, mostly traditional contracts are used that follow the Design-Bid-Build (DBB) contracts. Here, the contractor is usually brought in after the design phase, meaning that the project decision-making and material choice have often already been made and that their role in this is limited. However, there are also UAV-CG contracts, which are integrated models such as Design & Build (D&B) (PIANOo, 2025). Here, contractors have a more substantial influence over materialisation decisions. In these cases, their familiarity with timber construction, or lack thereof, can have a large impact on the feasibility or risk perception of timber as a material within the broader project team.

Unlike Law (2023), who places contractors and suppliers under the broad category of producers, this research is more in line with the findings of Roos et al. (2010), where the roles are separated. Contractors may not have formal decision-making authority, but when they are involved early, their advice can decide whether timber is used or not.

In integrated contracts, their views on buildability and risk perception help shape how realistic timber seems to other stakeholders, like the client and engineers. However, in traditional contracts, their role is extremely limited. As their bid comes after the design is finished, decisions have been made by other actors. This is also seen in Figure 3.4, where the different timelines between traditional and D&B contracts are shown, with the moment at which contractors enter the construction process.

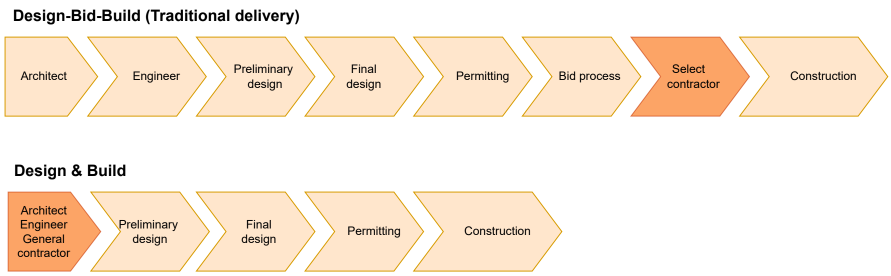

Figure 3.4: Timeline of traditional contract and D&B contracts (adapted from Ryan (2020))

In D&B contracts, contractors influence adoption primarily through shaping perceptions of risk and feasibility. Furthermore, when they have access to established supply chains, they can also influence material adoption. Though contractors often have no influence on material choice or design in traditional project structures, these structures are still dominant in the Netherlands. Because of this, this research places contractors between the circle of influence and the outer circle of no control. Their ability to shape outcomes increases when they are involved early and collaboratively. However, as Roos et al. (2010) points out, the dominance of concrete in the construction industry can make contractors a conservative force, especially when they lack experience with timber.

3.3.3. Circle of concern

Finally, actors who influence the broader conditions under which projects take place, without being directly involved in individual project decisions, are positioned in the outer circle, the circle of concern.

Dutch government and regulatory authorities

The Dutch government and regulatory authorities set the wider policy, legal, and technical framework that guides how construction projects are carried out. This includes setting building codes, safety standards, sustainability goals and offering financial incentives like subsidies or tax breaks. Although they are not directly involved in private projects and their decision-making, they strongly influence what materials can be used by shaping what is allowed, supported, or restricted across the sector.

As noted by Gosselin et al. (2018), public policy and institutional support can play an enabling role in timber adoption by influencing procurement practices, funding pilot projects, or shaping regulatory frameworks to match current technical possibilities. On the other hand, outdated or restrictive rules, especially those related to fire safety, noise, and structural standards, can hold back innovation. This makes early involvement from the public sector important for lowering perceived risks and encouraging a wider industry shift towards using timber.

Unlike Law (2023), who positioned government actors at the centre due to their role in public housing projects, this research focuses on the adoption of timber within multi-storey projects that are developed in a private-sector context. In the Netherlands, many office and market-rate housing projects are driven by private firms, while the government's role is mainly indirect, for example, through policy, regulation, and facilitation (Boelhouwer, 2019). Although the empirical cases studied here are privately initiated, the insights into the stakeholder mapping and roles are also relevant for semi-public and public developments facing similar adoption challenges.

While government actors are seen as influential at the system level, their role in individual project decisions is perceived as limited (Roos et al., 2010). Their influence may be indirect, but it is still important, especially when policies push for innovation or make timber more attractive through incentives. Government and regulatory authorities, therefore, are positioned in the outer circle of the model. They do not engage in private project-specific decision-making, but through policies they shape the wider environment that makes timber adoption more or less likely (Geels, 2014).

End-users

End-users are the individuals or organisations that will eventually occupy or use the building once it is completed. Their influence on timber adoption depends greatly on the project's development structure. In many cases, end-users are not involved during the design or construction phases, resulting in them having no ability to shape material or design choices. However, when they are known early, for instance, through pre-let agreements or direct involvement, they can play a more active role in influencing the direction of the project. In these cases, the end-users will (in part) act as clients to the project. However, when the project is constructed for general market use without a known occupant, end-users have little to no influence. Roos et al. (2010), however, note that end-users are often unaware of what structural material is used in the building, as well as rarely expressing their preferences about it. Highlighting how context-specific their influence on the project is.

Due to this variability, end-users can occupy different positions on the circle of influence model. In certain cases, when closely involved in early project stages, they can be positioned in the circle of influence or even in the circle of control if their expectations directly shape the project outcome. In projects where the occupiers are not known during construction, the end-users remain part of the outer circle, shaping demand at a broader market level but without affecting project-specific decisions. Their role in timber adoption, for this reason, depends on whether a building is designed for a specific user or general use.

3.3.4. Mapping stakeholder influence

This section has mapped the main stakeholders involved in adopting timber in multi-storey construction. By using the circle of influence model, this section shows the amount of influence one has in terms of shaping the project direction and materialisation. As shown in Figure 3.5, at the centre of this network is the client or project developer, whose role in setting goals and procurement requirements makes them highly influential. Other stakeholders, such as contractors, suppliers, architects, and structural engineers, play supporting roles. They contribute to timber adoption through their specific expertise and practical input. The level of influence that some of these actors, like the contractor, have can change. This is due to the project delivery method used and the resulting phase at which these stakeholders enter the construction process. Broader actors, like the Dutch government, are not directly involved, but they shape the use of timber through rules, policy goals, and financial incentives.

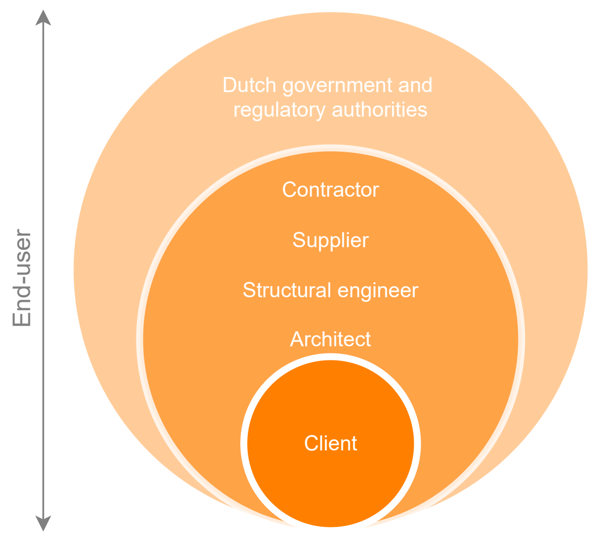

Figure 3.5: Relevant stakeholders as shown on the circle of influence

The layered approach used in this section clarifies the different roles in the multi-storey construction projects while also being a starting point for a future synthesis between the different stakeholders and the possible drivers and barriers, which are explored in more detail later on in this research.

3.4. Adoption and transition frameworks

As discussed in the introduction, timber construction is still slow to adopt, not just because of technical concerns like fire safety or structural reliability. Instead, this slow uptake reflects a broader reluctance in the construction industry, as it has long been characterised as slow to innovate, with deeply embedded structures that resist change. The industry is defined by its project-based structure and a high degree of organisational fragmentation (van de Rijt et al., 2010). As mentioned by Harty (2005), these features create an environment where no single actor holds autonomous centralised power, making it difficult to coordinate and for new practices to diffuse. Furthermore, new innovations and construction methods often require alignment across multiple firms with differing priorities and methods. For this reason, even though an innovation like timber construction is promising, it can still face large barriers to adoption.

The Multi-Level Perspective (MLP) framework was considered in this research for contextualising the transition dynamics of multi-level timber construction in the Netherlands. The MLP framework conceptualises transitions as the result of interactions across three levels:

- *Niches*: Niches are protected spaces where innovations, like multi-storey timber, are developed and tested (Geels, 2011);
- *Socio-technical regimes*: represent the current construction industry, with dominant structures, rules, and routines that stabilise existing practices, such as the widespread use of concrete and steel in Dutch construction;
- *Socio-technical landscape*: The socio-technical landscape is composed of external pressures,

such as climate change policies, demand for sustainability, and demographic trends that have an indirect impact on both niche and regime dynamics.

The MLP highlights how landscape pressures and niche innovations challenge and reshape the existing socio-technical regime by creating windows of opportunity where emerging technologies can break through into the entrenched system (Geels & Schot, 2007). For instance, timber construction has gained increasing attention as a sustainable alternative to conventional building materials such as concrete and steel, driven by rising societal and governmental pressures to reduce carbon emissions in the construction industry.

In the Netherlands, even though timber's potential is widely acknowledged, its use remains limited because of divided stakeholder interests and institutional lock-in mechanisms and path dependencies that favour established construction materials (Geels, 2004). Even though timber has been applied in a wider context and moved beyond early experimentation, it is still not yet integrated into the dominant construction regime, which remains largely reliant on concrete and steel. Currently, timber is therefore situated within the window of opportunity. Here, external landscape pressures, such as climate policies (e.g., the National Climate Agreement) and the urgency of the housing crisis, are beginning to destabilise the traditional system, creating room for new ways of building (Government of the Netherlands, 2019) (Haisma et al., 2023).

Figure 3.6 illustrates how multi-storey timber can be interpreted as a niche innovation influenced by broader landscape pressures. This provides background context for the adoption environment that is explored in this research.

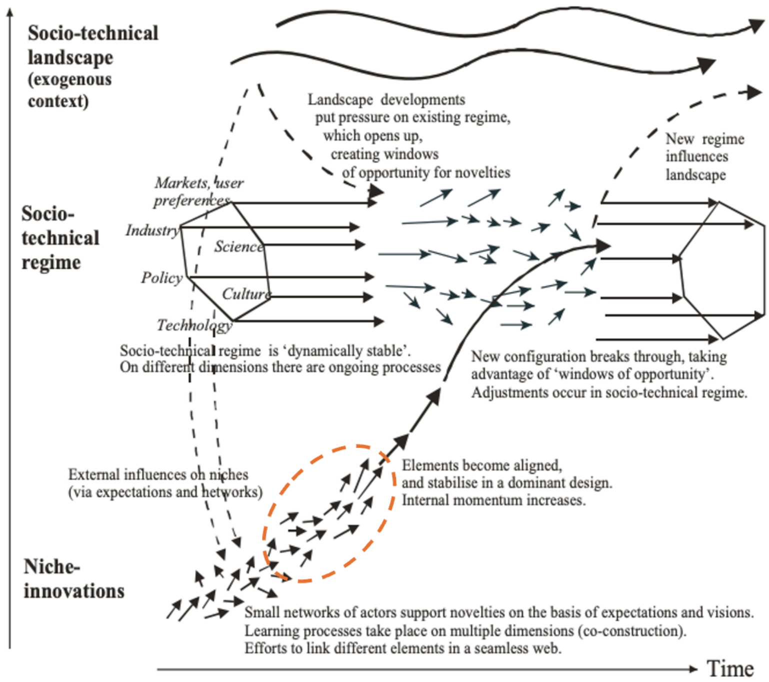

Figure 3.6: Conceptual positioning of multi-storey timber as a niche innovation that is under pressure by the landscape (adapted from Geels (2011))

3.5. Diffusion of Innovations (DOI) theory

Rather than studying innovation adoption at a broad societal level, this research focuses on how innovation spreads within the decision-making environment of construction projects. For this research, therefore, the Diffusion of Innovations (DOI) framework by Rogers (2003) is used, which explains how new ideas, products, or practices spread among members of a social system over time. In his theory, Rogers defined diffusion as ”the process by which an innovation is communicated through certain channels over time among the members of a social system”. In this research, DOI is selected because it models adoption as a time-bound, stage-based process inside projects, which helps explain where temporary, multi-stakeholder coalitions progress or stall. Furthermore, its five perceived attributes are used to interpret how stakeholders evaluate timber at key moments. DOI also centres communication and influence, which is critical in fragmented coalitions where this process unfolds collectively, and it provides a consistent framework to compare full- and hybrid-timber cases within the same analytical lens.

As Taylor and Levitt (2004) discussed in their paper, project-based industries face more difficulties with adopting systemic innovations, which are those that affect multiple project actors and phases, because each project is carried out by a different mix of firms. Multi-storey timber construction is a clear example of such a systemic innovation, as it requires novel prefabrication techniques, different engineering knowledge, and early collaboration between disciplines. Therefore, a project-focused process lens like DOI is well-suited to analyse how such options are adopted within specific projects.

In the fragmented construction industry, diffusion is therefore slowed down by the limited experience sharing, high perceived risks and a lack of shared standards (Roos et al., 2010). Klein Woolthuis et al. (2010) note that high entry costs, a focus on low-price procurement instead of sustainability, and limited incentives for trying new building methods make the sector resistant to change. These barriers encourage the risk-averse behaviour of stakeholders and slow down the adoption of sustainable innovations. DOI offers a strong framework for analysing these dynamics, as it breaks down the adoption process into five distinct stages, identifies key innovation attributes that shape adoption perception, and highlights the role of stakeholder perceptions and communication within a fragmented system.

3.5.1. Four main elements of diffusion

Rogers (2003) identifies four fundamental elements that define any diffusion process. These elements – the innovation, communication channels, time, and the social system – shape how and how quickly new ideas can spread within a certain context.

Innovation

Central to the diffusion of an innovation is the innovation itself. In the DOI theory, an innovation is an idea, practice, or object that is perceived as something new by the unit of adoption (Rogers (2003), p. 12). This is an important definition, because this also means that if something has existed for years, it is still considered an innovation if the individual or organisation (the unit of adoption) has not yet encountered or evaluated it before.

Every innovation involves some level of uncertainty, especially about its possible consequences, which are changes that occur within the social system due to the adoption or rejection of that innovation (Rogers (2003), as cited in Sahin (2006)). This uncertainty is seen as a central challenge to the adoption process because potential adopters often cannot be sure if the innovation will be what they had expected of it.

Applied here, engineered timber in multi-storey construction projects qualifies as an innovation at the project level: although timber as a material is longstanding, its multi-storey engineered application in the Netherlands is experienced as new by adopting coalitions and requires practices not yet institutionalised.

Communication channels

The second foundational element of the diffusion process is communication. Rogers (2003) describes it as the exchange of information between individuals in a way that helps them reach shared understanding. The spread of an innovation depends on how information is shared through channels between sources, which are individuals or institutions that originate a message. Roger, furthermore, explains that there are two types of communication channels:

- *Mass media*: These are typically effective at the early knowledge stage. These are able to reach a broad audience quickly, but they tend not to be personal and less persuasive.
- *Interpersonal communication*: Include conversations between peers, colleagues, or project partners. These, as opposed to mass media, become much more important later in the process, especially during the persuasion stage. These conversations allow for deeper discussions and direct feedback, and help people to understand how the innovations would actually work in their context. Rogers (2003) mentions that trusted people, called 'change agents' or 'opinion leaders', can strongly influence others' choices.

Time

A defining feature in the DOI theory is its focus on time, which sets it apart from other behavioural research (Sahin, 2006). In his research, different parts all include a time dimension, which are discussed in more detail below:

1. The five stages of the innovation-decision process
2. The categorisation of adopters
3. The rate of adoption

The main idea is that adoption is not a one-time decision, but it is a process that happens over time, which involves learning, convincing, testing, and confidence-building.

Social system

Finally, diffusion always occurs within a social system. This is described by Rogers (2003) as a group of people or units working together to solve a common problem. It is important that these social systems can be both formal, through companies, for instance, or informal, like networks between professionals or teams. The social structure (the norms, communication patterns, and relationships) of a system affects how easily innovations can spread within it.

The construction industry has a social system that is shaped by its fragmented and project-based nature. Coalitions between firms are for a limited time, highlighted by Dubois and Gadde (2002) as "loosely coupled systems", where coordination is weak and long-term relationships are rare. Each project often involves a new combination of actors, which makes consistent communication and shared learning difficult (Taylor & Levitt, 2004). This social system influences how an innovation is able to diffuse.

3.5.2. Decision-making units and prior conditions

Characteristics of the decision-making unit

In the DOI framework, the decision to adopt an innovation is made by a decision-making unit, which can be an individual or an organisation. Rogers (2003) highlights that the characteristics of the decision-making unit play an important role in how likely and quickly they are to adopt an innovation. These characteristics include:

1. *Socioeconomic status*: Individuals or organisations with greater financial, educational, or technological resources often adopt innovations earlier.
2. *Personal values*: Those who are open to change, willing to take on risks, and proactive are more likely to be early adopters.
3. *Communication habits*: Decision-making units that are more socially connected and actively seek new information tend to discover and adopt innovations sooner.

These characteristics help explain why innovation rarely follows a uniform pattern, even within one social system; responses vary depending on the people or organisations involved. In complex, temporary settings like project-based industries, these contrasts often become even more visible (Taylor & Levitt, 2004). In construction projects, however, the "decision-making" unit is a temporary coalition rather than a single organisation. The classic unit-level traits are distributed across multiple firms within the same team, resulting in these organisations having different risk attitudes and unequal levels of exposure to novel options among partners.

Prior conditions

In addition to these internal characteristics, Rogers (2003) identifies several external or contextual factors, the prior conditions, that influence how innovations are perceived from the outset. The four main types of prior conditions that are important are:

1. *Previous practice*: The more an innovation differs from established routines or technologies, the more it may be seen as risky or disruptive, leading to resistance and slowing down adoption.
2. *Felt needs or problems*: The likelihood of adoption increases when individuals or organisations feel a clear need for improvement. If the innovation directly addresses a recognised and relevant problem, it is more likely to be taken seriously and, therefore, also to be acted upon.
3. *Innovativeness*: This describes the degree to which a person or organisation is receptive to new ideas and adopts them earlier than others. This trait plays a significant role in shaping both the speed and the likelihood of adoption.
4. *Norms of the social system*: These are the shared beliefs, expectations, and behaviours that define what is seen as acceptable or credible within a given group. When an innovation aligns with these norms, it is more likely to be embraced. However, if it challenges dominant beliefs or ways of working, it may be met with scepticism or resistance, even if its technical benefits are clear.

Together, these four factors help explain why different actors may respond so differently to the same innovation. They also shape how the innovation is perceived during the early stages of the adoption process, especially in the knowledge and persuasion stage, as they influence whether it is seen as promising or problematic from the outset.

3.5.3. Five stages of adoption

Key to the Diffusion of Innovation theory is the five-stage decision-making process that an individual or an organisation goes through when considering an innovation. These five stages – knowledge, persuasion, decision, implementation, and confirmation – follow one another in a roughly chronological sequence. However, feedback and delays can occur within this theory. The five stages and how they can be interpreted in the context of a construction project are given below.

1 Knowledge

This is the first moment when someone or an organisation becomes aware of an innovation. The person or organisation will start to explore what the innovation is, how it works, and why it might be useful. At this stage, learning is mostly about understanding basic facts. It is a cognitive process. In the construction industry, this stage can entail stakeholders first coming across timber construction through, for instance, industry reports or by seeing a complete building. In short, the team becomes aware that timber is an alternative to steel or concrete and starts to build a basic understanding of how it can be used. Rogers (2003) distinguishes between three types of knowledge that play a role at this stage:

1. *Awareness knowledge*: Refers to the knowledge that the innovation simply exists. For timber, this might involve a stakeholder hearing about a project like Mjøstarnet or HAUT and becoming curious about timber as a structural material (Abrahamsen (2017); de Groot (2021)).
2. *How-to-knowledge*: This involves understanding how the innovation is used. A person or organisation will, for instance, research how engineered timber works.
3. *Principles-knowledge*: This is about understanding the functioning principles of how and why the innovation works. This includes recognising timber's role in reducing embodied emissions. Without this deeper insight, an innovation might still be adopted but risks being adopted incorrectly, which can increase the risk of discontinuation (Sahin, 2006).

2 Persuasion

At this stage, the person or organisation will start to form a clear opinion about the innovation. Having learnt about the adoption, one has formed either a favourable or unfavourable attitude. While the knowledge stage is about understanding the facts, the persuasion stage is more emotional (Rogers, 2003). The innovation becomes more personal, as an organisation may ask whether it fits their goals and values. During this phase, uncertainty about the innovation may decrease as the person or organisation actively seeks information and options to reduce that uncertainty (Sahin, 2006). To earn a positive attitude, the innovation must be perceived as sufficiently advantageous.

This stage is driven by several perceived attributes, discussed in detail in subsection 3.5.4, of an innovation that heavily influence this evaluative stage:

- Relative advantage
- Compatibility
- Complexity
- Trialability
- Observability

In the construction industry, the persuasion stage often involves key stakeholders discussing whether timber is a good fit. Positive experiences shared by others, such as hearing that the project was completed on time and within budget, can help create a more favourable view of the innovation. However, ongoing concerns can lead to a more negative attitude. By the end of the persuasion stage, organisations or persons usually have a clearer opinion about the innovation.

It is important that key stakeholders go through the persuasion stage, rather than having a decision imposed on them. Rogers (2003) notes that when people are left out of the persuasion stage in a top-down decision, they will often find ways to work around it and to continue with their old practices, rather than embracing the new system. Engineers might, for instance, specify hybrid materials or default back to concrete, while insurance companies might resist due to a lack of understanding.

3 Decision

During the third stage, the individual or organisation commits to a choice: to adopt the innovation or to reject it. Adoption here means committing to fully use the innovation, while rejection means choosing not to use it, either for now or permanently (Rogers, 2003). In some cases, the decision can follow a small-scale trial, which makes adoption more likely. However, in construction, this kind of testing is often difficult. As a result, the decision to use a material like timber often requires stronger assurance, such as expert advice, models, or proven examples from similar projects, discussed in section 3.6 and section 3.7. It is important to note that adoption at the organisational level does not automatically mean full commitment from every individual involved. Team members may still internally decide whether they truly support the innovation or prefer to stick to their traditional ways of working.

Rogers (2003) explains that rejection can happen in two ways:

- *Active rejection*: This occurs when the innovation was considered, and it may have even been tested, but was ultimately not chosen.
- *Passive rejection*: This, on the other hand, happens when the innovation has never really been seriously considered. For example, a project team may continue to rely on familiar materials without actively considering alternatives. In the construction industry, passive rejection is common, as firms often stick to what they know unless there is a strong reason to change (Jussila et al., 2022).

However, organisations can reverse their decision later. As shown in Figure 3.7, organisations are able to move from rejection to adoption at a later stage. For instance, when new information becomes available or external pressures increase. Similarly, after having chosen timber, a project team may abandon it due to unexpected complications. When reversal happens from adoption to rejection, it is known as discontinuance. These shifts highlight that the decision stage is not always final and that adoption is not at a fixed moment but an ongoing process that can be influenced by changing project conditions, team dynamics, and contextual developments (Rogers, 2003).

4 Implementation

In this stage, the innovation is put into practice. However, because it is still new, there can still be uncertainty about how it will perform in practice (Sahin, 2006), which in turn may require changes in behaviour or additional learning. Furthermore, this uncertainty may lead to users seeking support from change agents and experts to better understand how the innovation works and to reduce potential risks. Over time, the innovation will become part of normal routines, and it will feel less like something new and separate. Here, the innovation-decision process comes to an end (Rogers (2003), p. 180).

In construction, implementation is when the building is actually designed and constructed with the use of timber. This is also where practical issues may arise, like unforeseen construction issues or unfamiliarity with timber-specific techniques. To deal with these challenges, project teams may adjust details or workflows, a process with Rogers (2003) describes as ”reinvention”. Reinvention is the extent to which an innovation is modified by its users during adoption and implementation. Here, Rogers (2003) also explains that, unlike invention, where a completely new idea is created, innovation involves applying an existing idea that is able to evolve through use. The more reinvention takes place, the likelier it becomes that the innovation will become embedded in practice. Successful implementation, therefore, often depends not only on the technical execution but also on the ability to adapt and collaborate across teams. This will reduce uncertainty and make the innovation truly work in practice.

5 Confirmation

In the final stage of the innovation-decision process, the adopter reflects on the earlier decision and evaluates whether the innovation delivered the expected value, seeking reinforcement (Rogers, 2003). Adopters tend to seek information that confirms their decision and avoid signals that raise doubt. This pattern is described by Rogers as confirmation bias. A positive experience strengthens continued use and might even result in the adopters turning into advocates who promote the innovation to others within the industry.

However, if results are disappointing or if the individual or organisation is ”exposed to conflicting messages about the innovation” (Rogers (2003), p. 189), the adopter may reverse their decision. As is explained in ’Decision’, this is known as discontinuance, which can occur in two ways according to Rogers:

- *Replacement discontinuance*: Here, the innovation is abandoned in favour of a better alternative.
- *Disenchantment discontinuance*: This is where the innovation is rejected because it fails to meet expectations or lacks a clear relative advantage over traditional options.

In construction, the confirmation stage is further complicated by the industry’s temporary and fragmented project structures. The nature of the industry’s relationships as loosely coupled limits knowledge retention beyond project completion (Dubois & Gadde, 2002). Without structured reflection or long-term collaboration, valuable lessons from projects can be easily lost, reducing the chances of the adoption being sustained or scaled up over time.

The full five-stage innovation-decision process is shown in Figure 3.7.

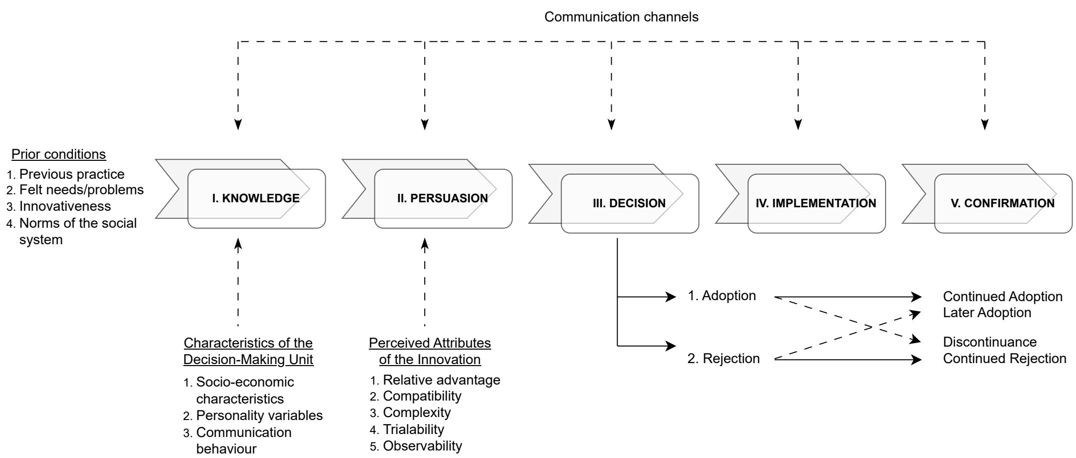

Figure 3.7: Original 5-stage innovation-decision process framework (adapted from Rogers (2003))

3.5.4. Five innovation attributes

Rogers (2003) describes the innovation-decision process as a process that reduces uncertainty. For this reduction, he identifies five main attributes that influence how individuals and organisations evaluate, and ultimately, adopt an innovation. The attributes of innovations are of importance during the persuasion phase, as mentioned above and help predict the 'rate of adoption'. This rate of adoption is the relative speed at which an innovation is adopted in a social system (Rogers, 2003). All five innovation attributes are of great importance to the rate of adoption; however, for Rogers (2003), relative advantage is the strongest predictor. The five attributes are listed below:

1. **Relative advantage**
   Refers to the perceived benefits of timber over the conventional options like concrete and steel. Multi-storey timber construction offers clear environmental advantages, including lower embodied carbon and carbon sequestration. Furthermore, it offers faster and quieter on-site construction through prefabrication. However, many stakeholders still perceive timber as more expensive, less scalable, and less proven in multi-storey applications (Jones et al., 2016). These perceptions undermine the attractiveness of timber.
2. **Compatibility**
   Timber construction challenges the current construction practices, centred around concrete and steel. It is therefore often seen as a disruptive innovation that requires adjustments (Hossain & Ng, 2018). In innovation theory, this relates to compatibility, which refers to how well multi-level timber construction fits with the existing values, practices, and experiences of potential adopters. If it aligns well, it is more likely to be accepted and integrated. However, when it demands great behavioural or structural change, it often faces greater resistance (Sridharan, 2021). However, compatibility is not static. As Haisma et al. (2023) points out, growing European policies, clearer building codes, and better prefabrication technologies are making it easier to adopt timber in mainstream construction. These developments improve compatibility, especially for companies already working with modular methods or focused on sustainability.
3. **Complexity**
   In innovation theory, complexity is about how difficult the innovation is to understand or use, where innovations that are easier to implement and maintain are generally adopted more quickly (Sridharan, 2021). Stakeholders often mention unfamiliar structural systems, acoustic detailing and fire safety as complexity concerns (Roos et al., 2010). Yet, while complexity can initially hinder adoption, Gosselin et al. (2018) mentions that it can eventually diminish with experience and collaboration.
4. **Trialability**
   Trialability reflects the extent to which the innovation is able to be tested on a small scale before being fully implemented (Sridharan, 2021). Even though trialability is low for custom, multi-storey projects, the use of (prefabricated or modular) pilot projects and digital design tools gives firms more ways to test timber in controlled or simulated settings.
5. **Observability**
   Finally, observability refers to how visible the results of the innovation are to others. The clearer the benefits, such as cost savings, performance, and successful implementation, are for potential adopters, the more likely they are to adopt. In the case of timber, buildings like Mjøstårnet in Brumunddal, Norway, and Haut in Amsterdam, the Netherlands, serve as important examples (Abrahamsen, 2017) (de Groot, 2021). However, as Roos et al. (2010) note, a lack of technical knowledge and limited industry support still hinders others from learning from these examples, reducing their wider impact.

These five innovation attributes provide a conceptual framework for identifying the main challenges and opportunities that shape the adoption of multi-storey timber.

3.5.5. Adopter categories

Finally, an important concept in the DOI theory is that individuals or organisations differ in their willingness and speed to adopt innovations. Members of a social system can be classified into five adopter categories based on their degree of innovativeness, which is the extent to which an individual is relatively earlier in adopting new ideas than others, as mentioned earlier (Rogers, 2003). This classification helps explain why adoption spreads gradually. An S-curve is formed over time, where a small number of people adopt early, followed by a rapid increase and finally a plateau as late adopters join.

The five categories, as defined by Rogers (2003), are:

1. **Innovators (2.5%)**: These are the very first individuals or organisations to embrace an innovation. They tend to be adventurous, well-informed, and connected to sources outside of their immediate environment. Innovators are open to experimentation and willing to take risks, which makes them crucial for introducing innovations into a system. Furthermore, innovators are the gatekeepers (the access point), bringing the information in from outside of the system. Because of this, they can be perceived as detached from local norms. Their technical competence allows them to manage uncertainty more easily than others (Rogers, 2003).
2. **Early adopters (13.5%)**: Early adopters play a vital role in influencing others. Unlike innovators, they are well integrated into the social system, often being regarded as opinion leaders. They are respected, and they often serve as a bridge between the more radical innovators and the broader population. Their approval carries weight and helps reduce uncertainty for others considering adoption. They are described as those that effectively ”put their stamp of approval” on an innovation, helping to legitimise it within their community (Rogers (2003), p. 283, as cited by Sahin (2006)).
3. **Early majority (34%)**: This group adopts the innovation just before the average person. This group is deliberate; they avoid risk, and they take longer to make decisions. They are well connected with others in their social system, but they do not have the leadership role like the early adopters. Still, through their interpersonal networks, they give the innovation momentum.
4. **Late majority (34%)** The late majority adopts after the average member. They are sceptical and cautious and often wait until most of their peers have adopted the innovation or until economic or social pressures force them to act. They heavily depend on peer influence and visible evidence of success. For them, adoption typically only happens when they feel like the risk is minimal and the benefits are clearly established.
5. **Laggards (16%)**: The last group to adopt an innovation are the laggards. They are strongly influenced by tradition, highly risk-averse, and usually have fewer resources and less access to information. Furthermore, their social networks are often closed, consisting almost only of others with similar views from the same category. As laggards require a lot of convincing and evidence before accepting something new, their adoption of an innovation only occurs when it has become mainstream or even outdated. Often they are influenced by pressure or necessity, rather than interest, and they wait until it is absolutely clear that the innovation works and is safe (Rogers, 2003).

This classification reflects a normal distribution of innovativeness across a social system, shown in Figure 3.8. However, Rogers points out that this curve only accounts for those who eventually adopt the innovation. It, therefore, excludes those who reject it or never considered the innovation at all (Sahin, 2006).

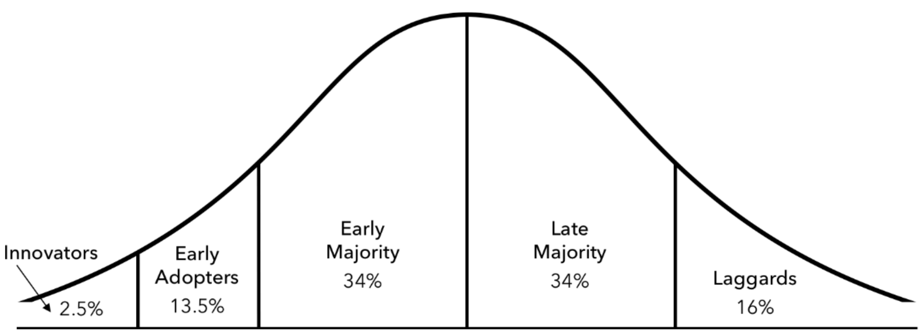

Figure 3.8: Law of diffusion curve (Rogers (2003), as cited in Gosselin et al. (2018))

The concepts discussed above provide the theoretical foundation for understanding innovation diffusion in general. In the next section, these principles are used to position the current status of multi-storey timber in the Dutch construction industry.

3.5.6. Positioning timber through the DOI

The position of multi-storey timber in the Dutch construction industry reflects a point where its potential is increasingly recognised, but it still faces industry resistance. Engineered timber in multi-storey construction is a project-level innovation: although the material timber is longstanding, its multi-storey engineered application in the Netherlands is experienced as new by the adopting project coalition and requires practices that are not yet institutionalised. At this scale, adoption entails a change in the project's delivery rather than a straightforward material swap. Even though there is growing external pressure from factors like climate policies, circular economy goals, and urban densification, timber still has not integrated into mainstream construction, and these pressures are still not strong enough to activate actors. Understanding this situation is important for identifying key barriers and enablers for scaling timber use in both individual projects and the wider sector.

At the start of this research, both the Diffusion of Innovations (DOI) and Multi-Level Perspective (MLP) were explored as possible frameworks. While the MLP offers valuable insights into long-term regime shifts, its focus did not align with this research's emphasis on project-level decision-making. It is, therefore, not selected as the framework for this research; DOI is adopted to analyse adoption dynamics within projects. Because the disruption described above materialises inside projects, the analytical focus needs to be on the process within the project rather than the sectoral regime.

Instead, the DOI was chosen as the primary analytical framework because it maps how adoption unfolds within projects across five stages – knowledge, persuasion, decision, implementation, and confirmation – allowing the identification of when and why project teams progress or stall. In this research, the stage model is used to analyse project dynamics; the five perceived attributes (relative advantage, compatibility, complexity, trialability, and observability) are used to interpret how stakeholders evaluate timber at key moments in the process. This makes DOI particularly suitable for construction, where decisions are taken by temporary, multi-stakeholder coalitions under uncertainty and fragmented collaboration. In short, DOI helps explain how project coalitions navigate the change introduced by multi-storey timber, either progressing with the innovation or continuing with established solutions. This research does not rank alternative low-carbon pathways; instead, it highlights an application-level innovation that reshapes project routines, a case where a stage-based, project-focused lens, such as DOI, is especially useful.

In the Diffusion of Innovations (DOI) theory, the S-curve represents how an innovation is gradually adopted in stages. It starts slowly with innovators and early adopters, then it accelerates as more actors join in. This happens as the innovation becomes more visible, better understood, and socially validated, which reduces their uncertainty and encourages wider adoption. Eventually, the late majority and laggards start adopting the innovation (Rogers, 2003). The rise in timber projects and firms exploring alternative materials shows that, slowly, more people are adopting timber, as explained in the DOI model. This trajectory is consistent with an option that is still perceived as new by project teams and not yet embedded in standard routines. As long as the routines for multi-storey timber are not institutionalised, uptake is likely to remain in the early-adopter phase despite growing visibility. These early adopters are encouraged by sustainability goals or new policy alignment, but they still work within an industry that favours traditional materials. Timber's broader adoption, however, remains limited due to several persistent barriers (see section 3.6) that negatively affect its perceived innovation attributes. In other words, the multi-storey engineered application functions as an innovation in practice rather than a straightforward material substitution. This results in cautious stakeholders, where timber is still not used as a common construction material, apart from some projects by innovators and early adopters.

However, a growing momentum is shown by recent developments, with both timber buildings like Mjöstårnet (Abrahamsen, 2017), and hybrid-timber buildings like HAUT (de Groot, 2021), pushing new heights and showcasing structural feasibility. As more examples accumulate and knowledge is shared, adoption may accelerate. According to studies by Santana-Sosa and Kovacic (2022), Roos et al. (2010), Hassan and Grobbelaar (2024), the current market for multi-storey timber construction remains limited, with uptake concentrated in pilot or demonstration projects and overall market share still very small in most European countries. Their descriptions indicate a phase still dominated by early adopters, with only isolated signs of transition towards broader uptake. Based on this interpretation, multi-storey timber can be positioned at the late stage of early adoption, with uptake uneven across actors and project types. This position reflects persistent perceived newness and limited institutionalisation of related practices. The future of multi-storey timber depends on how successfully remaining barriers can be addressed and enablers can be leveraged at the project level. The following section, therefore, explores how those key barriers and enablers interact with timber's perceived innovation attributes and how this affects adoption across projects.

3.6. Barriers

3.6.1. Introduction to timber adoption in context

There is a growing expectation that the construction industry in the Netherlands contributes to sustainability goals such as reducing embodied carbon, promoting circular design, and supporting more energy-efficient building designs (European Commission, 2020). However, as shown throughout this research, the Dutch construction industry is still heavily dependent on conventional materials like steel and concrete, despite timber gaining attention as a promising alternative that aligns with these ambitions. Even though policy goals and pilot projects are establishing a more sustainable approach, the actual uptake of timber construction is still relatively low. This indicates that this shift will not happen automatically, as a variety of barriers, including institutional and project-level obstacles, continue to limit the use of engineered timber.

The slow timber uptake has been discussed in recent research, which shows that adoption is more than simply a matter of technical feasibility or sustainability performance. Different international studies, such as the research by Santana-Sosa and Kovacic (2022) and Gosselin et al. (2017), have shown that timber is still rarely chosen in multi-storey projects, despite its potential benefits, citing uncertainties in fire safety and perceived construction risk, but also limited alignment, among others. Despite these barriers being recognised across the industry, they are often discussed desperately without a clear framework that links them to the actual decisions made in projects. This section, therefore, aims to structure these insights by examining how enablers and barriers affect adoption decisions on construction projects.

To provide structure to these insights, as reported in the academic and policy literature, this section synthesises the barriers and enablers of multi-storey timber through the Diffusion of Innovations (DOI) framework by Rogers (2003). This framework, extensively discussed earlier in this research, identifies five critical factors that influence how innovations are evaluated and adopted: relative advantage, compatibility, complexity, trialability, and observability. This will help provide a more integrative way to classify the enablers and barriers related to timber adoption.

Despite the growing potential of timber, its adoption in multi-storey construction remains limited. This is due to a variety of complex barriers, ranging from technical uncertainties and fragmented project delivery to conservatism in the industry, risk-averse stakeholders and misalignment with regulations. This chapter goes into these different barriers, as mentioned in the literature, and structures them through the lens of the Diffusion of Innovations framework to reveal how these constrain the use of timber within mainstream building practices.

3.6.2. Relative advantage

Relative advantage is the perceived advantage of the innovation compared to the status quo; in this context, the use of timber construction compared to the use of traditional materials like concrete and steel. There are, however, several prominent barriers in the industry that hinder timber from being perceived as better.

Cost disadvantage

The main barrier in terms of relative advantage is the cost disadvantage or uncertainty related to timber, as stakeholders frequently experience or perceive greater upfront costs for timber constructions (Gosselin et al., 2017). These costs not only include materials but also additional costs for maintenance and insurance, which greatly increase the initial expenditure for a timber building (Hassan and Grobbelaar (2024); Laguarda Mallo & Espinoza 2015, as cited in Gosselin et al. (2017)).

Furthermore, budgeting might be challenging due to price volatility in wood markets. During recent events of disruption, such as the COVID-19 pandemic but also climate extremes, wood prices were highly volatile, which led to availability concerns and planning and budgeting difficulties (Horsting et al., 2024). This uncertainty, coupled with the slim profit margins that characterise the construction industry, often discourages decision-makers, drawing them to more familiar materials (Santana-Sosa and Kovacic (2022); Hassan and Grobbelaar (2024)). This issue is further worsened by traditional tendering practices that provide contracts to the lowest bidder and the short-term profit orientation of the industry. This effectively penalises innovation and reinforces the status quo, as novel design practices like timber construction sometimes come with higher upfront costs (Santana-Sosa & Kovacic, 2022) and, as a result, lead to less competitiveness, as was found in Amsterdam (Ancapi et al., 2025).

In addition, timber's environmental benefits, like carbon sequestration and emission reductions, are rarely monetised in current project evaluations, which limits timber's relative advantage (Santana-Sosa and Kovacic (2022); Haisma et al. (2023)). Moreover, the broader environmental benefits of timber buildings are not counted as material assets, which makes timber less attractive in cost-driven decisions (Campbell, 2019).

In addition to this, this lack of market incentives or subsidies to reward sustainable building choices also means that authorities and regulators currently have little motivation to approve and promote new materials, as this costs money and time (Hassan & Grobbelaar, 2024). This all results in a situation where, purely from a short-term financial perspective, timber is not the better option compared to the status quo, which makes its diffusion difficult.

Technical performance

Another well-cited barrier, which has been mentioned earlier in this research, is the concern about timber's technical performance relative to steel or concrete. Apart from the general strength concerns of timber in multi-storey applications, further issues with acoustics, durability and maintenance are often mentioned, as timber is perceived as having weaker sound insulation and being vulnerable to moisture, decay, and pests (Santana-Sosa and Kovacic (2022); Gosselin et al. (2017)). Another ongoing concern is fire safety. Many stakeholders still feel that engineered timber presents a greater danger of structural collapse during fire, despite advancements made in fire-resistant design for mass timber (Hassan & Grobbelaar, 2024). This dynamic is also seen in the Netherlands by the new discussion around the 'Nederlands Technische Afspraak' (NTA) 6125, a new standard regarding fire safety. This NTA will introduce additional fire safety requirements for mass timber buildings. While these measures aim to address real risks like longer-lasting fires and extinguishability, they go beyond what is currently legal. This has resulted in a debate about their necessity, proportionality and whether it will slow down innovation (Duurzaam Gebouwd, 2025).

3.6.3. Compatibility

Industry culture

The most prevalent compatibility barrier is that timber does not align well with the current culture and practices of the construction industry. The industry is known to be conservative and traditional, meaning that any innovation that does not align with established norms faces resistance. For the construction industry, many markets have focused on concrete and steel for decades, making timber an outsider. Santana-Sosa and Kovacic (2022) mention that there is a “wealth of experience, standards, knowledge and tradition around concrete and steel, whereas there is a lack of timber knowledge. Firms have established supply chains for steel and concrete, as well as their business models and relationships built around these materials. They may, therefore, see timber as less of a fit or even a threat (Vihemäki et al., 2020). All of this leads to path dependency, where these companies keep relying on established subcontractors and suppliers of steel and concrete, making it difficult to integrate new suppliers or processes for timber (Hassan & Grobbelaar, 2024). So, many stakeholders simply feel comfortable with the status quo, resulting in a risk-averse, conservative attitude (Gosselin et al., 2017). Even within project teams, this lack of willingness can be a deciding factor in new material options. If the team members are not philosophically or professionally aligned with the use of timber, it will not be used (Knowles et al., 2011, as cited in (Gosselin et al., 2017).

Misalignment with building codes

Furthermore, the misalignment with current building codes and regulatory frameworks poses a large challenge. Historically, a lot of building codes were written for steel and concrete, resulting in strict constraints on timber. According to Gosselin et al. (2017), outdated perceptions on fire performance still govern fire safety regulations. Even though codes are evolving, regulations always lag behind technology, with officials and authorities slow and reluctant in approving new timber systems in the absence of strong motivations (Hassan & Grobbelaar, 2024). This slow pace of adaptation of regulatory frameworks hinders the scalability of timber in urban settings (Quesada et al., 2018).

Fragmentation and silo-thinking

Apart from the above-mentioned barriers, industry fragmentation and siloed practices also form a barrier. The current construction industry is very fragmented (van de Rijt et al., 2010), which is incompatible with the successful implementation of timber, which demands a more integrated and collaborative approach. However, the timber sector is also perceived as fragmented, with few qualified actors and a lack of collaboration. In practice, many construction companies have created their own “in-house” solutions that are unique to each firm (Santana-Sosa & Kovacic, 2022). This silo-thinking, where companies operate separately without shared interfaces or expectations, creates a lack of universal standards and hinders larger projects that might require various firms to work together. Furthermore, it also leads to mistrust and poor information because companies fear losing their competitive advantage or having their intellectual property misused, leading to limited collaboration. Cross-company teamwork, which is necessary to execute complex timber buildings, is not possible in such an environment, which leads to diffusion being stalled (Santana-Sosa & Kovacic, 2022).

Project delivery models

There is a compatibility issue with timber construction and traditional project delivery models and contracts. Methods, such as design-bid-build, finalise many design features in a later stage, while trades are divided into distinct phases. Timber requires early design coordination and prefabrication, which does not fit with this linear approach (Santana-Sosa & Kovacic, 2022). Early manufacturer involvement and detailed planning up front benefit timber projects, but current fee structures and contracts rarely support this. Similarly, current procurement structures and delivery models also lack provisions for this early collaboration, and timber typically needs a significant redesign when it is taken into consideration only after the design is developed, as is often the case with ‘material neutral’ tenders, making it ineffective and unattractive for project teams to implement (Santana-Sosa & Kovacic, 2022).

3.6.4. Complexity

Lack of knowledge

Knowledge and skill gaps in timber construction remain a structural barrier to timber’s wider adoption. This was also found in a lot of the studies, where the general lack of expertise and experience with timber by architects and engineers was mentioned as an obstacle, as they often lack the required knowledge about the unique structural characteristics and the design principles for timber (Santana-Sosa and Kovacic (2022); Roos et al. (2010)). One of the main reasons for this is the lack of academic and professional training in modern engineered timber practices. University programmes have historically put a large emphasis on concrete, masonry, and steel, leaving new graduates with relatively little knowledge of timber practices (Santana-Sosa & Kovacic, 2022). According to Gosselin et al. (2017), even translating existing timber building codes into practice can be very challenging for practitioners who are not used to them, with structural engineers mentioning that they do not know how to calculate wood member sizes, for instance. This educational gap can be seen in practice, where both the decision-makers and the engineers perceive it as complex and risky, which discourages further adoption. Furthermore, also on site, this lack of knowledge is cited, as there have been issues with on-site assembly like misalignments, problems with moisture handling, and overall inexperience of crews, among others (Santana-Sosa & Kovacic, 2022).

Project complexity

Apart from individual complexities, timber also increases the project complexity, as it requires more coordinated and integrated building processes. Compared to traditional projects, multi-storey timber requires that important decisions like structural design choices, connection detailing, or service integration, for instance, are made earlier (Santana-Sosa & Kovacic, 2022). With the use of prefabrication, it is more important that components fit together exactly. However, this earlier decision-making, as mentioned under delivery models, is unconventional, as in the traditional approach, architects, engineers, and contractors may make their own decisions in succession. Without a shared understanding and coordination, the different stakeholders often overlook each other's needs, which leads to miscommunications that result in changes later in the project, which are costly (Santana-Sosa & Kovacic, 2022). This coordination is not only important for the main stakeholders. Subcontractors like electricians or plumbers often have limited knowledge about multi-storey timber construction and prefab buildings, even though, for these stakeholders, timber buildings also require pre-planning to integrate all systems correctly.

Further complexity comes in the hybrid timber-concrete constructions, which are common in multi-storey projects. Here, concrete floor toppings, for instance, reduce timber's time-saving potential and complicate scheduling, as these are often not prefabricated. Furthermore, interfaces between timber and concrete, such as foundations and lift shafts, require careful coordination because of their variations in material behaviour and shrinkage, which could cause large problems if not planned carefully (Santana-Sosa & Kovacic, 2022). According to the literature, this interface has a reputation for being problematic and, when mismanaged, can create large cost and time overruns.

Lack of standardisation

Another prominent complexity barrier, mentioned very often in the literature, is the lack of standardisation in timber building components and methods (Gaston et al., 2001; Bysheim & Nyrud, 2008; Nolan, 2011, as cited in Gosselin et al. (2017)). Whereas steel and concrete benefit from decades of standardised components, well-established best practices, and consistent building codes, this is not the case for timber, where these standards are still evolving and being developed. As explained in the chapter on silo-thinking, there is a large variety of, for instance, types of CLT panels and glulam connectors, in part because of the silo-thinking of companies. In their research, Santana-Sosa and Kovacic (2022) found that planners often have to redraw details every time due to the lack of standards for specific connections and because of the wide variety of timber components used within the industry. This also results in repeated testing and certification for different projects, as components are often project-specific. These include tests like fire-resistance, acoustic, or structural calculations, which add time and costs to the project.

This lack of standardisation is further seen within the Building Information Modelling (BIM) environment. Even though BIM is used in the industry to ensure better and efficient management of project complexities, challenges often arise in software compatibility as architects and engineers use BIM or CAD software, while timber manufacturers often use special fabrication software that does not seamlessly work together. In their paper, Santana-Sosa and Kovacic (2022) found that as a result, timber companies often have to recreate the digital building model in their own software for fabrication. This sometimes makes the process even more manual and complicated than without the use of BIM.

Limited industry capacity

Finally, the last main complexity barrier relates to the limited industry capacity that makes timber projects more difficult to deliver. In many regions, only a few firms are able to handle multi-storey timber buildings, which leads to limited options and adds complexity (Santana-Sosa & Kovacic, 2022). Furthermore, smaller Dutch fabricators often work at full capacity or lack the scale or equipment to fabricate elements for large projects. As a result, developers have to work with a small number of suppliers, often across borders, which presents logistical challenges and longer lead times (Reuters, 2024). Also, fabricators are cautious about expanding their production without a steady demand stream, which results in a dilemma where capacity will not grow without more projects, but projects remain difficult without more capacity (Santana-Sosa & Kovacic, 2022). The Netherlands does have projects that try to build up sustainable supply chains, but the Dutch timber industry is still a less developed environment (Bosschaert, 2020).

3.6.5. Trialability

Limited pilot projects

The biggest barrier concerning trialability for engineered timber diffusion in the Netherlands is the limited number of opportunities for pilot projects or experimentation. Cautious and conservative clients have few options to gain experience with timber without having the risk of a full-scale project. While some innovations can be tested in small components, like new materials used in a limited part of a building, this is less of a possibility for engineered timber, as its main benefits are most evident at a larger building scale. Adopting a new building approach like mass-engineered timber, therefore, is in a sense an 'all-or-nothing' commitment (Santana-Sosa & Kovacic, 2022). Because they perceive the risks and consequences to be high, many clients and developers are unwilling to be the first mover. This results in a wait-and-see approach, where clients prefer other companies to pioneer timber projects to prove their success before trying it out themselves. Even though this direct experience is essential for lowering the perceived risks, there are currently few possibilities for this (Grobbelaar, 2025). This limited trialability is further worsened by an earlier introduced barrier: the lack of direct experience with engineered timber by stakeholders such as clients, architects, engineers, and contractors. Because of the limited possibilities of pilot projects, combined with the limited experience of important stakeholders, diffusion is limited.

3.6.6. Observability

The final set of barriers is about the limited observability of timber construction. According to Rogers (2003), observability is about the extent to which the results of an innovation are visible and understandable to others.

Lack of reference projects

Multi-storey timber construction is not just a niche innovation, but it is also being adopted by a wider group of early adopters and a hesitant early majority. However, wider adoption is still slow. From an observability perspective, the main barrier is the lack of widely recognised reference projects and documented case studies. Both public and stakeholder scepticism remain without visible, everyday examples. Reading about a building in a different country is different from being able to walk through a building. Therefore, as also found in the literature by Santana-Sosa and Kovacic (2022), there needs to be a broader range of ordinary, mainstream timber buildings, such as multi-storey apartment buildings or offices, that make this innovation more relatable and observable in the daily lives of people. In the Netherlands, most timber projects remain stand-alone, and foreign expertise is sometimes difficult to translate to Dutch laws and practices, which leads many stakeholders to hesitate simultaneously, which slows diffusion (Horsting et al., 2024).

Poor dissemination of benefits and performance

This limited observability is strongly related to the insufficient communication of the benefits and performance of timber to a broader audience, a barrier mentioned often in the literature. Even though timber construction offers real advantages, such as faster build times, reduced carbon emissions, and occupant satisfaction, these are not always visible or quantifiable to clients, developers, and other important decision-makers. Santana-Sosa and Kovacic (2022) highlight that this lack of strategic communication within the sector is a key issue, as "success stories" often stay within their own project teams or academic circles, instead of being shared with the broader stakeholders like clients, financiers, or the wider industry. The result of this is that many stakeholders rely on outdated information when they want to evaluate the benefits of timber. Hassan and Grobbelaar (2024) found that there were still low awareness levels among industry experts like engineers and architects, as observability is not only about seeing the buildings but seeing data and evidence, which is just as important.

This gap is also visible in long-term economic benefits like life-cycle cost reductions, increased energy efficiency, and design flexibility due to more usable floor area, which are rarely included in early project decisions because they are difficult to calculate. Furthermore, intangible benefits that are not easily reduced to numbers, like improved occupier well-being due to the exposed timber, are not included in cost-benefit analyses (Santana-Sosa & Kovacic, 2022). As a result, timber's relative advantage is underestimated in early project stages.

Technology transfer

Another factor that contributes to poor observability is the weak connection between research and practice. Although many studies and demonstration projects on timber are being done, and prototypes are made, a lot of them are not translated into actual building practices. Gosselin et al. (2017) note that these innovations rarely reach architects, engineers, or contractors. This ties into the observability barrier, as timber knowledge from researchers is often not well transferred to practitioners. As a result, promising timber innovations remain largely invisible to the wider market, which limits learning opportunities across the building sector. This limited availability of pilot projects, combined with knowledge and experience and supply limitations, reduces the ability of firms to test new timber construction methods on a small scale, which slows the diffusion of these innovations.

Persistent negative perception

This limited observability is further worsened by the view of timber as an "old-fashioned" material, which raises questions regarding its fire safety, strength and load-bearing capabilities (Hassan & Grobbelaar, 2024). As a result, many clients, regulators and members of the public question its suitability for modern, large-scale buildings. These concerns often do not stem from direct experience but from assumptions that remain unchallenged in the absence of visible timber projects (Santana-Sosa & Kovacic, 2022).

As Santana-Sosa and Kovacic (2022) point out, this perception gap can only be bridged when stakeholders are exposed to concrete, local examples that visibly show timber's technical performance and architectural quality. Without this visible proof, they remain sceptical, leading to less investment in the very projects that could change their view. This creates a self-reinforcing cycle where the lack of visible reference projects keeps negative perceptions alive, and those negative views prevent new observable examples from being built. To change this, this cycle needs to be broken so that timber construction becomes more visible and accepted.

3.7. Enablers

While in the last chapter, the variety of barriers was discussed, timber also presents clear advantages that drive its uptake in construction projects. These enablers range from sustainability opportunities and circularity to increased building speed and aesthetics, but also alignment with new sustainability policies and the chance to strategically differentiate by companies. This chapter explores how these conditions and factors influence timber's diffusion in a positive way.

3.7.1. Relative advantage

Environmental sustainability

The most cited enabler for timber construction is also its main characteristic: its environmental sustainability. As found in the literature by Gosselin et al. (2017), over 31% of the motivations across sources by industry experts and stakeholders cited environmental sustainability as timber's biggest advantage. Timber can sequester carbon, and using it instead of concrete or steel can substantially reduce the CO_2 impact of a project. As shown in subsection 3.2.2, worldwide the construction sector accounts for around 37% of CO_2 emissions when considering both operational and embodied emissions (UNEP, 2022). This challenge can be immediately addressed by replacing concrete and steel, two high-emission materials, with engineered timber (Giacomello et al., 2024). This was also found in a policy analysis done in Amsterdam, where engineered mass timber was found to be one of the most effective options for reducing construction emissions (Ancapi et al., 2025).

Furthermore, because of their sequestration capacity, where trees capture and store CO_2 via photosynthesis, sustainably managed forests can act as a long-term carbon sink (Giacomello et al. (2024); Haisma et al. (2023)). This carbon storage is ultimately temporary, as carbon will be re-released upon the biomass decomposition (Hawkins, 2021). However, this release can be delayed when timber is used in buildings with long lifespans or when elements are reused. A recent empirical study by Van der Lugt (2021) demonstrates that for CLT, the overall CO_2 balance remains negative throughout its entire lifecycle, even when end-of-life burning of the material is included. Figure 3.9 shows that while concrete results in the net emissions of +244 kg CO_2/m^3, CLT ends its lifecycle with -238 kg CO_2/m^3. Moreover, if timber is reused instead of being burnt, the CO_2 benefit is even greater, which further strengthens the role of timber in carbon storage and circularity. According to researchers, nearly all timber used in Dutch construction today is sourced from sustainably managed forests, as is assumed in this enabler. These forests use selective farming and replanting, which help with long-term carbon sequestration while also keeping the forests in good health and productive (AMS, 2024).

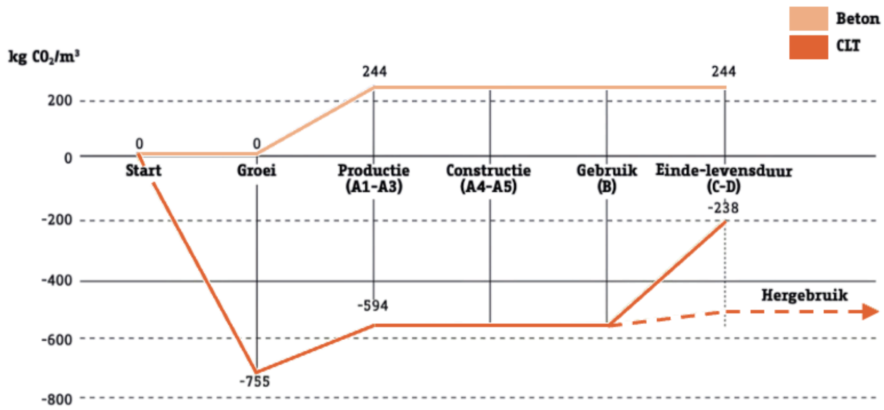

Figure 3.9: Life cycle CO_2 balance of CLT vs. concrete (adapted from Van der Lugt (2021))

In addition, timber supports circular economy principles, as compared to steel and concrete, timber components are often easier to disassemble and reuse, which helps to minimise waste and resources (Santana-Sosa & Kovacic, 2022). Also, because of its prefabrication potential, building deadlines are accelerated and on-site emissions and waste are decreased (Gosselin et al., 2017). Timber buildings, furthermore, require a lot less energy to build. This results in a lower embodied energy per unit compared to conventional materials (Hassan & Grobbelaar, 2024). Finally, timber is a renewable material. This means that timber can be regenerated naturally within a lifetime (Hawkins, 2021), unlike concrete and steel, which rely heavily on finite materials and fossil fuels in their production process (Giacomello et al., 2024). With policymakers and certification bodies focusing more on low-carbon materials, these characteristics of timber make it an important part of the decarbonisation of the construction industry (UNEP, 2022). According to Hassan and Grobbelaar (2024), when these environmental benefits are recognised, the adoption of timber among governments and communities prioritising sustainability will increase. Thus, this makes it a key enabler for both public and private actors to choose timber.

Speed, efficiency, and flexibility

In addition to the relative advantage of the environmental sustainability properties of timber, another well-cited enabler, shortly mentioned above, is timber's speed and efficiency. Prefabricated engineered timber elements can be installed faster, saving on-site labour and reducing disturbances. Gosselin et al. (2018) mentions that these reduced disturbances create a quieter workplace that also produces less dust, which increases worker well-being and safety. CLT, for example, has proven to be installed a lot faster than concrete, saving time and costs, while also allowing for earlier building occupancy (Gosselin et al., 2018). This was also found in the qualitative study by Smith et al. (2017). As shown in Figure 3.10, they concluded from their case studies that the use of mass timber construction resulted in an average 20% schedule reduction compared to traditional building methods.

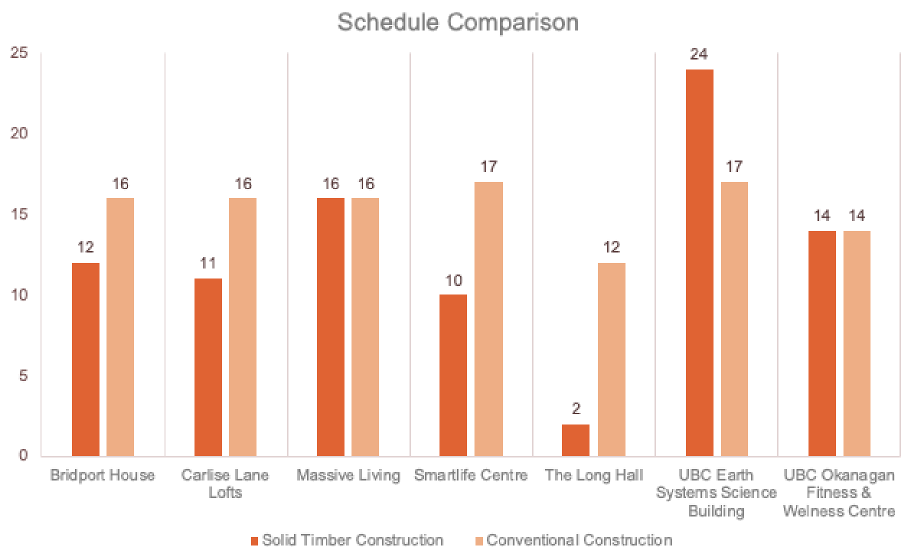

Figure 3.10: Comparison of schedule durations in months between mass timber and traditional construction (adapted from Smith et al. (2017))

Moreover, Roos et al. (2010) shows that timber construction has proven to have a lower energy demand during the construction phase compared to traditional methods, which increases both its environmental and operational properties.

Furthermore, engineered timber systems, like CLT and glulam, allow for more flexible layouts. Timber also enables modular design, giving possibilities for future expansion or adaptations (Gosselin et al., 2018). Finally, timber is a lightweight material. This makes it very suitable for difficult building site conditions, while it also adapts better to urban infill. This also adds to timber as a more flexible design choice compared to traditional building methods (Horsting et al., 2024). This also adds to the structural performance of engineered timber, as it has a high strength-to-weight ratio and proven seismic resilience. Its adoption based on structural performance, therefore, is tied more to stakeholder perception than to objective testing, as engineered timber meets modern standards (Hassan & Grobbelaar, 2024).

Biophilic design

Timber's relative advantage goes further than sustainability and structural properties. Both Gosselin et al. (2017) and Horsting et al. (2024) found that the beauty and unique aesthetics of timber structures inspired many early adopters. With the exposed timber, clients and architects can differentiate themselves in the market, which is appealing. Moreover, as mentioned in short in the previous chapter about barriers, some studies have found that timber interiors improve occupant well-being, as they reduce stress and improve comfort, which concrete rooms can not (Hassan & Grobbelaar, 2024). For end-users, this biophilic advantage makes timber buildings attractive to work or live in.

Market advantage

For companies, timber construction has notable market and reputational benefits. The environmental sustainability advantages, as explained above, help developers with meeting climate targets, but they also enhance their green image. According to (Gosselin et al., 2017), it is an important motivation for their adoption of timber construction, as it can give the companies a competitive advantage. This competitive advantage is also mentioned within the industry itself, as shown in Figure 3.11. Survey participants mentioned that value preservation or increase of their buildings was the main driver for sustainable construction (Soulti & Leonard, 2016).

Furthermore, in the Netherlands, stricter regulations that favour bio-based materials are in place, like the Nationale Aanpak Biobased Bouwen (Rijksoverheid, 2023). Companies that are timber-oriented have an advantage here in securing tenders and drawing new clients who care about sustainability. Furthermore, prefabrication and the material's light weight can shorten construction timelines, as mentioned above, but it also saves money, which may give early adopters an economic edge over competitors (Hassan & Grobbelaar, 2024). Thus, for certain companies, adapting their business models and positioning themselves as sustainability leaders can give them both a competitive and a reputational advantage within the building sector (Horsting et al. (2024); Gosselin et al. (2017)).

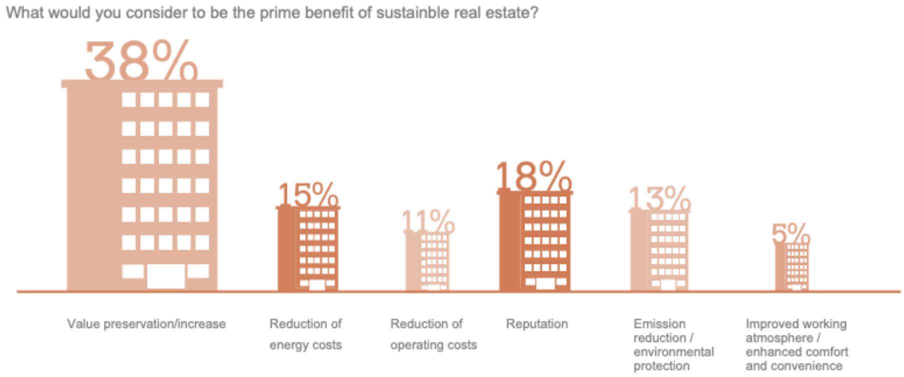

Figure 3.11: Benefits of sustainable real estate (adapted from DLA Piper (2014), as cited in Soulti and Leonard (2016))

3.7.2. Compatibility

Alignment with policy and societal goals

When discussing the barriers in the previous chapters, compatibility barriers were present mainly due to the fragmented Dutch building industry and silo thinking, but also because of the misalignment with building codes. Closely tied to this barrier, however, is a large compatibility factor: the growing emphasis on sustainability in policy frameworks (Horsting et al., 2024). Multiple sources noted that timber building is explicitly favoured to reduce emissions in policies on all levels of government, such as international agreements, national climate initiatives, city development plans, and procurement regulations (Ancapi et al. (2025); Vihemäki et al. (2020)). In the Netherlands, these include strategies such as the National Climate Agreement and the Nationale Aanpak Biobased Bouwen (Government of the Netherlands (2019); Rijksoverheid (2023)), but also green standards such as BREEAM, which is used by most firms also in the Netherlands to rate and classify the sustainability of a building (Dutch Green Building Council, 2018). This perceived compatibility with national and global policies is further reinforced when timber is framed not just as a low-carbon alternative to concrete and steel but also as a material that supports long-term environmental, social and economic sustainability (Roos et al., 2010). In countries, including the Netherlands, different instruments are emerging that support this alignment, such as carbon pricing. The carbon tax introduced in 2021 in the Netherlands, which increases to €125 per tonne CO_2, will increase the costs of traditional materials like concrete and steel by a great amount, while timber will remain largely unaffected. This is visualised in Figure 3.12. This tax will create a long-term economic advantage for timber, which will make timber not only more sustainable but also a strategically better choice (Bronsvoort et al., 2020).

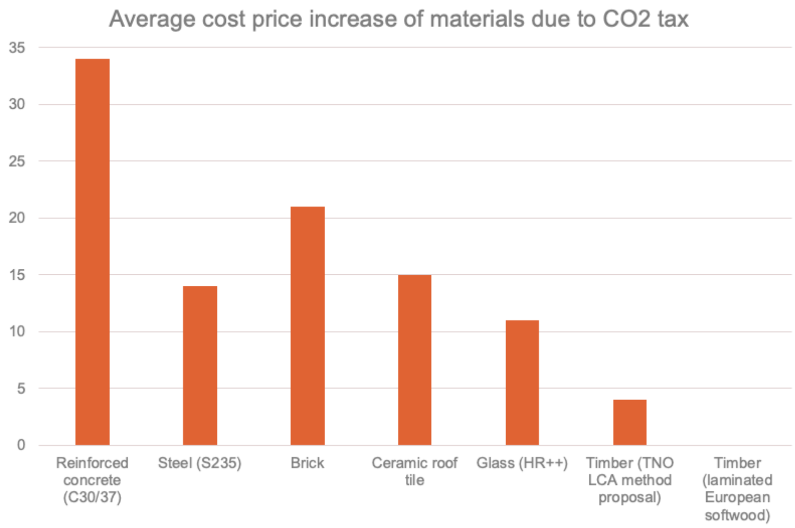

Figure 3.12: Average Cost Price Increase of Materials Due to CO_2 Tax of €125/ton CO_2 (in %) (adapted from Bronsvoort et al. (2020))

As timber is recognised more as a way to achieve sustainability and lower carbon emissions, with costs decreasing, both political and public opinion shift in its favour. In Finland, for example, the government strongly supports timber as a multi-storey building material as part of their national carbon reduction plan. This makes timber more accepted and aligned, which increases its adoption (Vihemäki et al., 2020). In the Netherlands, a recent study by Horsting et al. (2024) shows that contractors and developers are adapting their operations to support timber construction and align with these policies. They, for instance, mention that over 60 construction companies now have separate departments around timber construction, showing that it is becoming more compatible with business operations (Horsting et al., 2024). This shows that it is becoming more compatible with business operations.

3.7.3. Complexity

Complexity is a pertinent issue around timber construction. Some of the enablers mentioned for relative advantage are also, in part, enablers for complexity issues. Furthermore, as noted by Quesada et al. (2018), engineered-timber suppliers are now able to deliver entire prefabricated modular systems that combine timber, glulam and CLT so that they can be shipped as one building set. This decreases complexity, as on-site standardisation and ease of assembly are greatly improved by this. These prefabricated elements avoid weather delays and fitting errors, while these standardised element dimensions decrease design complexities Quesada et al. (2018). In addition, empirical evidence by Quesada et al. (2018) found that prefabrication was among the top drivers of CLT adoption by industry professionals.

3.7.4. Trialability

One of the biggest enablers for timber construction is pilot projects and demonstrations, but, as mentioned in the previous chapter, these are limited. However, as found by Hassan and Grobbelaar (2024), when professionals have been involved in one timber build, they are far more likely to use timber in another project. The trialability through direct experience with timber can change stakeholders with negative timber perceptions into timber adopters.

Furthermore, (Gosselin et al., 2017) show that this trialability extends to further incremental adoption strategies like hybrid construction. Their study describes a case in Quebec, Canada, where timber was gradually introduced. A government office, for instance, combined a glulam timber structure with conventional material, like concrete, and a social housing project combined CLT and traditional steel framing. These hybrid projects allow stakeholders to test and monitor timber performance while still relying on familiar materials to reduce regulatory and risk concerns.

Also, in Europe, this has recently been done. Hybrid building systems have become more dominant in multi-storey construction because they can combine innovation with performance certainty (Nordic

Homes, 2024). Timber is strategically combined here with concrete and steel through the use of, for instance, a concrete core for stability or composite timber-concrete floors to adhere to acoustic and vibration standards. However, these hybrid buildings serve more than just a technical solution, as they also build confidence. They allow developers, regulators, and occupants to see that timber can work at scale. As noted by Nordic Homes (2024), each hybrid project serves as a ”learning laboratory”, where the viability of multi-storey engineered timber can be proven and building techniques can be further improved. This makes hybrid buildings also a good enabler for confidence-building.

3.7.5. Observability

How fast an innovation like timber construction is able to spread also depends on how visible and shareable its results are. Platforms that capture and share this knowledge greatly improve timber's observability (Santana-Sosa & Kovacic, 2022). In many countries, timber projects are now included in publications and online databases. In Finland, for instance, the 'open-source wood' initiative was launched for architects, designers, and engineers to collaborate and share their ideas. To build a shared knowledge base around large-scale modular timber buildings (de Architect, 2017). Likewise, WoodWORKS! is a Canadian initiative to promote the use of timber by sharing best practices and connecting individuals offering design support for non-residential and tall timber buildings (Canadian Wood Council, 2025).

Apart from these websites and databases, another enabler is the growing professional and public outreach of successful timber projects. As mentioned in the literature by Hassan and Grobbelaar (2024), collaboration between timber industry actors and the broader construction industry, through, for example, promotional events, helps increase stakeholder familiarity and acceptance of timber products. This is especially evident in countries like Sweden and Finland, where government agencies and industry organisations act as key intermediaries. They support timber uptake and share information by showing exemplary projects, while also coordinating training programmes and public campaigns to increase the visibility and trust in timber construction (Vihemäki et al., 2020).

Lastly, the use and dissemination of performance data were identified as an enabler in the literature. Ancapi et al. (2025) found that further adoption was visibly encouraged when cost reductions and expertise growth from earlier projects were made visible. This shows that each documented project and its outcomes serve as concrete examples that support diffusion by providing visible, real-world proof.

3.8. Conclusion literature review

This chapter answered the first sub-question of this research: *What are the current barriers and enablers influencing the adoption of timber in multi-storey construction?*

The literature shows that timber construction remains in the early adoption phase while becoming more widely adopted by a cautious early majority because its potential is being more recognised. However, its adoption is still slowed by persistent barriers.

To better understand these dynamics, a structured literature review identified various barriers and enablers to adopting multi-storey timber construction, which were analysed using the Diffusion of Innovations (DOI) framework, where the findings were organised into the five key attributes of innovation.

Furthermore, a stakeholder mapping was developed to identify and rank the different stakeholders based on their influence on material decisions throughout the project. This showed that clients were most influential in the early design phase, where material choices are first introduced, as they hold instrumental power through financial control and project mandates. The advice of architects through discursive power influenced material framing, while structural engineers and consultants often shape outcomes via structural power through technical feasibility. The influence of other actors, such as contractors or suppliers, strongly depends on when they are brought into the process, as early involvement can shift power balances and increase alignment around timber decisions.

The main barriers and enablers, as identified through the DOI attributes, are summarised in Table 3.2:

Table 3.2: Summary of barriers and enablers for multi-storey timber adoption, structured by DOI attributes

DOI attribute	Barriers	Enablers
Relative advantage	High (upfront) costs Difficult to monetise benefits	Environmental sustainability Faster & more efficient Branding & market advantage
Compatibility	Risk-averse industry culture Misalignment building codes Fragmentation & silo-thinking Traditional project delivery models	Alignment with policy and societal goals CO_2 tax Green standards (e.g. BREEAM)
Complexity	Lack of knowledge Project complexity Lack of standardisation	(Potential) for more integrated design
Trialability	Limited piloting	Hybrid timber can build confidence
Observability	Lack of reference projects Poor dissemination of benefits & performance Weak technology transfer Persistent negative perception	(Potential) platforms and sharing initiatives

While the literature provides a strong theoretical basis on barriers and enablers, it does not explain how these work out in practice and how these are shaped by project-specific dynamics. In particular, little is known about how stakeholder motivation, influence, and timing affect the way barriers are addressed or enablers are activated. Furthermore, the distinction between full timber and hybrid timber is rarely made in the literature, even though this could have real implications for the project decision-making. To fill this gap, in the next chapters, this research investigates two Dutch projects using semi-structured interviews.

4 Empirical data collection and findings

4 Empirical data collection and findings

In this chapter, the findings from the interviews with the stakeholders will be presented. As mentioned in chapter 2, themes were identified from the empirical data using the Gioia method. These themes are about the barriers and enablers found in the two case study projects, as well as the project dynamics and the role of motivation within the context of timber adoption.

4.1. Interview respondents

As described in subsection 2.3.1, this research focuses on two projects: a full-timber residential development driven by client ambition, and a hybrid timber-concrete office project shaped by tenant involvement within a commercial development. It was important for the recruitment of interview respondents that they were affiliated with either of the two contrasting projects. The primary goal of the interviews was to capture whether the different stakeholder roles, project dynamics and motivation affected the presence and handling of barriers and enablers related to multi-storey timber adoption. For the selection process, guided by subsection 3.3.4, therefore, respondents were intentionally selected from diverse professional backgrounds to not only capture the broad stakeholder landscape on a timber construction project but also to reflect the different layers of influence. This way, a comprehensive understanding of the interactions and different nuanced perspectives among stakeholders could be captured. This reflected the various factors that have an impact on the decision-making process in multi-storey timber construction projects.

In total, 15 interviews were conducted with different stakeholders, as shown in Figure 4.1. The interview protocol can be found in Appendix A.

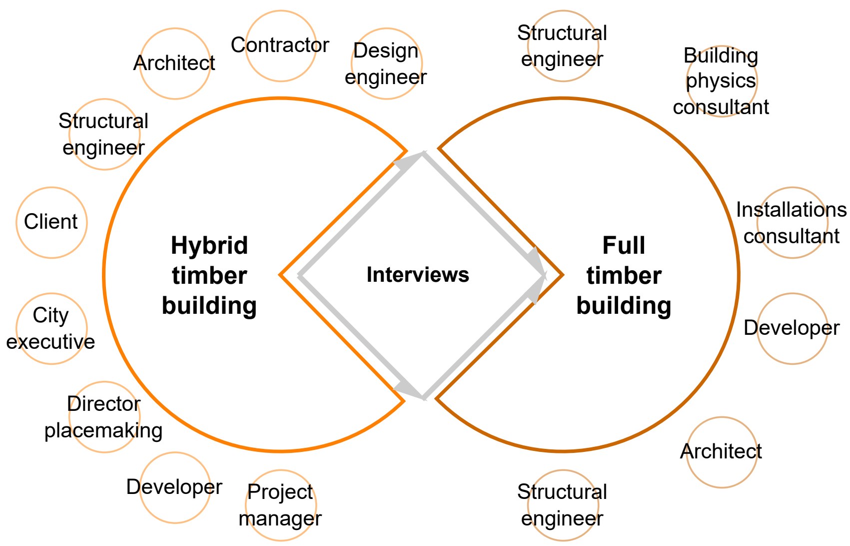

Figure 4.1: Overview of interview respondents

Furthermore, Table 4.1 shows a table providing more in-depth information about the different interviews conducted.

Table 4.1: Overview of interview respondents and interview duration

#	Stakeholder role	Project involvement	Date	Duration [min]
1	Structural engineer	Hybrid timber project	13-06-2025	43
2	Architect	Full timber project	17-06-2025	67
3	Contractor	Hybrid timber project	18-06-2025	39
4	Structural engineer	Full timber project	20-06-2025	47
5	Design engineer	Hybrid timber project	25-06-2025	45
6	Director placemaking	Hybrid timber project	26-06-2025	30
7	Building physics consultant	Full timber project	27-06-2025	48
8	Client	Hybrid timber project	27-06-2025	30
9	Project manager	Hybrid timber project	27-06-2025	50
10	Developer	Full timber project	30-06-2025	59
11	Structural engineer	Full timber project	02-07-2025	43
12	Architect	Hybrid timber project	04-07-2025	39
13	City executive	Hybrid timber project	04-07-2025	62
14	Developer	Hybrid timber project	08-07-2025	43
15	Installation consultant	Full timber project	10-07-2025	76

In this chapter, the findings from the stakeholder interviews are presented. As mentioned earlier, the interviews were conducted with 15 stakeholders from diverse roles who were involved in either the full timber project or the hybrid timber project. The chapter is structured thematically, meaning that in the different sections, the findings from a specific topic are synthesised. This is done through the use of the first-order concepts derived from the interviews and recurring themes. This analysis provides a nuanced understanding of timber adoption by examining how barriers, project dynamics, and motivational shifts interact across construction projects. The resulting data structure from this coding process is visualised in Figure 4.2, which offers an overview of the relationships between first-order concepts, second-order themes, and aggregate dimensions, serving as a roadmap for the thematic sections that follow.

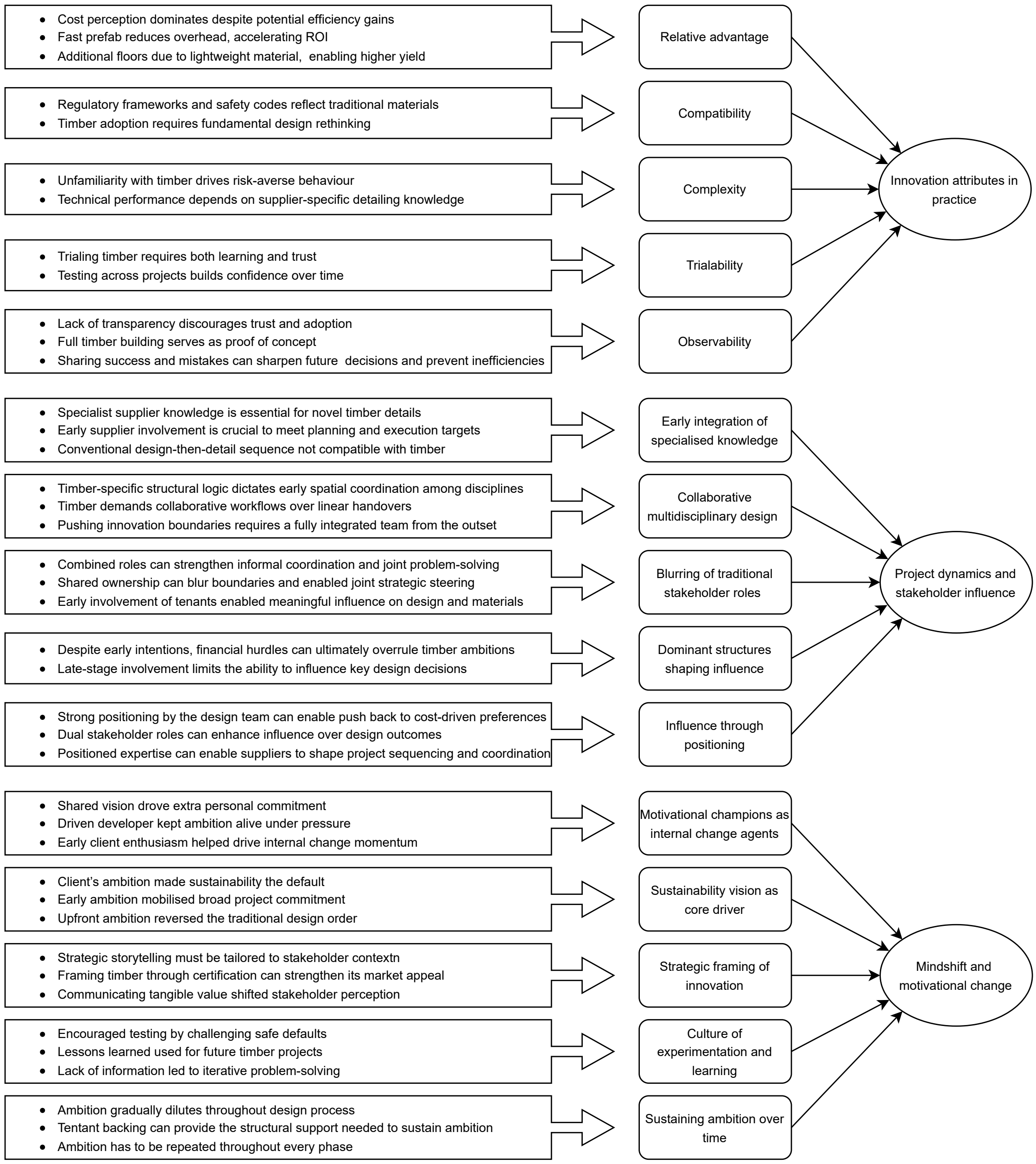

Figure 4.2: Data structure of empirical findings using the Gioia method

4.2. Innovation attributes in practice

The perceived qualities of timber as a construction material have played a central role in shaping project decisions. In both projects, stakeholders consistently discussed timber in terms of its advantages and limitations. These qualities align with well-established innovation attributes such as relative advantage, compatibility, and observability. In practice, however, these qualities were highly context-specific. Instead of being fixed characteristics of timber, they were debated and interpreted differently throughout the project. They were seen as either supporting or hindering adoption based on how they were understood, presented and managed by the actors. The following section examines how these attributes influenced decisions in the projects.

4.2.1. Perceived relative advantage of timber

Stakeholders frequently compared timber to traditional materials, revealing its strengths and weaknesses in a complex and sometimes contested view of its relative advantage. In both projects, a key point of discussion was the perceived financial performance of timber, which had a large impact on early design choices. Despite some interviewees expressing that timber could be cost-competitive, it was often viewed as more expensive. This was due to the lack of generally recognised standards and the enduring market narrative. The perception of cost-conscious stakeholders, therefore, that timber would automatically increase upfront construction costs by 10 to 15% posed a significant barrier to its adoption. Long-term savings were, as a result, overshadowed, with one project manager explaining that their developer ultimately based the decision on whether a €4.5 million timber structure could deliver the expected return. This illustrates how concerns about upfront costs and further financial risks shaped investment decisions.

These cost-related doubts were reinforced by concerns about liability. Stakeholders who needed to offer guarantees were sometimes hesitant, having seen past timber projects encounter issues; they leaned towards familiar materials like concrete. In another case, timber was considered for flooring, but stakeholders requested additional comparisons. Even though the right requirements were met, precast concrete was seen as slightly more reliable based on experience, resulting in a concrete decking floor. Showing that perceived risk, whether contractual or technical, shaped decisions, even when timber performed within the right margins.

This perception, however, was not accepted by everyone. In both projects, some actors wanted to redefine the narrative. A common example was reduced construction time through prefabrication, with one interviewee noting that, unlike traditional methods, timber construction could be completed a lot faster, reducing interest payments and allowing a faster return. Likewise, timber's lightweight properties enabled extra floors, increasing usable space and justifying the timber choice.

> *"The key benefit for our client was that the lightweight construction allowed us to maximise floor space on top of the existing parking garage. That convinced him."*

This highlights how benefits, while context-specific, could tip the balance in timber's favour for some stakeholders. It shows how timber could create both spatial and financial value in ways not always captured conventionally.

Apart from financial-related characteristics, to some stakeholders, carbon storage and the indoor climate created with timber are aligned with broader sustainability goals while supporting a distinct project identity. In one instance, the exposed timber columns were celebrated not just structurally, but also as an architectural element.

These findings reveal that timber's relative advantage cannot be seen as fixed. Instead, it was actively constructed and reframed throughout the projects, shifting between economic, environmental, and symbolic, depending on the context and the involved stakeholders. The eventual decision to use timber was often less about objective performance but more about how its advantages were understood and aligned with project goals.

4.2.2. Alignment of timber with existing norms and practices

Timber construction still clashes with existing regulations and building traditions, which still reflect assumptions based on concrete and steel. Multiple interviewees described how safety authorities required additional fire resistance measures for timber buildings, even though the right performance norms were met. This was all because of a lack of guidelines specific to timber in current building codes, which forced the teams to defend their designs with outdated regulatory models. This disconnect also affected formal testing, as performance claims based on simulations or past projects were often met with scepticism, and strict requirements were imposed before real-world validation could be achieved.

Another challenge was the absence of industry-wide standardisation. Each supplier brought its own detailing and prefabrication logic, necessitating continuous alignment. This complicated the process integration, especially when material choices were postponed to late design stages. Several interviewees noted that when timber was introduced after the initial concept phase, it required substantial reworking due to different dimensions, tolerances, and details, which could even hamper complete timber adoption. In many cases, these issues were worsened by long-standing routines. The preference for traditional workflows, or the attitude that "this is how we've always done it", made it more difficult to adjust to timber's specific requirements. However, in one of the projects, the use of more flexible contract models allowed for iterative problem-solving. As a result, more time was allowed for adjusting to the material's needs. This suggests that compatibility issues are not purely technical, but that they also depend on how project frameworks support adaptation and feedback.

4.2.3. Perceived complexity and uncertainty of timber use

Timber was not widely seen as an inherently complex material. Multiple interviewees even pointed out that certain tasks, like attaching installations, were easier with timber than with concrete, which they were used to. Still, timber projects introduced different forms of coordination and preparation, unfamiliar to many stakeholders. Most elements required clear planning, but this was not perceived as technically difficult, just more front-loaded and interdependent.

The real source of complexity lay in limited experience. Many consultants and contractors were not familiar with timber-specific detailing, making it harder to judge what was technically possible, especially for integrated aspects like fire and acoustic performance. Without input from suppliers or past examples to learn from, uncertainty increased. Some interviewees noted that this lack of knowledge reinforced risk-averse behaviour, with stakeholders opting for familiar, traditional alternatives. The limited availability of skilled timber labour and specialised logistics was mentioned as adding to this sense of uncertainty. These gaps were not seen as permanent barriers but as transitional challenges linked to timber's current stage of market maturity.

Rather than viewing timber itself as a very complex design solution, most stakeholders saw the complexity as situational. It was driven by fragmented knowledge, limited examples, and the need for more and better coordination. Some interviewees believed these challenges could decrease over time, while others were less convinced that the market would adapt on its own, noting that without active investments in knowledge, standardisation, and collaboration, the perceived challenges may continue to slow adoption.

4.2.4. Trialability with multi-storey timber

Both projects revealed how timber adoption benefits from the ability to test, adapt, and learn over time. Various interviewees described trialling timber as an enabling process that builds confidence through experience. Most actors noted that their project was their first with actual timber implementation and that small-scale experience was rare. Still, the idea of testing timber across projects, learning from results, and building internal confidence was seen as important for progress. This would also enable them to, in the future, construct more efficiently.

So, rather than treating it as a barrier, most saw it as a pathway, but to initiate the first project requires a degree of trust. To some, though, it was a deliberate step into uncertainty to try constructing with timber, taken with the hope of building future advantage.

4.2.5. Timber visibility and knowledge sharing

Where trialability provides space for internal learning, observability makes that learning visible to others. In both projects, interviewees emphasised how the visibility of timber shaped perception, not just among external people, but also within the project teams. Public and industry curiosity brought a sense of energy and pride to the teams, and through site visits, social media updates, and guided tours, timber "became real". Especially in the full timber project, visibility was seen as a key way to build trust and spark interest, both to the outside and the internal team.

At the same time, this visibility was not always achieved. In one of the two projects, the large parts of the timber structure ended up being hidden behind interior finishes and an outside facade cladding. Stakeholders expressed regret over this decision, noting that the project could have served more strongly as a demonstration.

The reduced observability was not only caused by visual limitations, as some interviewees mentioned that technical knowledge and performance data were often not openly shared across organisations. In one instance, people hesitated to communicate lessons learnt because they feared that they might expose flaws or raise questions about building code compliance. One interviewee explained that this reluctance to share created uncertainty and 'kills enthusiasm' for others, resulting in them falling back on traditional materials like concrete, simply because the story was incomplete.

At the same time, interviewees described mixed experiences with knowledge sharing across projects. Some noted the absence of a cross-project exchange. As a result, lessons learnt would not become visible to people who might benefit from them, which limits collective learning. On one of the projects, however, several stakeholders mentioned that they were actively involved in knowledge-sharing initiatives. These platforms provide a space to openly communicate challenges, solutions, lessons, and innovations, which enables others to learn without having to start from scratch. To them, the willingness to share was seen as an important enabler for broader adoption.

Together, this section described how the five core innovation attributes were experienced and negotiated in practice. Across both projects, these attributes emerged, rather than being fixed properties of timber. They were shaped by the specific conditions, expectations and actions of involved stakeholders. The first-order instances and second-order themes of these attributes can be found in Table 4.2.

Table 4.2: Aggregate dimension - Innovation attributes in practice

#	1st Order Instances	2nd Order Themes
1	Cost perception dominates despite potential efficiency gains	Relative advantage
2	High upfront costs and uncertainty weaken timber's investment case	
3	Liability concerns can lead to preference for proven materials	
4	Conservative benchmarks favour traditional materials	
5	Fast prefab reduces overhead, accelerating ROI	
6	Additional floors due to lightweight material, enabling higher yield	
7	Carbon sequestration strengthens timber's environmental value	
8	Exposed timber structure adds architectural value	
9	Regulatory frameworks and safety codes reflect traditional materials	Compatibility
10	Innovative materials face rigid standards before real testing	
11	Lack of standardisation complicates process integration	
12	Timber adoption requires fundamental design rethinking	
13	Late-stage material decisions complicate design integration	
14	Established routines obstruct innovation	
15	Flexible contracts support iterative problem-solving	
16	Unfamiliarity with timber drives risk-averse behaviour	Complexity
17	Lack of skilled labour and logistics limit timber's execution reliability	
18	Design complexity encourages better preparation	
19	Integrated timber design demands spatial clarity and stricter coordination	
20	Technical performance depends on supplier-specific detailing knowledge	
21	Testing across projects builds confidence over time	Trialability
22	Trialling timber requires both learning and trust	
23	Familiarity through repetition improves efficiency	
24	Trailing timber seen as future-proofing experience	
25	Timber structure hidden from view limits observability	Observability
26	Fear of non-compliance discourages open performance sharing	
27	Lack of transparency discourages trust and adoption	
28	Full timber building serves as proof of concept	
29	Curiosity and enthusiasm around timber creates observability	
30	Reference projects by suppliers increase trust and reduce perceived risks	
31	Active knowledge dissemination through industry platforms	
32	Sharing success and mistakes can sharpen future decisions and prevent inefficiencies	

4.3. Project dynamics and stakeholder influence

In addition to how timber was perceived through its innovation attributes, the dynamics between stakeholders played a large role in its adoption. This adoption did not occur in isolation, and this section, therefore, describes how stakeholder positioning, stakeholder roles, early involvement, and project collaboration affected material choices and design outcomes.

4.3.1. Dominant structures and influence through positioning

The extent to which actors were able to shape material and design outcomes varied between the two projects and was closely linked to their roles. Often, the developer held the most power, particularly when controlling the finances. Several interviewees mentioned that in previous projects, early timber ambitions were dropped as soon as cost concerns arose. In one case, even though timber was part of the initial design, the developer opted for concrete, seeing it as a safer investment.

This dynamic was reinforced by the way teams were organised. Design teams are often limited to giving advice, especially when they lack a direct client-facing role or ownership stake. One project manager shared that they could advocate for timber as much as they wanted, but that eventually the ”one who pays still decides”, and that their input, therefore, could be overruled. Others explained that their influence on material choices and design concepts was limited, as they only became involved after decisions were made.

Despite these limitations, because of their specific positioning within the project, some actors were able to assert meaningful influence. In one case, the design team insisted on leaving the project if timber was removed. Their influence was stronger because their company functioned both as the design team and as the future tenants. This dual role allowed them to defend timber from both a design and a user perspective. More generally, tenant involvement was seen as an important factor in keeping timber central to the project's vision. By representing long-term users, they had a clear stake in the building's quality and sustainability level, which helped them exert more influence.

Finally, suppliers with timber experience were positioned so that they were able to steer the project coordination. Their recognised expertise enabled them to influence which parties had to be involved and when. This is, according to interviewees, often underestimated in conventional project structures.

4.3.2. Blurring of traditional stakeholder roles

In both projects, several actors took on responsibilities that extended beyond their formal roles. In the full timber project, this was especially clear as the structural engineer and timber supplier worked so closely that they were seen as a single design team. The engineer contributed expertise in high-rise structures, while the supplier offered detailed knowledge of timber connections and product specifications. By combining their expertise into a single new role, they were able to fill each other's gaps, and this informal partnership became necessary for making design decisions early in the process and ensuring buildability. Their combined role blurred the line of traditional expertise, enabling them to function outside traditional silos.

This type of role convergence also appeared at the strategic and execution levels. In one of the projects, the architect also functioned as the co-owner of the building, allowing them to take part in strategic decisions rather than purely acting as consultants. This shared ownership model increased their influence, steering the project vision in alignment with long-term user ambitions. The project team operated in a more integrated way, where traditional boundaries between roles became less fixed. This was also visible during the execution phase, where instead of working with a traditional main contractor, responsibilities were shared across the team. Here, the line between design, management, and execution was blurred, which strengthened horizontal collaboration across disciplines.

Similarly, in the other project, the future tenants, engaged from the start, were able to actively participate in key design phases instead of just giving user feedback. Their early involvement gave them leverage in discussions that would otherwise be dominated by the client or developer.

4.3.3. Early integration of specialised knowledge

Timber construction required teams to integrate specialised knowledge much earlier than in conventional projects as a driver and a response to timber's needs. In both cases, teams recognised that traditional sequencing, where the design is made first, followed by the detailing, was incompatible with timber. Critical structural aspects, like dimensions and joints, depended heavily on specific connection details. This meant that buildability constraints had to shape design decisions from the start, requiring early engagement from specialists who conventionally enter the process later, like timber suppliers. One phrase was repeated across interviews:

”In timber construction, the devil is truly in the details.”

This quote captures how early technical choices had large consequences for feasibility and sequencing. Without specialist input, design teams risked committing to unfeasible solutions.

The complexity was further increased due to the variation in production methods between suppliers. With differing prefabrication tolerances and assembly methods, teams had to align early with a specific supplier and adapt the structural and spatial design to fit their system. Interviewees mentioned that this alignment was necessary through many stages of the process and that without it, there was a risk that planning targets could not be met.

Because of this dependency on supplier-specific systems, interviewees mentioned that detailing decisions had to be resolved before spatial layouts could be finalised. This was described in the interviews as a different way of working, where projects could not rely on standard detailing libraries or copy-paste solutions from other materials. Rather than treating suppliers as passive subcontractors, the project teams had to involve them early as active design partners, with their knowledge being essential throughout the entire design process.

However, in one of the projects, this early integration did not fully materialise. Interviewees reflected that this delayed involvement had reduced the opportunity for optimisation. While the timber supplier was integrated in time to deliver the timber part of the construction, several team members, including some engineers, noted that their involvement came later than preferred. The interviewees indicated that earlier involvement might have led to improved design quality and alignment. Because the contractor had not yet selected supply chain partners at that stage, there was no established collaboration routine in place. This made the integration slower and more reactive.

4.3.4. Collaborative multidisciplinary design

Timber construction requires not only earlier involvement from specialists but also alternative methods of collaboration across disciplines. In both projects, teams experienced that conventional handovers between design phases, where one discipline finalises its input before passing it on, did not work with the iterative and interdependent nature of timber detailing. One interviewee described that timber required them to think more ahead so that, rather than developing layouts and structure separately, spatial design had to be aligned with technical constraints. The floor plans, therefore, were not shaped by architectural preferences alone but were developed in close collaboration with the structural and technical experts to align with the possibilities of timber systems.

In one of the projects, the need for continuous collaboration was supported by the presence of a clear project vision that was defined at the very beginning of the design process. This shared ambition was described as guiding decision-making across disciplines, acting as a common reference point.

Especially in projects that aim to push the boundaries of timber, for instance, in terms of structural feasibility, interviewees spoke about the importance of starting with a fully integrated team. Bringing disciplines together from the outset was necessary to resolve technical challenges more efficiently, as well as to encourage shared exploration. By immediately tackling issues together, the team was able to create more ambitious design solutions. The first-order instances and second-order themes of the above-mentioned themes can be found in Table 4.3.

Table 4.3: Aggregate dimension – Project dynamics and stakeholder influence

#	1st Order Instances	2nd Order Themes
33	Despite early intentions, financial hurdles can ultimately overrule timber ambitions	Dominant structures shaping influence
34	Centralised developer control can disrupt collaborative influence among design actors	
35	Without formal project roles, influence remains limited to advisory input	
36	Late-stage involvement limits the ability to influence key design decisions	
37	Strong positioning by the design team can enable push back to cost-driven preferences	Influence through positioning
38	Tenant involvement was decisive in keeping timber central to the project's vision	
39	Engineer input shaped defining visual and conceptual aspects of the design	
40	Dual stakeholder roles can enhance influence over design outcomes	
41	Positioned expertise can enable suppliers to shape project sequencing and coordination	
42	Combined roles can strengthen informal coordination and joint problem-solving	Blurring of traditional stakeholder roles
43	Shared ownership can blur boundaries and enable joint strategic steering	
44	Execution was redistributed across actors in the absence of a main contractor	
45	Early involvement of tenants enabled meaningful influence on design and materials	
46	Informal role-taking supported sustainability ambitions across the project team	
47	Specialist supplier knowledge is essential for novel timber details	Early integration of specialised knowledge
48	Early supplier involvement is crucial to meet planning and execution targets	
49	Diverse production methods require continuous alignment with specific suppliers	
50	Conventional design-then-detail sequence not compatible with timber	
51	Structural detailing constraints require early design adaptation to timber logic	
52	Lack of timely partner selection complicates integration	
53	Timber-specific structural logic dictates early spatial coordination among disciplines	Collaborative multidisciplinary design
54	Timber demands collaborative workflows over linear handovers	
55	Pushing innovation boundaries requires a fully integrated team from the outset	
56	A shared project vision guides continuous collaboration	

4.4. Mindset shift and motivational change

Timber adoption in both projects was not just the result of technical or organisational factors, but it was driven as much by internal motivation and shared ambition. This section examines how motivation, ambition, and learning contributed to a collective mindset shift in the project teams that could be sustained across the design and execution of the timber buildings.

4.4.1. Motivational champions as internal change agents

In both projects, certain actors played a key role in protecting and pushing the sustainability ambition because they believed in it, not because they necessarily had to. One developer, for instance, consistently defended the bio-based vision, even when technical concerns about aspects like fire safety came up. Rather than dismissing these concerns, they were acknowledged, but it was insisted that they should not delay or block the vision. This persistence allowed solutions to be explored, but for this to happen, driven advisors were also necessary. Interviewees noted that for a pioneering project, the project team needed advisors who not only provided input but also proactively kept sustainability embedded in the project scope. Their commitment ensured that the topic remained central, especially during moments of concern.

However, this internal drive was not always shared by everyone involved. In one case, the project started with a strong sustainability ambition from the design team, but other stakeholders had been instructed to deliver a low-cost building. These different starting points created tension that took a lot of effort to overcome. Here, active work was necessary to close this gap between ambition and what seemed feasible before the team could find alignment. In contrast, in another case, the project benefited from early client endorsement, which helped establish a shared mindset from the beginning. As one interviewee put it:

"Yes, I really think that makes or breaks it. If a client or initiator is positive about bio-based construction, then they've already taken the first step."

This early commitment from the client built confidence in the team to invest in the ambition. Moreover, one interviewee mentioned that due to the drive of these motivational champions, a shared Paris-proof goal had been established, resulting in project actors willingly putting in extra hours. When this shared vision was present, individuals felt encouraged to contribute beyond what was formally required.

4.4.2. Sustainability vision as driving motivation

Both projects started with a stated ambition to build sustainably, but the way in which that vision was interpreted and acted upon differed. In one project, the different parties appeared to share the same goals, but their definitions of sustainability later proved to be quite different. While one party aimed for extensive use of bio-based materials, among other improvements, the other had a narrower view of what sustainability involved. This misalignment only became clear during the design phase, causing confusion and delays. Although there was a shared vision, the lack of common understanding formed a barrier.

On the other project, the client made the sustainability ambition and the use of timber explicit and almost non-negotiable from the beginning. As one interviewee explained:

"It completely changes the discussion. It becomes the default; you almost have to justify not doing it."

This upfront clarity shifted the design process, as instead of exploring what was possible first and then considering sustainability, the team now started with the ambition and worked backwards, looking at how to make this technically feasible. This reversal of the usual design logic reflected a different mindset altogether.

Furthermore, in another case, one of the interviewees explained that by taking this pioneering mindset, different stakeholders were brought together who had the ambition to go a step further and push timber construction forward. This built a strong early commitment and created a collaborative atmosphere where innovation felt achievable and essential.

4.4.3. Strategic framing of innovation

According to interviewees, in other projects, turning sustainability ambition into project reality often depended on how timber was introduced in project discussions. Timber-minded stakeholders had to actively shape how timber was presented to fit the priorities and perspectives of different stakeholders. One interviewee mentioned how, in the project, the hesitation from a key stakeholder shifted once it was clearly shown that timber would not increase risk but could actually lead to added value. By highlighting clear benefits like faster construction and lower execution costs, timber was presented not only as an environmental ideal but also as a practical alternative.

Interviewees noted that the story related to the stakeholder environment. What convinced one stakeholder might not work for another, so the language and focus had to be carefully tailored. In some cases, economic arguments were more effective than environmental ones. For example, timber buildings with a BREEAM certificate were framed as premium assets that could attract higher rent in central urban areas, making it worth the investment, according to an interviewee.

In this way, by framing, interviewees noted that the gap between ambition and acceptance could be bridged. Not by oversimplifying, but by connecting the message to what mattered most to each stakeholder.

4.4.4. Culture of experimentation and learning

Working with timber in these projects meant having a different mindset, one that was shaped by continuous problem-solving. Interviewees described how, when pioneering with timber, certain aspects lacked clear precedents or readily available knowledge. As a result, both project teams found themselves discussing more among disciplines to come to a solution. This iterative problem-solving differed from the more linear path, which is common for traditional projects, according to an interviewee.

This process, however, was not without compromises. One interviewee mentioned that design ambitions had to be scaled back in certain areas to maintain feasibility, with the agreement that sustainability goals would be made up for elsewhere. These trade-offs were not described as failures but as necessary steps to keep the overall vision intact. Furthermore, some stakeholders actively pushed for experimentation, challenging others to avoid automatically going back to what felt safe or familiar. One example involved looking abroad to see how others approach similar timber challenges. This willingness to test and adapt allowed for more possibilities in the project.

Interviewees, finally, noted how their gained knowledge would directly inform their approach in future timber projects. They saw it as an interactive process, where each decision made under uncertainty became part of a longer-term learning cycle.

4.4.5. Sustaining ambition over time

Sustainability ambitions often started high, but interviewees noted how they could fade as the project advanced. As risks, costs, or timelines became more pressing, initial goals were sometimes scaled back. This shift was not always deliberate; it often happened gradually through different design phases.

To prevent this, teams needed to keep repeating the original goals. One interviewee explained how this was done to ensure it stayed on track. It was not just about embedding this vision in the beginning, but just as much about putting in the effort to maintain it across all stages. In one of the cases, where this was most present, external backing by influential tenants helped. As these tenants supported the sustainability goals, their involvement gave the design team added leverage to keep those goals aligned throughout the phases. An overview of all first-order instances and their associated 2nd-order themes can be found in Table 4.4.

Table 4.4: Aggregate dimension – Mindset and motivational change

#	1st Order Instances	2nd Order Themes
57	Shared vision drove extra personal commitment	Motivational champions as internal change agents
58	Advisor influence helped embed sustainability in project scope	
59	Driven developer kept ambition alive under pressure	
60	Early client enthusiasm helped drive internal change momentum	
61	Conflicting starting points made alignment on timber ambition difficult	
62	Client's ambition made sustainability the default	Sustainability vision as driving motivation
63	Early ambition mobilised broad project commitment	
64	Pioneering mindset made bold steps possible	
65	Upfront ambition reversed the traditional design order	
66	Diverging interpretations of sustainability goals lead to confusion	
67	Communicating tangible value shifted stakeholder perception	Strategic framing of innovation
68	Strategic storytelling must be tailored to stakeholder context	
69	Framing timber through certification can strengthen its market appeal	
70	Trade-offs accepted to keep ambition alive	Culture of experimentation and learning
71	Encouraged testing by challenging safe defaults	
72	Lessons learnt used for future timber projects	
73	Lack of information led to iterative problem-solving	
74	Ambition gradually dilutes throughout the design process	Sustaining ambition over time
75	Tenant backing can provide the structural support needed to sustain ambition through design	
76	Ambition has to be repeated throughout every phase	

5 Theoretical Development

5 Theoretical Development

5.1. Introduction

As introduced in chapter 3, the Diffusion of Innovations (DOI) theory forms the central theoretical lens used to understand how timber construction is adopted within the Dutch construction sector. The framework consists of two core elements: the five-stage innovation-decision process, which spans from initial awareness to post-adoption confirmation, and the five key attributes that influence how innovations are perceived (relative advantage, compatibility, complexity, trialability, and observability). While the innovation attributes guided the analysis of barriers and enablers in both the literature and empirical data, the five-stage decision model is changed here to show the project-level dynamics found in the two cases.

While this approach offered a helpful foundation, the empirical findings from the full-timber and the hybrid-timber projects reveal limitations in how well the theory can capture the dynamic, project-based nature of material adoption in construction. For instance, decision-making did not always follow a linear progression, and contextual factors, such as stakeholder motivation and project structure, played an important role in shaping how and when timber was embraced.

This is particularly relevant in construction, where projects are temporary, fragmented, and involve changing groups of actors (Taylor & Levitt, 2004). As a result, adoption decisions often happen under time pressure, with uneven information, changing responsibilities, and evolving goals. These conditions challenge the clear, sequential structure of the classic model.

This chapter, therefore, revisits the DOI framework in light of the empirical findings, exploring which elements remain applicable in practice and which aspects do not reflect how adoption unfolds in real-life projects. By comparing each stage of the innovation-decision process with what happened in real construction projects, this chapter proposes an extended version of the DOI model. The resulting framework adapts the original model to better reflect the conditions of project-based innovation in construction, taking into account project-specific motivations, feedback loops, and the role of different actors. It will be presented both visually and in text, and it forms the basis for reflection in the discussion chapter.

Although this chapter focuses on timber construction, several of the observed dynamics may reflect broader characteristics of project-based innovations. So, while the framework that is presented here is based on timber-related cases, its potential applicability to other forms of construction innovation will be explored further in the discussion chapter.

5.2. Recap of the original DOI framework

As described in the introduction, the Diffusion of Innovations (DOI) model by Rogers (2003) describes innovation adoption as a five-stage decision-making process, moving from initial awareness to adoption and later confirmation. The stages: knowledge, persuasion, decision, implementation, and confirmation show a linear progression over time, each serving a specific purpose.

In the knowledge stage, the potential adopter is first exposed to the innovation and begins to understand how it works. This is followed by the persuasion stage, where either a positive or a negative attitude towards it is formed. This attitude is largely shaped by the five key attributes: relative advantage, compatibility, complexity, trialability, and observability. The decision stage then involves committing to either adopting or rejecting the innovation. If the innovation is adopted, the process moves to implementation, where the innovation is put into practice. Finally, in the confirmation stage, the adopter seeks reinforcement. A positive experience can strengthen further use within the organisation, or a negative experience can result in discontinuance (Rogers, 2003). A visual representation of this model is shown in Figure 5.1. Rogers (2003) also groups adopters into five categories: innovators, early adopters, early majority, late majority, and laggards. The total uptake of an innovation by all adopters can be represented by an S-shaped curve over time.

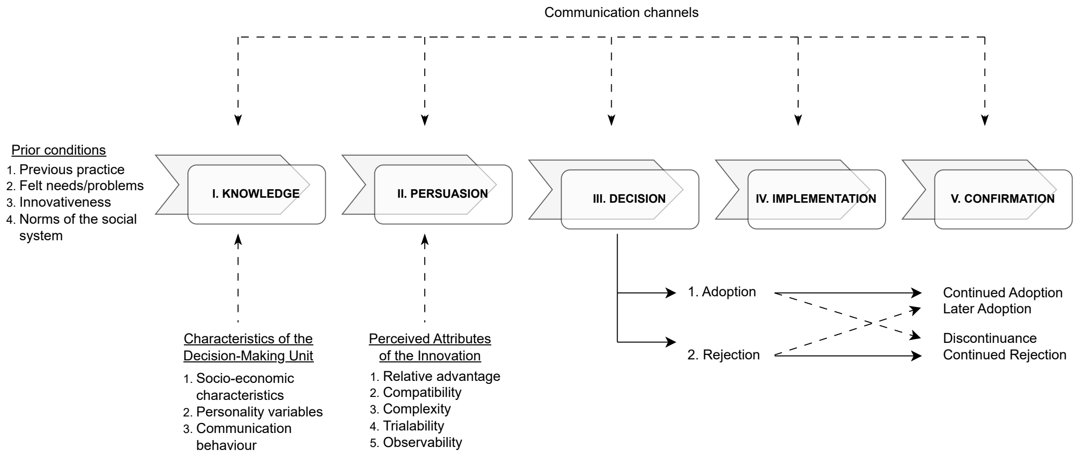

Figure 5.1: Original 5-stage innovation-decision process framework (adapted from Rogers (2003))

The DOI theory is built on several core assumptions. First, it frames adoption as an internal process, occurring within a single individual or organisation. Decision-making units are seen as self-contained, acting on their assessment of the innovation's attributes and their prior conditions. Furthermore, the social system is positioned as a set background context with shared norms influencing behaviour. Also, while Rogers (2003) acknowledges communication, this is described as a way to reduce uncertainty through exposure and peer influence. Lastly, Rogers (2003) does acknowledge that adoption can involve reinvention or repeated interactions between change agents and adopters, but his core diffusion model is linear, treating feedback loops as exceptions.

Together, these elements form a widely used framework for understanding how innovation spreads across a sector. The next section, however, will go into the limitations of this model in the context of project-based construction, using empirical evidence from the two timber construction cases.

5.3. Limitations of the DOI Model in construction practice

5.3.1. Adoption as a group process

In the model by Rogers (2003), adoption is framed as an internal process occurring within a single individual or organisation, especially evident in the knowledge and persuasion stages. The persuasion stage here is shaped mainly by the perception of the innovation's five key attributes, which serve as the main means of reducing uncertainty and guiding the decision-maker from a factual understanding towards a value-driven position. Rogers (2003) also notes that adoption is shaped by the norms of the social system in which it occurs. In construction, this system is fragmented and project-based (Taylor & Levitt, 2004), with ”loosely coupled” coalitions of firms that work together only temporarily (Dubois & Gadde, 2002). Shared norms and trust are often built from scratch, making persuasion less about operating within established norms and more about actively creating alignment. This challenges Rogers' reliance on the ”decision-making unit” as a stable organisational entity guiding adoption. In project-based construction, no single unit exists; instead, decision-making authority is dispersed across temporary coalitions of multiple stakeholders.

In this study, the unit of analysis is therefore defined as the project and not a single organisation. The ”decision-making unit” is operationalised as the temporary project coalition, composed of multiple stakeholders, which dissolves once the project is completed. Furthermore, the empirical findings show that in both case projects, persuasion was a collective process involving clients, architects, engineers, (sometimes) contractors, and timber suppliers. The choice between timber, hybrid, or traditional solutions was never made by one single actor. Instead, it required group alignment and frequent revisiting as technical, financial, or regulatory challenges arose. Consequently, the decision stage in this context is not a single, one-off organisational commitment, but a project-level decision trajectory made up of several moments where stakeholders decide whether to continue, adapt, or partially scale back the use of timber. These choices are not final: they can be revisited and revised when new technical, financial, or regulatory information emerges during the project.

Several dynamics, absent in the description by Rogers (2003), that play a decisive role in shaping persuasion outcomes have emerged from the empirical findings. Early involvement of specialists was essential for reducing technical uncertainty and influencing perceptions of feasibility. Uncertainty was not reduced simply by evaluating the five attributes but through collaborative problem-solving that reshaped how those attributes were understood. Also, professional roles often overlapped, with suppliers and engineers, for instance, stepping beyond their usual scope to contribute to design and strategic decisions. Furthermore, integral collaboration replaced typical sequential handovers. These factors also changed how the five attributes were understood. Relative advantage was redefined when structural engineers and specialists demonstrated that timber's light weight could support additional floors, thereby increasing project value. These findings show that in construction, reducing uncertainty, the core of persuasion, is achieved through multidisciplinary and iterative collaboration, rather than being managed internally by a single decision-making unit.

5.3.2. Mindset shift and motivation in early stages

In the DOI model, the early stages of adoption are shaped by an individual's or organisation's prior conditions and their evaluation of the five innovation attributes (Rogers, 2003). Within this framing, motivation is not treated as a distinct or central factor; it appears only indirectly, either through perceived needs and problems or through the influence of change agents. Rogers presents these change agents primarily as individual actors who accelerate adoption by bridging communication gaps, but in this context, it is assumed that adoption can, in principle, proceed without them, provided that the attributes of the innovation are evaluated positively.

While collective decision-making dynamics shaped the structure of persuasion, the findings show that the mindset and motivation of those involved were also important. In both projects, early alignment on material choice was only achieved when stakeholders shared, or were persuaded to adopt, a common ambition for timber. This ambition was not always present for every stakeholder at the start, but was fostered by motivational champions who defended sustainability targets, put them central on the agenda, and framed timber in ways that matched each stakeholder's priorities.

The findings also challenge the relevance of Rogers' "prior conditions" in project-based construction. Temporary coalitions of firms typically do not share previous practice, established norms, or long-standing relationships at the start of a project. Alignment instead depended on whether sufficient motivation was present among key actors, making prior conditions irrelevant in this context. Here, motivation acted as a gatekeeping condition: without it, projects did not progress beyond passive awareness. This dynamic goes further than Rogers (2003), where change agents appear only indirectly as supportive background actors rather than as indispensable drivers of adoption.

Motivation shaped how stakeholders interpreted the five innovation attributes by Rogers (2003). For example, a sustainability-focused client saw timber's relative advantage in its environmental benefits and reputational value, while, for instance, a risk-averse contractor associated it with financial and technical risk. Stakeholders emphasised varying aspects, from speed and carbon reduction to extra floor space and market value. Without deliberate framing, uncertainty persisted and persuasion stalled. The projects also showed that a shift in mindset could reverse the usual design sequence. In one case, timber was set as the default from the outset, requiring technical and cost considerations to be adapted around it. In contrast, when sustainability goals were vague, interpretations diverged during design, reducing alignment and weakening timber support.

Ultimately, mindset and motivation were key drivers in the collective persuasion process. In Rogers' model, the early stages emphasise how an individual's or organisation's prior conditions and use of the five attributes influence adoption (Rogers, 2003). The empirical findings, however, show that in multi-stakeholder projects, these factors alone cannot fully explain why or when alignment emerged. Motivation influenced not only how people understood the innovation's features but also whether they wanted to get involved with it at all.

5.3.3. Iterative feedback loops in the adoption process

The Diffusion of Innovations model, as outlined by Rogers (2003), describes how innovations spread through a linear sequence of five stages: knowledge, persuasion, decision, implementation, and confirmation, as detailed in section 3.5. While this staged structure remains a useful framework for describing an innovation like timber adoption, the findings indicate that in project-based construction, it is rarely experienced as a strictly linear process. Rogers (2003) acknowledges that feedback and delays can occur between stages, but in his model, these are treated as exceptions rather than structural features of the process. This challenges the assumption in the original model that adoption mostly happens in a forward, linear sequence. MacVaugh and Schiavone (2010) support this critique by arguing that iteration and feedback are not exceptions but essential features of innovation processes in complex environments.

Analysis of the case projects indicates that while teams generally progress through these stages in sequence, the process often involves interactive feedback loops. These occurred when new technical or regulatory developments required revisiting earlier decisions. For instance, additional fire safety measures were demanded even though performance requirements had already been met. This reflected a broader pattern where innovation progressed faster than the regulatory environment. Therefore, the team had to revisit persuasion and decision discussions, revisiting feasibility and adjusting the design to maintain compliance. Other instances of iteration included the later introduction of timber in the design, which required a major rework.

This iterative pattern was not only driven by technical or regulatory factors but also by the dynamics of persuasion itself. In multi-stakeholder projects, securing timber support often required repeated strategic framing to address different priorities. Motivational champions were key in re-engaging hesitant actors and reframing timber's benefits to suit the evolving context. These cycles of persuasion made alignment an ongoing effort rather than a one-time moment. Iteration, therefore, was not an occasional disruption but a structural and expected feature of moving forward with adoption.

5.3.4. From reinforcement to knowledge transfer

In Rogers' model, the confirmation stage involves reinforcing an adoption decision within the same individual or organisation, with positive experiences leading to continued use, while negative ones potentially result in discontinuance. This stage is intended to strengthen internal commitment over time, helping it become embedded in ongoing practice.

This type of internal confirmation also occurs in project-based construction, as individual organisations such as contractors, architects, or clients may validate their positive experience with timber and decide to apply it in future projects. However, the temporary coalition of stakeholders formed for a single project typically disbands once the project is completed. This means that while confirmation can boost commitment within individual organisations, it does not necessarily lead to wider adoption across the whole sector. This is because, once the project team disbands, any knowledge or experience gained stays with these organisations, if it is retained at all, and often does not reach the wider industry.

This creates a structural gap in the DOI model when applied to project-based construction. The original view of confirmation by Rogers (2003) rests on the assumption that reinforcement is only an individual process. In construction, however, this project structure disbands at the end of each project, meaning that the confirmation stage alone cannot explain how adoption knowledge is shared across the sector. As a result, the model overlooks both the importance and the challenge of inter-project learning in industries where innovation depends on temporary collaborations.

5.4. Improved innovation decision-making framework

5.4.1. Revised model

Figure 5.2 presents the improved new Diffusion of Innovations model developed in this research. The black elements represent the original five stages by Rogers (2003), while the orange elements highlight extensions based on the gaps discussed in section 5.3. The new model includes two extra stages: motivation and project shaping, along with explicit iteration loops and an expanded confirmation stage that incorporates inter-project learning. The new arrows illustrate the dynamic and less linear nature of adoption in project-based construction. Furthermore, as outlined in section 5.3, certain categories from Rogers' model, such as the decision-making unit, were removed as they did not fit the realities of temporary project coalitions. Together, these changes adjust the framework by Rogers (2003) to be able to capture the collective decision-making found in the project-based construction industry, as revealed by the empirical findings. The following subsections explain how the adaptations address the gaps in the original model.

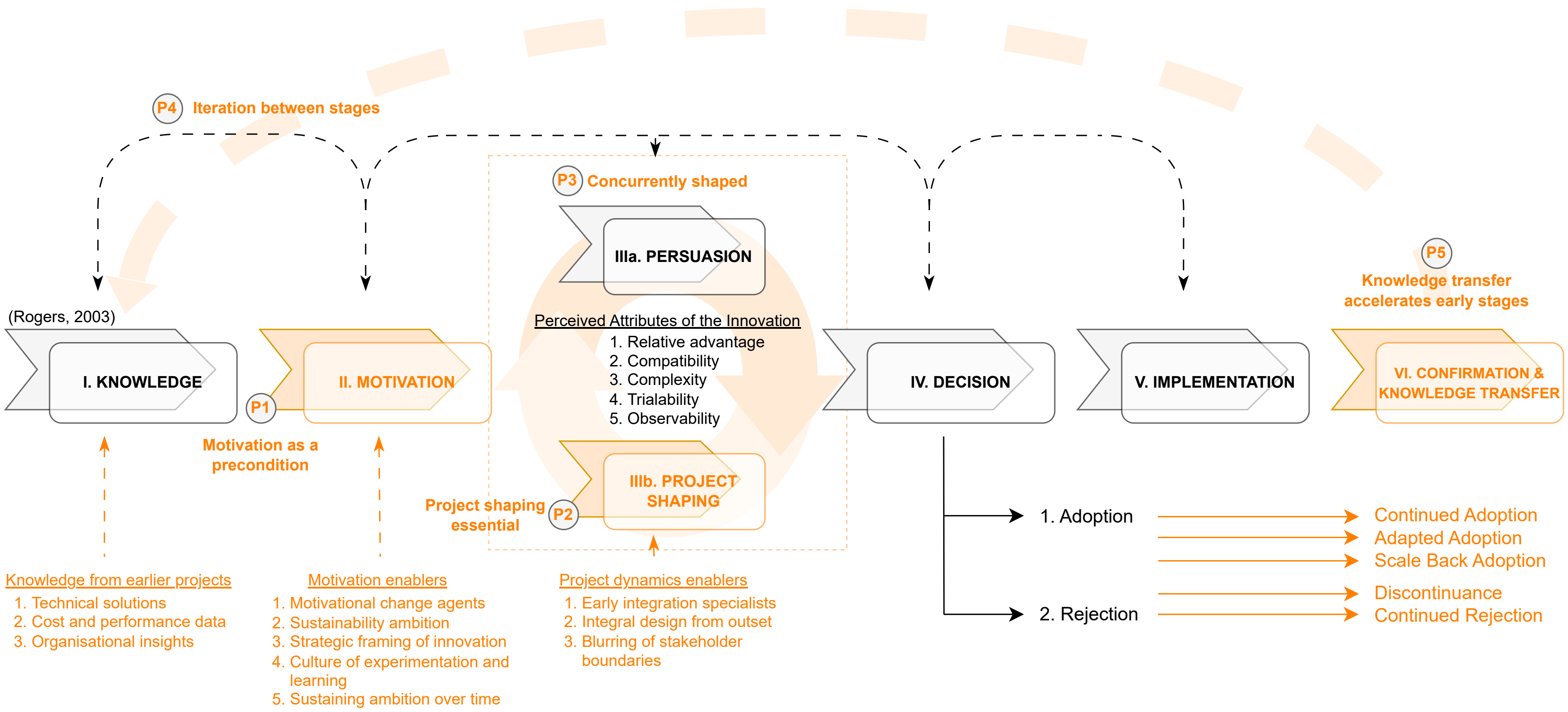

Figure 5.2: Improved six-stage innovation decision-making process (adapted from the five-stage innovation decision-making process by Rogers (2003))

5.4.2. Motivation as requisite condition

Firstly, in the model by Rogers (2003), the early stages of adoption are shaped by prior conditions and an individual's or organisation's evaluation of the innovation's attributes. However, motivation is not treated as a distinct driver in the original model, but it appears only indirectly through needs, problems, or agents. In Rogers' framing, such agents act mainly as supportive individuals who bridge communication and speed up diffusion rather than constituting a separate stage, and adoption is assumed to proceed when attributes are perceived positively. In project-based construction, the findings show this framing is insufficient: early alignment on material choice was only achieved when stakeholders shared, or were persuaded to adopt, a common ambition for the innovation. For this reason, the revised model removes "prior conditions" as an explanatory factor. This reframing is novel relative to Rogers (2003) because it elevates motivation from an implicit facilitator to an explicit mechanism required to build alignment in temporary coalitions that lack shared history or norms.

This is reflected in the revised model (Figure 5.2, where *Motivation* is introduced as a distinct stage between *Knowledge* and *Persuasion*. This stage reflects the clear empirical finding that motivation functions as a requisite condition for timber to even enter serious consideration within a project; it is a gatekeeping stage. Awareness of the material's existence and properties is not enough. Timber only entered the agenda when motivated change agents, sustainability-driven stakeholders, or strategic framing pushed it forward. This motivation could arise from organisational values, targets, or efforts by said change agents within the team. Motivational actors were in both cases essential for making timber a viable option for discussion, presenting it as aligned with project goals rather than as an abstract technical possibility. For a technical innovation in the early stages of adoption, when regulatory drivers are not yet present, particularly in the conservative construction sector, the presence and influence of motivational actors are essential. Without such actors, there is little drive for stakeholders to even consider the innovation, resulting in a tendency to default to established practices.

Placing *Motivation* before *Persuasion* reflects its role as the bridge between awareness and active evaluation. Without it, the process could stall at general awareness with no substantive exploration of feasibility or benefits. When motivation was present, it influenced how the innovation attributes were understood and prioritised in the next stage. Motivational champions tailored their framing of timber to align with different stakeholders' values. This framing helped reduce perceived uncertainty and fostered the willingness needed for the group-level persuasion process to take place. Positioning *Motivation* explicitly before *Persuasion* clarifies how projects move from passive awareness to an active willingness to evaluate timber at the project level.

Proposition 1 (P1): In multi-stakeholder projects, motivation is not a background factor but a distinct stage between knowledge and persuasion, acting as a prerequisite for adoption to progress.

5.4.3. Importance of project shaping to attributes

In the model by Rogers (2003), *Persuasion* is the stage where an individual or an organisation forms an attitude towards an innovation, largely based on their perception of its five key attributes. The findings show that in multi-stakeholder construction projects, once there is motivation, this process is closely intertwined with structural project dynamics. Early integration of key specialists, integrated design processes, and the blurring of traditional stakeholder boundaries, for instance, were all decisive in shaping how these attributes were perceived. This reflects the empirical findings of the innovation attributes in practice, which showed that they were actively shaped by collaborative project structures and not fixed from the beginning. These dynamics did not merely form the backdrop for persuasion; they actively created the technical and organisational conditions under which adoption became viable. The revised model, therefore, adds *Project shaping* as a distinct stage, positioned alongside *Persuasion*, with a side arrow indicating its enabling mechanisms.

Proposition 2 (P2): Structural project dynamics operate alongside persuasion, creating the technical and organisational conditions that influence how the five key innovation attributes are perceived.

While *Project shaping* and *Persuasion* are presented as distinct stages in the revised model, the empirical findings show that they typically develop concurrently and do not occur in strict sequence. In the model by Rogers (2003), as mentioned above, the five key attributes are essential for the stakeholders' perception. In contrast, *Project shaping* refers to the structural and organisational setup that significantly affects how those attributes are interpreted in practice.

Once motivation to explore timber was in place, project teams typically began shaping the project structure by, for instance, integrating key stakeholders and establishing collaborative processes, while simultaneously engaging in stakeholder persuasion. These processes reinforced another: strong project dynamics improved the flow of information and problem-solving needed to address uncertainties, which in turn fostered a more positive perception of timber's attributes. Meanwhile, growing stakeholder support stimulated more active collaboration and problem-solving. This concurrent, mutually reinforcing development created an iterative loop, with teams moving back and forth between persuasion efforts and project-shaping actions as challenges and opportunities arose, making this stage a combination for building both the technical feasibility and the attitudinal support required for adoption.

Proposition 3 (P3): Persuasion and project shaping develop concurrently, with each reinforcing the other to create the technical feasibility and stakeholder support necessary for adoption.

5.4.4. Iteration across stages

The revised model makes iteration an explicit and permanent feature of the adoption process. While Rogers (2003) acknowledged that feedback between stages could occur, this was treated as an exception. The findings from this research indicate that, in project-based construction, iteration is not just an exception, as teams regularly revisit earlier stages to address new technical, regulatory, or stakeholder challenges. This was most evident between *Motivation*, *Persuasion*, and *Project shaping*, where shifts in feasibility or alignment lead to renewed discussion and reframing. In the revised model, iteration is therefore shown as a permanent feature across all stages, acknowledging that iteration is possible in the decision-making process of a technical innovation.

Within this adaptation, the decision stage is also reconceptualised as a project-level decision trajectory. Rather than a single, definitive organisational commitment, the decision happens at one moment, but through iteration, the project coalition can decide whether to continue, adapt, or partially scale back the use of timber. Adapting adoption may, for example, lead to a hybrid structure instead of a fully timber one, while scaling back adoption can mean reducing the share of timber or biobased materials to a smaller volume. So the choice for the innovation is made, but its implementation is not final and can be revisited and revised when new technical, financial, or regulatory information arises during the project, underlying the fluid and iterative nature of decision-making in multi-stakeholder construction contexts.

In the original DOI model, arrows between stages represented ”communication channels”, emphasising information exchange in adoption. In fragmented, multi-stakeholder projects, however, adoption rarely unfolds through linear information exchange. Instead, progress depends on recurring cycles of revisiting earlier stages. The iteration loops in the revised model; therefore, replace communication channels, serving the same connective role but reflecting the recursive and negotiated character of innovation in construction.

Proposition 4 (P4): Iteration between stages is inherent in construction projects, with revisiting earlier stages necessary for alignment and adoption.

5.4.5. Knowledge transfer and confirmation

In the revised model, the *Confirmation* stage extends beyond the original focus on reinforcing adoption within the single organisation (Rogers, 2003). As discussed in subsection 5.3.4, project-based construction rarely benefits from this form of internal reinforcement alone since project coalitions disband upon completion. What matters for sector-wide diffusion is whether the knowledge gained is actively transferred to other projects.

By making knowledge transfer an explicit part of the final stage, the model highlights the importance of inter-project learning for early-stage innovations like timber construction. Actively sharing technical solutions, cost and performance data, and organisational insights not only strengthens understanding and increases knowledge but also reduces uncertainty in the first stage, making timber less of a ”leap of faith”. Furthermore, it directly influences how the five key innovation attributes, such as relative advantage, complexity, and especially observability, are perceived in the *Persuasion* stage. This means that well-structured dissemination can shift stakeholder perceptions in favour of the innovation, making persuasion more effective and increasing the likelihood of adoption. The case studies reveal that while some teams integrated structured dissemination into their project closure, others retained the lessons internally, limiting wider impact.

In the revised model, the long top arrow represents this circular process: knowledge generated at the *Confirmation* stage in one project flows directly into the *Knowledge* stage of subsequent projects. This means that the *Knowledge* stage now includes not only general awareness but also concrete insights from earlier projects, such as technical solutions, performance data, or organisational lessons, which reduces uncertainty. In this framing, *Confirmation* is no longer only the endpoint of a single project but a bridge to future ones. When knowledge transfer is embedded, each project will become a stepping stone in a continuous, sector-wide diffusion and learning process, rather than a stand-alone case of adoption.

Proposition (P5): Knowledge transfer from completed projects accelerated early adoption stages by improving understanding and shaping perceptions of innovation attributes.

6 Discussion, Recommendations, and Limitations

6 Discussion, Recommendations, and Limitations

This chapter provides a critical discussion of the research findings in relation to the study objectives, the existing literature and practical considerations in the construction sector. It further outlines recommendations based on the results, offering practical and theoretical implications. Finally, the chapter addresses the study's limitations, highlighting areas for improvement and opportunities for future research.

6.1. Discussion: Timber adoption in practice

In this section, the findings from the literature and the qualitative data are described in the context of the 6-stage innovation-decision framework that was introduced in chapter 5.

6.1.1. Awareness in a pioneering market

The innovation-decision process starts with initial awareness of the innovation. In both cases, this initial awareness of timber often stemmed from prior exposure to reference projects, industry journals, or contact with other industry actors. While this aligns with the concept of awareness-knowledge by Rogers (2003) as the first stage of adoption, the findings show that in project-based construction, awareness alone would not progress without further activation. In several instances, stakeholders were aware of timber's existence but had not yet considered it a viable option, reflecting that knowledge at this stage was often superficial and lacked concrete local performance evidence. This aligns with Santana-Sosa and Kovacic (2022)'s observation that, in the Austrian context, low visibility and a lack of proven local examples continue to pose significant barriers to timber adoption, a pattern also evident in the Netherlands according to the present findings.

Whereas Santana-Sosa and Kovacic (2022), Roos et al. (2010), and Hassan and Grobbelaar (2024) suggest that the timber sector is moving towards the end of the early adopter phase, the empirical evidence from these cases paints a different picture. Adoption in the Dutch construction industry is still largely pioneering, with only a small group of committed early adopters leading projects. The limited visibility of multi-storey timber buildings means that for many stakeholders, timber remains a novel and relatively untested option. This low market maturity leaves stakeholders entering projects with partial knowledge.

6.1.2. Motivation as an active stage

The findings from the cases reveal that, in the Dutch construction sector, motivation is not merely a background factor but a crucial precondition for advancing timber adoption. This motivation could come from different sources, whether intrinsic commitment as seen in dedicated change agents, organisational sustainability goals, or deliberate framing aimed at persuading others. In every form, it proved essential for ensuring that timber became a topic of serious consideration.

This insight builds on the Diffusion of Innovations (DOI) framework by showing that, for a technical innovation in the early-stage adoption, with high uncertainty and no regulatory incentives, particularly in traditional sectors like construction, adoption cannot be understood solely through the lens of innovation attributes. Whereas the model by Rogers (2003) suggests that early-stage alignment develops naturally from exposure to an innovation and its perceived benefits, these cases reveal that such alignment often needs an intentional catalyst: at least one motivated stakeholder or organisation willing to champion the innovation, actively push it onto the project agenda, and create the conditions for it to be explored seriously. In doing so, these actors often reframed benefits, such as sustainability identity or market positioning, to match the priorities of different stakeholders. This moves beyond the framing by Rogers (2003) of change agents as supportive facilitators, as here, motivation itself determines whether adoption progresses at all.

This also aligns with findings by Greenhalgh et al. (2004), who argue that adoption is shaped not only by the inherent attributes of an innovation but also by the meanings stakeholders construct through interaction and framing, and who highlight the role of ”champions” as key actors that mobilise support, protect innovators from resistance, and connect projects to external knowledge and networks.

In the literature, motivation is mostly implicit, appearing through enablers like environmental sustainability, market advantage, or policy alignment, with the focus placed on the attributes of timber and structural conditions rather than on specific actors driving change. Change agents often appear in the background (Vihemäki et al. (2020), Hassan and Grobbelaar (2024)), without being examined as central, active forces within projects. In contrast, the findings present motivation, such as environmental sustainability and change agents, as direct, influential drivers of adoption trajectories. This difference is important: Rogers acknowledged change agents, but in fragmented project environments, motivation functions as a structural stage that replaces the role of ”prior conditions”. The prominent role of change agents and motivation in project-based adoption is largely overlooked in existing literature.

In practice, this means that in temporary, multi-stakeholder environments like construction projects, the diffusion of early-stage innovations depends heavily on whether such motivational actors are present and empowered. Without them, recognition of an innovation's potential often stays passive, and teams are likely to revert to familiar materials and practices. This finding aligns with Horsting et al. (2024), who show that in the case of timber construction, motivation is a decisive factor in moving from passive awareness to active adoption. Stakeholder mapping in these two cases indicates that these motivational champions were often actors who possessed both influence in decision-making and credibility among the wider team. Here, motivation is not simply an added catalyst but, in practice, often acts as a gatekeeping stage, with its presence making the shift to persuasion far more likely.

Framing motivation as a separate, necessary stage shifts the early Diffusion of Innovations process from being solely driven by prior knowledge and the attributes of the innovation to being equally driven by the actors involved. This marks a key departure from Rogers (2003) where he treats change agents as supportive facilitators. The findings show that motivation itself functions as a structural stage that determines whether adoption progresses at all. This also implies that, in comparable contexts, successful adoption will require deliberate efforts to identify, enable, and connect these motivational actors so their influence can overcome sectoral conservatism and move projects from awareness to active consideration.

6.1.3. Co-creating feasibility through project shaping and persuasion

In project-based construction, early alignment around material choice is never isolated. As noted by Dubois and Gadde (2002) and Taylor and Levitt (2004), the industry's ”loosely coupled” and temporary coalitions mean that shared norms and trust must often be built from scratch. In both cases, once there was motivation, technical feasibility and support for timber developed concurrently through intentional project-shaping measures. These included bringing key specialists on board early, setting up collaborative processes, and blurring of traditional role boundaries to improve the flow of knowledge and decision-making, a point that resonates with Greenhalgh et al. (2004), who emphasise that feasibility is often co-constructed through stakeholder interaction rather than discovered as an already existing property. The findings confirm earlier literature identifying early specialist integration as a critical enabler (Santana-Sosa and Kovacic (2022); Gosselin et al. (2018)), but extend it by showing how early involvement of engineers and suppliers directly reduced perceived complexity, particularly in a market still building its technical and organisational capacity for timber. This was clear when early input from suppliers addressed detailing challenges before they became cost or schedule risks, reflecting Roos et al. (2010) on the value of targeted expertise in overcoming skills gaps. By contrast, industry fragmentation and linear handovers restrict the early collaboration timber requires, reinforcing why deliberate project-shaping measures are necessary to overcome systemic barriers.

This dynamic challenges the sequential view in the model by Rogers (2003), where persuasion is treated mainly as an attitudinal stage shaped by the innovation's perceived attributes. In Rogers (2003)'s model, the five attributes are addressed by the decision-making unit within a fixed organisational structure. In construction projects, however, the 'structure' is temporary and can be deliberately shaped to influence those evaluations. This is consistent with findings by Hassan and Grobbelaar (2024), who argue that adaptive project governance, particularly in early-stage, sustainability-oriented projects, directly shapes how innovation attributes are perceived and valued.

Persuasion, however, was inseparable from the project's structural setup: without the right team composition and collaboration methods, uncertainties could not be resolved effectively, and timbers' perceived relative advantage could not improve. In practice, project shaping and persuasion reinforced one another; stronger collaboration enabled better problem-solving, which in turn strengthened timber support and encouraged further collaborative efforts. Here, feasibility was not a fixed, observable quality of the innovation but something that was co-created through the project's structure and the interactions it enabled.

Positioning project shaping as an active, concurrent process to persuasion reframes early adoption as a collective, designable condition rather than purely a matter of individual or organisational perception. For early-stage innovations in conservative, multi-stakeholder sectors, this means adoption is not achieved by simply presenting the concept to an existing team. Still, it is embedded in how the team is assembled and how the working methods are chosen. This aligns with the finding of Vihemäki et al. (2020) that collaborative structures and early trust-building are critical for embedding sustainability innovations into practice, as intermediaries play a central role in connecting actors and creating shared frameworks for action. Consistent with this, leaders promoting timber must therefore go beyond showcasing its attributes, deliberately creating project environments where those attributes can be demonstrated, maybe even tested, and refined in practice.

6.1.4. Decision-making in a dynamic project context

In the model by Rogers (2003), the decision stage follows persuasion as a distinct, mostly definitive step. The findings show that in practice, the nature of this stage can vary significantly. In some projects, a motivated champion effectively sets the material choice early, making the decision more predetermined. In others, the decision emerges more gradually, shaped by evolving project conditions and the reframing of timber's benefits. Taylor and Levitt (2004) observed that in temporary, multi-stakeholder coalitions, decision-making is often negotiated and adaptive, which is in line with the findings.

Adoption in project-based construction rarely follows the linear sequence described in Rogers (2003). While his model allows for occasional feedback, the findings, consistent with MacVaugh and Schiavone (2010), show that iteration is a structural feature of early-stage adoption in complex environments. Technical and regulatory changes, such as unexpected fire safety requirements or late-stage timber introductions, often prompted teams to revisit persuasion and decision discussions.

These loops were also driven by social factors, as persuasion was maintained over time as motivational champions reframed timber's benefits to preserve alignment through changing conditions. This reflects observations by Santana-Sosa and Kovacic (2022), who found that reframing benefits is often needed to bring stakeholders back on board when projects face setbacks. This pattern contrasts with Rogers (2003) view of iteration and aligns with MacVaugh and Schiavone (2010) argument that feedback is a structural necessity in complex settings. In project-based construction, the temporary and evolving nature of stakeholder coalitions makes the boundaries between the earlier stages inherently fluid.

In this iterative environment, the decision stage was not observed as a one-off choice between adoption and rejection but as a project-level decision trajectory. Choices such as continuing, adapting (for example, opting for a hybrid structure), scaling back the use of timber, or even discontinuing could emerge during the decision-making process. These options were revisited and revised as technical feasibility, regulatory requirements, and stakeholder alignment evolved.

An important divergence from the literature emerged regarding hybrid timber structures. While Gosselin et al. (2017) and Hassan and Grobbelaar (2024) suggest hybrid buildings can act as a lower-risk "stepping stone" towards full timber adoption, the findings from this research revealed that a hybrid building did not serve this role. Instead, the choice for a hybrid was a context-driven solution. In terms of the revised model, this represents an "adapted adoption" outcome rather than a traditional step. Project actors regarded this decision as equally pioneering and equally complex as a full timber approach. This highlights that context, such as existing structural constraints or site-specific requirements, is often overlooked in the literature, yet can act as both a barrier and an enabler.

From this perspective, the decision stage in timber adoption cannot be seen solely as a single definitive moment but also as a revisitable milestone within a decision trajectory, achieved when technical feasibility, contextual conditions, and stakeholder alignment come together.

6.1.5. Implementation as real-time trialling

In Rogers' (2003) model, implementation is where the technical innovation is actually used. In both cases, this stage highlighted how factors such as stakeholder expertise, supply chain maturity, and technical readiness influenced the amount of difficulty or ease of delivering timber in practice. Fast construction time was often cited as a tangible enabler once building began, reinforcing earlier persuasion and decision stages.

Grobbelaar (2025) and Grobbelaar (2025) discuss trialability in terms of pilot projects or smaller-scale demonstrations that allow stakeholders to experiment with an innovation in a controlled way. The findings extend this view by showing that, in a pioneering market context, even large multi-storey projects were perceived as trialling timber. Because most actors involved were new to the material, their projects functioned as full-scale tests, building confidence and technical knowledge in real time rather than in a prior, smaller setting, noting that new practical advantages to timber were discovered through constructing, instead of through prior research.

While implementation reinforced earlier positive perceptions, it also revealed new barriers. Reflecting Santana-Sosa and Kovacic (2022), novel materials required greater coordination: prefabricated elements demanded precise sequencing, close interdisciplinary collaboration, and careful logistical planning. Limited flexibility for late design changes demonstrated that implementation involves managing emerging risks, as it is about delivering anticipated benefits. These issues were typically seen as challenges to be managed rather than definitive barriers, underlying that real-world delivery can temper the expectations of earlier stages, especially in a market still building its collective experience with timber. In this sense, implementation acted not only as delivery but also as a learning process, feeding directly into the knowledge base for future projects.

6.1.6. From confirmation to knowledge transfer

The findings highlight that a structural limitation in the model by Rogers (2003) is his conceptualisation of the confirmation phase. In his model, confirmation primarily reinforces an adoption decision within the same individual or organisation, embedding the innovation into ongoing practice. In project-based construction, this mechanism is only partially effective. While individual organisations such as contractors, architects, or developers may decide to apply timber again in future projects, the temporary coalition that delivers the project disbands at completion. As Dubois and Gadde (2002) noted, such institutional fragmentation hinders the transfer of experiences and learning beyond the original project stakeholders.

Roos et al. (2010) note that in timber construction, valuable knowledge often remains confined within individual projects due to weak inter-project links and fragmented industry networks. This is reflected in the present cases: one team actively shared insights across the industry, while the other acknowledged the value of doing so but limited dissemination to its immediate project network and internal organisation. This limited dissemination also restricted observability, an enabler emphasised by Santana-Sosa and Kovacic (2022) and Hassan and Grobbelaar (2024) as critical for building trust in emerging innovations. Without visible, accessible reference projects and transparent sharing of technical and performance data, future adopters have fewer concrete examples to reference. In one case, although timber was used extensively, its visibility was diminished by concealing the structural elements, a design decision that unintentionally limited its demonstrative value.

This pattern creates a gap between the DOI model's assumptions and the realities of early-stage, project-based innovation: without an intentional mechanism for inter-project learning, the knowledge gained in one project often remains isolated, limiting its value for accelerating broader diffusion.

From a DOI perspective, the absence of structured knowledge transfer is a missed opportunity. For early-stage technical innovations such as timber construction, where uncertainty is high and proven references are more scarce, systematic dissemination can directly influence how key innovation attributes are perceived in future projects. By sharing concrete technical solutions, performance data, and examples of effective organisational setups, knowledge transfer can expand the knowledge base for future projects and strengthen key attributes such as increasing relative advantage, reducing perceived complexity, and enhancing observability. This, in turn, makes the knowledge and persuasion stages easier and more effective for new adopters.

Framing confirmation as a bridge rather than an endpoint shifts its role from reinforcing existing use to actively enabling future adoption. In effect, the final stage of one project becomes the first stage for the next. This view supports the idea that in fragmented sectors, sustained diffusion relies not only on adoption decisions within individual projects but also on those projects contributing to a cumulative learning process across the industry. Embedding structured knowledge transfer into project closure is therefore not an optional step but an essential requirement for sector-wide acceleration.

6.2. Theoretical contributions

Advancing the Diffusion of Innovations (DOI) for project-based construction

This research extends the Diffusion of Innovations model of Rogers (2003) by adapting it to the realities of a temporary, multi-stakeholder, project-based environment, introducing novel elements to the innovation-decision process. The first contribution is the introduction of motivation as a distinct stage positioned between knowledge and persuasion. Rogers (2003) acknowledged the role of change agents but treated them as supportive facilitators rather than as a structural stage in the process. In contrast, this research shows, through the full timber and hybrid timber cases, that in temporary coalitions without prior conditions, motivation determined whether timber advanced beyond passive awareness. Stakeholders needed an intrinsic drive or organisational ambition simply to put timber on the table as an option worth analysing. Furthermore, these motivated champions actively reframed timber in ways that aligned with diverse stakeholder priorities. Without this initial commitment, the material was not considered at all, and the project team would default to conventional materials. This elevates motivation from being an indirect background factor to a structural gatekeeping stage that effectively replaces Rogers' notion of prior conditions. In doing so, it challenges the DOI assumption that early-stage alignment emerges naturally from the perceived attributes of an innovation. In sum, explicitly designating a 'motivation' stage as part of the process is a novel theoretical contribution, highlighting a gatekeeping role that was not formalised in Rogers' original model.

Secondly, this study reframes persuasion by introducing project shaping as a concurrent stage. In multi-stakeholder construction, the five key innovation attributes are not fixed inputs, but they are actively shaped through early integration of specialists, collaborative design processes, and the blurring of traditional stakeholder boundaries. These structural dynamics do not just provide a backdrop for persuasion, but they also influence how attributes are perceived. By recognising this mutual shaping as an inherent feature of adoption in complex projects, the adapted DOI framework expands beyond the original sequential model by Rogers (2003). This mutual relationship means persuasion and project shaping develop together, with each reinforcing the other to build both the technical feasibility and the stakeholder support required for adoption. By embedding the organisational dimension directly into the persuasion stage, this reframing makes the model more applicable to temporary, multi-stakeholder contexts such as construction. In doing so, it identifies a parallel project-shaping dynamic within persuasion. This is an original insight of this research, which highlights how innovation attributes and stakeholders co-evolve, extending Rogers' framework.

A third theoretical contribution is recognising iteration as an inherent component of the adoption process. Adoption decisions evolved through repeated loops of problem-solving, rather than following a strict linear sequence. This shows that the DOI's linear stage model should be revised to incorporate iterative feedback to reflect the nature of temporary, multi-stakeholder projects and extend beyond stable organisational contexts. Within this reframing, the decision stage is not treated as a single definitive moment of adoption or rejection but as a project-level decision trajectory composed of revisitable choices such as continuing, adapting, scaling back, or discontinuing the use of timber. By conceptualising decision as more than a one-off event, this research makes iteration a core dynamic in the adoption model. This marks a departure from the DOI's traditional linear progression.

Finally, the study reframes confirmation in DOI as including both internal reinforcement within a project and structured knowledge transfer between projects. In temporary coalitions, internal confirmation rarely occurs within the same team beyond project completion. Instead, the main impact comes from intentional dissemination of lessons to other projects, making inter-project learning the real driver of sustained diffusion in this context. By expanding the confirmation stage to include inter-project transfer, the adapted DOI model captures how innovations continue and spread in fragmented, project-based industries. This reconceptualises confirmation as a stage of knowledge transfer occurring across projects, introducing a novel shift that expands diffusion theory beyond the scope of an individual project or organisation.

These four contributions are not only described in text but also visually captured in an adapted DOI model (see Figure 5.2). This figure has been substantially redrawn compared to Rogers' original version: it explicitly introduces motivation as a new stage between knowledge and persuasion; it places project shaping concurrently with persuasion to show their co-evolution; it adds iterative feedback loops that connect stages and redefine the decision stage, rather than assuming linear progression; and it reconceptualises confirmation as an outward-looking process of inter-project knowledge transfer. Rather than serving as a purely illustrative adjustment, this redrawing is a theoretical statement in itself: the adaptations are embedded directly into the structure of the model, making the visual changes an integral part of the theoretical contribution. By altering the model's structure, the adaptation demonstrates that adoption in project-based construction follows different dynamics than those assumed in Rogers' sequential, organisation-centred framework. In doing so, the redrawn framework both captures these novel insights and makes them directly accessible to scholarly and practical audiences.

Extending timber adoption theory in construction

Beyond contributing to innovation theory, this research deepens the understanding of how multi-storey timber is adopted in the built environment. By linking adoption dynamics to the adapted DOI stages, it clarifies why some enablers succeed while others fail to overcome common industry barriers. The findings show that technical and environmental benefits alone were insufficient; timber only remained viable when stakeholder motivation and alignment were actively built into the process. This shifts the focus of timber adoption research beyond material performance and regulatory frameworks, highlighting that in project settings, motivated actors and a shared ambition are decisive for whether timber is even considered. In doing so, the study complements prior work that emphasised systemic drivers by showing how adoption depends equally on the social and organisational dynamics unique to each project. Moreover, while much of the existing literature positions multi-storey timber at the late stage of early adoption, the Dutch cases studied here reveal a more tentative, pioneering phase, where adoption is still exceptional and heavily reliant on motivated coalitions. This contrast underlines that the barriers to adoption in the Netherlands are not only technical or regulatory, but that they are embedded in project-level practices and stakeholder dynamics. This highlights the added value of examining timber through an adapted DOI lens.

This research also reveals the influence of project dynamics on material feasibility. Early specialist involvement and the way teams were structured, for instance, strongly shaped whether timber was introduced and remained important up until implementation. In addition, by comparing a fully timber building with a hybrid timber design, the study offers early insights into whether material composition meaningfully changes adoption dynamics. While some differences emerged in technical decision-making and perceived risk, many adoption challenges were the same, indicating that structural context and stakeholder alignment often matter more than whether a project is fully timber. This finding contrasts with much of the timber literature that focuses primarily on technical system choice by showing that organisational setup and collaborative processes are often the decisive variables. Together, these insights bridge the gap between innovation theory and the practical realities of adopting new materials in construction. By incorporating social, organisational and iterative dynamics into the DOI framework, the research provides a stronger explanation of how innovations gain traction in complex, project-based environments.

6.3. Generalisability of findings

Although the study was based on two Dutch multi-storey timber projects, several of its findings are transferable to other contexts. The adapted DOI framework addresses adoption dynamics that are common in temporary, multi-stakeholder, project-based settings. The addition of motivation as a separate stage, the inclusion of project shaping alongside persuasion, and the recognition of iteration and knowledge transfer between projects are not unique to timber. These mechanisms apply to any innovation in a fragmented, risk-averse sector where decisions are negotiated among many actors without strong regulatory directives.

From a material perspective, the findings also apply to other early-stage sustainable construction innovations, such as biobased materials, modular systems, or circular construction methods. In all these cases, technical or environmental benefits alone are unlikely to ensure adoption without active stakeholder alignment and supportive project structures.

Finally, while grounded in the Dutch context, the stage-based framework and mechanisms identified here offer a framework to study innovation adoption in other countries or sectors, with only limited adaptation needed to account for innovation- or sector-specific factors (e.g., contract types or material-specific enablers or barriers). While most applicable in settings with similar project-based multi-stakeholder structures, they can also guide strategies in more integrated or regulated contexts by showing the social and organisational work needed to turn awareness into adoption. Further research could apply and test this framework in different geographic, sectoral, and innovation contexts to assess its robustness and refine its applicability.

6.4. Research limitations

This research was based on two ongoing multi-storey timber projects in the Netherlands, with 15 interview participants, which limits the range of contexts captured. The case study approach allowed for a detailed analysis of adoption dynamics, but the small sample size means the findings cannot be generalised to all projects in a statistical sense. Instead, they offer analytical insights that can inform, rather than predict, adoption processes in other contexts that can then be tested. Including projects at different stages, or an even broader range of project roles, could have revealed further differences, such as those related to project size, client type, or location.

During the data collection, both projects were still in progress. As a result, the later implementation and confirmation stages could be assessed only in part, and insights into post-completion performance, reinforcement, or long-term knowledge transfer remain incomplete. Certain dynamics, such as whether lessons were later institutionalised, could not be fully observed. Observing the projects over a longer period could give a clearer view of how adoption patterns evolve once projects are completed and teams have disbanded. Related to this, the long-term operational and financial performance of timber buildings (e.g., lifecycle costs, productivity, comfort, or resale value) could not be assessed. These aspects are essential for understanding the full cost-benefit profile of timber but fall outside the scope of this study because the case projects were not yet completed.

Thirdly, data were primarily gathered through semi-structured interviews. This provided detailed, practice-based perspectives but was influenced by the views and experiences of the interviewees. There is a possibility of recall bias, selective memory, or post-rationalisation, especially for events that happened earlier in the projects. Additionally, participants may have also presented their experiences strategically to make their organisation or role look more favourable. Comparing these statements with more direct observations or measurable performance data could have made the findings even more reliable.

The specific characteristics of the Dutch construction sector also influence the findings. This includes having a strong tradition of design-bid-build procurement, a fragmented industry, and regulations for timber use that are developing but are still limited. Cultural norms and collaboration in the Dutch market may not align with those in other countries. In places with stricter regulations, more integrated supply chains, or different market incentives, the mix of barriers and enablers could have been different.

Finally, the adaptation of the DOI framework and the thematic coding of interview data involved interpretive choices by the researcher. Although these decisions were based on the literature and checked, qualitative analysis inevitably reflects the lens of the researcher. Future studies could apply the adapted DOI framework with other research themes or in other innovation contexts to assess its reliability and improve its relevance.

6.5. Recommendations for future research

There are several ways future research can further develop the insights from this research. First, the adapted DOI framework developed in this research would benefit from being tested beyond the scope of this research to examine its real-world applicability. Although it is informed by both theory and detailed case findings, its value as a practical decision-making tool for navigating innovation adoption in project-based construction has not been demonstrated. Future studies could apply the framework within projects to see how well it helps practitioners pinpoint adoption challenges, align diverse stakeholder groups, and design mechanisms for effective inter-project learning.

Second, while this study applied the adapted DOI framework to two Dutch multi-storey timber projects, its propositions could be strengthened by conducting comparative case study research. Such research could span both Dutch and international contexts, as well as other innovation types such as bio-based materials, modular building systems, or circular construction methods. This could reveal whether key mechanisms such as motivation, project shaping, and iteration operate consistently across contexts, or whether they are shaped by, for instance, local market structures, regulatory environments, or cultural factors.

Third, conducting longitudinal studies that follow projects from early design through to several years post-completion would address the gap created by studying projects still in progress. Researchers could reveal how adoption decisions hold up over time. Also, these could give data about whether sustainability ambitions are maintained and how knowledge transfer occurs once project teams disband, questions that this research could only partially answer.

Fourth, future research should examine the long-term operational and financial performance of multi-storey timber buildings. While this study focused on the early phases of adoption, the cost-benefit profile of timber over the building lifecycle remains insufficiently understood. The business case for timber would be strengthened by empirical evidence on lifecycle costs, energy performance, user comfort, productivity, and durability. This would also make it possible to more effectively define the benefits of timber from a financial perspective. This type of research would provide important support for positioning timber as both a sustainable and cost-effective choice.

Finally, by undertaking a cross-sectional comparative study of multiple full-timber and hybrid timber projects, this study can build on its preliminary insights into the role of material composition. Such research could clarify whether variations in, for instance, technical performance, perceived risk, and stakeholder alignment are linked to the proportion of timber used or whether they stem from broader project conditions like procurement approach, team experience, or regulatory context. This would make it possible to better distinguish the specific impact of material choice from other adoption drivers and enablers.

6.6. Practical recommendations for the sector

The recommendations build on the barriers, enablers, and project dynamics identified in this research. As outlined in section 3.3, adoption dynamics are shaped by different layers of stakeholders, which can be understood through the Circle of Influence model. Clients and developers (circle of control) have direct decision-making power; design teams and consultants (circle of influence) shape adoption through their expertise and framing, while government and sectoral institutions (circle of concern) set the wider enabling environment. The recommendations below, therefore, indicate which circle they primarily relate to, while also recognising that many recommendations apply to multiple layers. Although both case studies analysed in this research were privately led projects, the lessons are transferable to semi-public and public clients facing similar adoption challenges.

6.6.1. Five headline recommendations

The five recommendations below summarise the most important actions that follow from this research. They represent sector-wide priorities that address both project-level adoption and longer-term diffusion of timber. Figure 6.1 highlights them in a concise form before the more detailed recommendations are discussed.

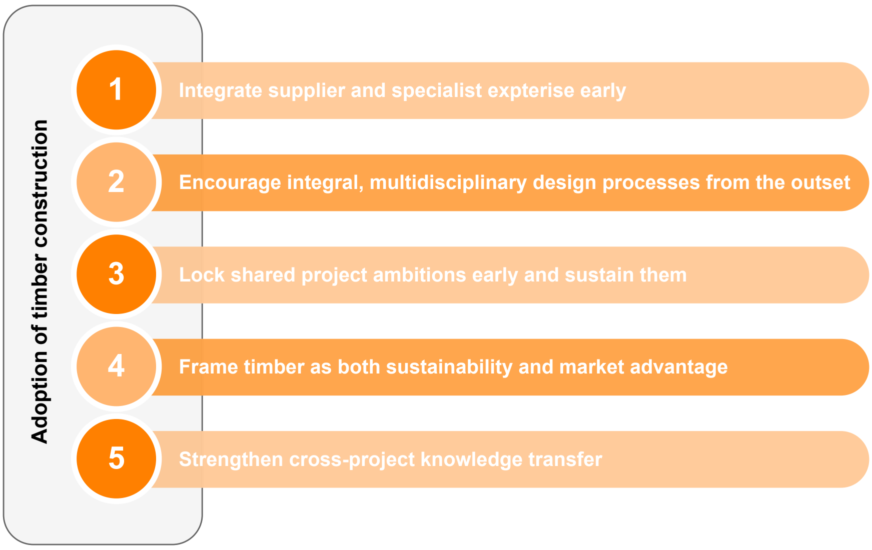

Figure 6.1: Five main practical recommendations

6.6.2. Practical recommendations

Based on the stakeholder mapping in section 3.3, the recommendations are deliberately positioned within the circle of influence. While some decisions are formally initiated by the client, such as the definition of the project ambitions, in practice, these choices are shaped within the circle of influence. Engineering consultants and actors, like project managers, play a key role in framing options and facilitating ambition-setting, making their influence crucial in how these early decisions are taken. Furthermore, in the circle of influence, actors such as engineering firms, architects, and suppliers can expand their impact by introducing, framing, and sustaining timber strategies across projects. The following recommendations, therefore, focus on measures that can strengthen this influence, presented under thematic headings.

Project setup

- **Integrate supplier expertise into the design process**
  Involve specialist engineers and suppliers during the concept design stage to integrate timber requirements into the structural and architectural design from the outset. Early commitment avoids redesign, reduces risk, and ensures detailing, grid layouts, and prefabrication plans are optimised for timber as part of an integral design process from the start. In this role, suppliers contribute as advisors as well as providers, using their technical expertise to actively shape feasible and efficient design solutions.

- **Choose procurement models that enable early collaboration**
  Select and advise procurement routes with contracts that enable early collaboration (e.g., Design&Build, Bouwteam, DBM) and secure timber expertise in the core team from the outset. This helps with collaborative problem-solving and timely decision-making before the design is finalised.

- **Define and lock shared project ambitions early**
  Early ambition-setting requires alignment across the client, advisors, and project partners. Before diving into technical details, jointly establish sustainability, cost, and performance targets. This collaborative approach prevents ambition dilution and provides a stable reference point for subsequent design and procurement decisions.

- **Blur traditional stakeholder boundaries**
  Encourage engineers to contribute to design concept development and architects to engage in

technical feasibility from day one. In timber, these roles are highly interdependent and benefit from an integral approach to design collaboration.

- **Standardise repeatable details**
  Tested connections, floor/wall assemblies, and interface solutions should be documented so that most of the details can be reused in future projects. As timber is highly prefabricated, this will reduce design time and uncertainty in future projects.

Knowledge sharing

- **Create or join an open-access timber database**
  Group tested solutions, performance data, and design precedents from multiple projects through knowledge-sharing platforms (e.g., Build-by-Nature, Build-in-Wood). These platforms often operate internationally, enabling Dutch actors to exchange insights with countries where multi-storey timber is more established. This (cross-country) knowledge sharing reduces risk for both new and experienced timber adopters and accelerates decision-making.

- **Facilitate cross-disciplinary knowledge networks**
  Host or join regular (e.g., bimonthly) knowledge groups with actors from different disciplines, including municipalities, to exchange innovations and explore how they can be applied in specific urban contexts.

- **Create internal cross-discipline knowledge transfer**
  Ensure that lessons from completed projects are systematically shared across all relevant disciplines within a company, not just within the same specialism. For instance, structural engineers should brief project managers, architects, and building services teams on both successes and challenges. This cross-pollination strengthens the company's position in future timber tenders.

- **Share both successes and challenges transparently**
  Make sure not to only promote the polished outcomes but also communicate what was difficult and how it was resolved. This builds trust and accelerates industry learning.

- **Build continuity across projects to break the ”one-off” cycle**
  Retain and reassemble experienced timber teams for follow-up projects, reducing the inefficiencies of the fragmented, one-off project culture. This continuity can strengthen trust, preserve knowledge, and accelerate innovation.

- **Strengthen long-term client relationships around timber**
  By engaging with clients after project completion, there is a possibility to review results and explore follow-up opportunities. Taking the position of a partner who can de-risk their next project increases the likelihood of repeated collaboration, strengthens trust, and helps accelerate the broader adoption of timber construction.

Mindset shift and motivation

- **Set and facilitate clear timber ambition and champion it throughout the project**
  Make the environmental and innovation goals explicit at the briefing stage through discussions and the use of tools such as a sustainability web. Designate a person or team responsible for reiterating sustainability and timber ambitions, countering cost-driven dilution to ensure the original intent is maintained throughout design, procurement, and delivery.

- **Provide timber alternatives to designs** Even if the initial briefing suggests conventional materials, task the structural team to produce a timber variant so its feasibility can be seriously considered.

- **Use performance metrics to strengthen persuasion**
  Conduct a thorough risk and feasibility study, which includes MPG, CO_2, and circularity calculations. Presenting these quantified results makes sustainability benefits concrete and directly comparable to conventional materials. This will strengthen the case for timber with decision-makers.

Strategic framing

- **Leverage timber's unique properties for context-specific solutions**
  Recognise that timber's material qualities, such as lightweightness and prefabrication potential, can offer decisive advantages in certain project contexts. By proactively assessing these opportunities early, timber can become an enabler.

- **Link timber to tangible value gains**
  Frame proposals around added rentable space, faster construction times, or distinctive market positioning (e.g., wellness, biophilic design) rather than only environmental benefits.

- **Leverage timber's prefabrication potential to the fullest**
  Identify components and systems that can be prefabricated beyond current practice, where lessons learnt from earlier projects are used to increase prefabrication potential. This will further increase speed and reduce construction costs.

- **Target larger volumes and standardised components**
  Bundling projects and standardising dimensions across projects (e.g., consistent grid sizes, panel widths) can make manufacturing more efficient, reducing waste and lowering both material and labour costs over time.

7 Conclusion

7 Conclusion

This research examined how the adoption of multi-storey timber buildings can be accelerated in the Netherlands by identifying key barriers and enablers. Using Rogers' Diffusion of Innovations (DOI) framework, supported by practical insights, this research combined a structured literature review with semi-structured interviews from two case studies: a full timber project and a hybrid timber project. The objective of this chapter is to synthesise the main findings of this research, which aimed to explore the factors shaping adoption in practice and to provide a structured basis for developing strategies that could support broader uptake. The primary focus is on answering the central research question:

> **How can the adoption of timber in multi-storey construction projects be accelerated by identifying key barriers and enablers using the Diffusion of Innovations framework?**

The main research question was addressed by answering three sub-questions, as outlined in section 1.4.

What are the current barriers and enablers influencing the adoption of timber in multi-storey construction?

The literature review suggests that multi-storey timber remains in an early adoption phase, with cautious movement towards a wider uptake as its potential becomes more widely recognised. Yet, adoption is slowed by persistent barriers. Financial constraints, particularly high upfront costs and limited monetisation of life cycle carbon benefits, as well as technical concerns, remain present across all project phases. Compatibility barriers are also prominent, as timber often misaligns with established supply chains, planning routines, and building norms, while industry fragmentation, silo-thinking, and traditional delivery models restrict the early collaboration timber requires. Regulatory frameworks, such as outdated fire codes, further limit alignment. In addition, cultural aspects of the industry, like reliance on established materials and processes, further reinforce path dependency and slow acceptance of timber solutions.

Furthermore, complexity barriers arise because there is a widespread lack of timber expertise, and timber projects demand early and detailed coordination and lack standardised components, which encourages risk-averse behaviour. Trialability is low, as full timber projects require significant upfront commitment, which is often lacking, while the true performance of a timber building is difficult to test on a small scale. Finally, observability is limited by the lack of performance data, the small number of multi-storey examples, and minimal knowledge sharing between projects. Information on timber's benefits and technical performance often remains within the project, leaving other stakeholders with limited verified evidence. This lack of transparent, comparable information makes it difficult for actors new to the material to build confidence, slowing the diffusion of timber adoption.

Despite these challenges, the literature identifies some clear enablers. Timber's strong environmental benefits, such as carbon sequestration and its lower embodied emissions, make it an important material for achieving climate goals. Prefabrication allows quicker construction with less waste and also flexible design options. Exposed timber, furthermore, boosts aesthetic qualities and occupant well-being while also offering developers a distinctive selling point and market advantage. Policies like national CO_2-reduction targets, green building standards, and carbon taxes increasingly reinforce timber's advantages. Furthermore, although still used little, knowledge sharing platforms can increase performance and knowledge sharing across projects, thereby improving visibility and trust among industry actors. Finally, several literary sources mention that hybrid timber projects can serve as confidence-building steps for the use of timber in multi-storey construction. Overall, the literature offers a clear theoretical understanding of these barriers and enablers but provides limited insight into how they interact in practice and what strategies can effectively address them in real project settings, a gap addressed by the empirical research.

How do stakeholder roles and project dynamics influence the presence of barriers and enablers in full timber and hybrid timber projects?

Project dynamics, particularly structures, processes, and timing, played a decisive role in determining whether barriers remained or enablers could be leveraged. Where teams used collaborative, multidisciplinary workflows from the outset, timber's compatibility and trialability improved as design discussions incorporated diverse perspectives early, allowing constraints to be addressed before they became lock-in issues. In contrast, linear handovers, where design was largely completed before key technical actors became involved, reduced opportunities for adjustment and introduced detailing and coordination issues that became increasingly difficult to address once designs were more fixed.

The configuration of roles, furthermore, shaped project outcomes. Although clients typically held decision-making power, project dynamics sometimes allowed other stakeholders to extend their influence through strategic positioning or operating across blurred boundaries. In several cases, dual positions or overlapping roles, such as stakeholders acting both as tenants and design partners, expanded influence and created stronger alignment, allowing barriers of compatibility and complexity to be addressed earlier. In particular, bringing key suppliers and specialists into the process early proved vital: incorporating production tolerances and assembly needs during the design stage enhanced compatibility and prevented expensive rework. Furthermore, the early integration and blurred boundaries supported early resolution of issues related to challenges, such as fire safety and connection detailing, helping to reduce complexity and align technical feasibility with design goals. On the other hand, when supplier input came too late, opportunities for efficiency gains and timber-specific optimisation were lost, resulting in costly redesign.

What role does stakeholder motivation play in initiating and sustaining the adoption of timber in multi-storey construction?

Motivation emerged as a prerequisite and decisive factor in initiating and sustaining multi-storey timber adoption. Without committed actors, project dynamics alone did not carry adoption through. When the financial sponsor lacked motivation, timber was unlikely to be seriously considered; cost-driven or risk-averse stakeholders defaulted to familiar, low-risk materials rather than engaging with an unfamiliar system perceived as costly or uncertain. Conversely, when the main decision-maker or important stakeholders were strongly motivated, this commitment set a clear direction for the project and ensured timber remained a central option for design and planning. In one case, the developer's clear, non-negotiable goal of using timber set the standard, focusing decisions on its benefits, such as long-term climate goals and identity. Furthermore, this motivation drove the team to address challenges like compatibility and complexity through early planning and a culture of experimentation and learning, which facilitated tailored solutions. In the other case, a cost-driven stakeholder was offset by motivated tenants and the design team. In both cases, the motivated actors acted as internal change agents who kept timber central in discussions and provided the structural backing needed to sustain ambition across phases.

Motivation worked in several ways. A clear shared sustainability vision from the outset aligned actors and prevented the project from losing that focus. Strategic framing helped communicate timber's value to different stakeholders, for instance, by highlighting faster construction and returns for cost-focused stakeholders and carbon storage, certification, and indoor quality for sustainability-focused ones. This strengthened the timber's perceived relative advantage, making it more beneficial and suitable. Furthermore, the culture of experimentation and learning encouraged trialability, where teams accepted trade-offs, challenged safe defaults, and saw this early project as steps towards building skills. Finally, motivated actors fostered observability by sharing progress and lessons with other industry members through site visits and platforms, while warning that not sharing performance data ”kills enthusiasm” and keeps uncertainty alive. Thus, motivation acted as the prerequisite that enabled other conditions, from project structures to technical solutions, to align for successful adoption in practice.

Main research question

The main research question, as defined in section 1.4 is:

> *How can the adoption of timber in multi-storey construction projects be accelerated by identifying key barriers and enablers using the Diffusion of Innovations framework?*

This research shows that acceleration hinges on more than resolving technical challenges: it depends on aligning stakeholder motivation, structuring collaborative project dynamics, and deliberately targeting the innovation attributes that shape adoption in practice. By combining the literature review with empirical case studies, the research extends the DOI framework by introducing motivation as a prerequisite for persuasion, showing that persuasion and project shaping occur concurrently, as project dynamics actively shape how innovation attributes are perceived and managed. The findings also highlight the collective, evolving nature of decision-making in multi-stakeholder, project-based environments. These insights are synthesised in the adapted DOI framework, through its redesigned visual model that makes the new stages and feedback loops immediately tangible and underlines the theoretical novelty of the contribution.

Adoption begins when key actors actively commit to timber and frame its benefits in ways that resonate with diverse stakeholders. Without this drive, cost-driven or risk-averse actors default to conventional materials. Once motivation is present, acceleration depends on how projects are structured. Collaborative, multidisciplinary processes from the outset not only improve compatibility and minimise complexity but also provide trialability by embedding system constraints and supplier input into design discussions. In contrast, late involvement and linear handovers limited adjustment opportunities and locked in detailing and coordination issues. Adoption progresses in an iterative rather than linear manner, requiring teams to revisit earlier design and framing decisions to balance constraints and maintain ambition. In this context, the decision stage is not a single, definitive moment of adoption or rejection but rather a revisitable trajectory in which choices can be reconsidered. Recognising this iterative character as inherent to project-based construction helps prevent it from being framed as a failure and instead positions it as a deliberate mechanism for reinforcing adoption. Crucially, motivation is not a one-time trigger but a continuing condition that must be sustained throughout the project to prevent barriers from re-emerging as pressures increase.

To ensure real diffusion across the sector, acceleration requires connecting individual projects to the wider industry. At present, knowledge about timber's performance often stays within single projects. Creating clear ways to share lessons and data across projects can build trust and visibility, allowing new adopters to rely on verified evidence rather than marketing claims. This makes timber less of a ”leap of faith” and more of a trusted option, lowering risk perceptions and encouraging faster adoption. Structured knowledge transfer is not just a supporting measure but a decisive accelerator, turning isolated pioneering projects into stepping stones for mainstream practice. By embedding mechanisms for compatibility and visibility across projects, the sector can shorten learning cycles, reduce uncertainty, and position timber as a trusted standard rather than a risky experiment.

In conclusion, adoption can be accelerated when motivation drives serious consideration, when project structures enable integration and iteration, and when knowledge is systematically transferred across projects. Together, these extensions to the DOI framework turn timber from an experimental material into a credible mainstream choice, enabling the transition from isolated pioneering projects to sector-wide diffusion. They ultimately provide a pathway for the construction sector to meet its climate goals while breaking away from longstanding reliance on conventional materials.

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A Interview Questionnaire

English

****START RECORDING****

I have prepared around ten questions, but we will mainly follow your story. If you would like to elaborate on something or provide an example, please do, as that would be most helpful for my research. The interview will take about 45 minutes. There are no right or wrong answers; I am interested in understanding why certain choices were made so I may ask some follow-up questions for clarification. That is what makes this research interesting.

Informed consent signed?

Introduction and motivation

1. What was your role in this project, and how did you become involved?
2. How did the use of timber influence your work or way of collaborating?
   - What challenges did you face, and what stood out compared to other materials?
3. Which aspects of this project appealed to you the most?
4. What did you notice about how other stakeholders approached this project?
   - Did you observe any differences?

Project experience and material use

5. Can you describe a situation where the use of timber had a real impact on design or organisation?
6. Why was a [hybrid construction / fully timber] chosen in this project instead of [fully timber / hybrid]?
   - Who ultimately made the decisive call, in your opinion?

Collaboration and influence

7. How did collaboration between the different parties develop, and did the choice of material play a role in that?
   - Did the use of timber affect collaboration?
   - To what extent did you feel the team was aligned during the project, and how did that impact collaboration?
8. Which party do you think had the most influence on the progress of this project and the choice of timber?
   - Did you, from your role, also have direct influence on decisions regarding timber use or collaboration in this project?
   - How was the use of timber framed or presented?
9. Did timber construction fit within your organisation's usual way of working, or did it require adjustments?

Reflection and future

10. Have you worked in the context of both fully timber and hybrid projects, and do you see differences in how timber construction is approached?
11. And how do you see the difference between mid-rise and high-rise buildings in timber?
    - From your role, are there other risks, persuasion challenges, or technical dilemmas?

12. Has your perspective on timber changed during or after this project, and if so, how?
13. Looking ahead to future projects: what do you think would make timber construction easier or more successful?

Nederlands

****START RECORDING****

Ik heb ongeveer tien vragen voorbereid, maar we volgen vooral jouw verhaal. Als je ergens langer op in wilt gaan of een voorbeeld hebt, heel graag, dat helpt mijn onderzoek het meest. Het interview duurt ongeveer 45 minuten. Geen enkel antwoord is goed of fout, ik wil graag weten waarom die keuzes zijn gemaakt, dus daar probeer ik ook op door te vragen. Dat is wat interessant is voor mijn onderzoek.

Informed consent getekend?

Introductie en motivatie

1. Wat was je rol in dit project en hoe raakte je betrokken?
2. Hoe beïnvloedde het gebruik van hout jouw werkzaamheden of manier van samenwerken?
    - Waar liep je tegenaan, wat viel op t.o.v. andere materialen?
3. Welke aspecten van dit project spraken jou het meest aan?
4. Wat viel jou op in hoe andere partijen dit project benaderden?
    - Merkte je daar verschillen in?

Projectervaring en materiaalgebruik

5. Kun je een situatie noemen waarin het gebruik van hout echt invloed had op ontwerp of organisatie?
6. Waarom is in dit project gekozen voor een [hybride constructie / volledig hout] en niet voor een [volledig hout / hybride]?
    - Wie gaf daarin uiteindelijk de doorslag denk jij?

Samenwerking en invloed

7. Hoe verliep de samenwerking tussen de verschillende partijen, en had het materiaalgebruik daar invloed op?
    - Had het materiaalgebruik invloed op de samenwerking?
    - In hoeverre merkte je dat het team op één lijn zat tijdens het project, en hoe werkte dat door in de samenwerking?
8. Welke partij had volgens jou de meeste invloed op het verloop van dit project en de keuze voor hout?
    - Had jij vanuit jouw rol ook echt invloed op beslissingen m.b.t. houtgebruik of samenwerking in dit project?
    - Hoe werd het gebruik van hout geframed of gepresenteerd?
9. Paste houtbouw binnen de gebruikelijke manier van werken in jouw organisatie, of vroeg dit om aanpassingen?

Reflectie en toekomst

10. Heb jij in de context van zowel volledig hout als hybride gewerkt en zie jij verschillen in hoe er wordt omgegaan met houtbouw?
11. En hoe kijk je naar het verschil tussen middelhoge gebouwen en hoogbouw in hout?
    - Zijn er vanuit jouw rol andere risico's, overtuigingskracht of technische dillema's?
12. Is jouw kijk op hout veranderd tijdens of na dit project, en waardoor?
13. Als je kijkt naar toekomstige projecten: wat zou volgens jou helpen om houtbouw makkelijker of succesvoller te maken?

B Informed consent form

Informed consent form

Participant Information/Opening Statement

You are being invited to participate in a research study titled *Branching out: Timber adoption in multi-storey construction*. This study is being done by master student Sjors Hooijmaijers from the TU Delft in cooperation with Arcadis under supervision of Wouter Slotman (Arcadis), and Johan Ninan (TU Delft).

The purpose of this research study is to explore how the adoption of multi-story timber construction can be accelerated by identifying key barriers and leveraging enablers, as perceived by actors involved in the hybrid-timber Cube House project and the full timber Urban Woods project. The interview will take approximately 30 to 60 minutes to complete. The data will be used for a master's thesis at the TU Delft and may be included in academic publications or presentations. We will be asking you to reflect on your involvement in the timber project. The questions are semi-structured and aimed at capturing your professional perspective on the opportunities and challenges of timber adoption.

This research is conducted in cooperation with Arcadis, who is supporting the research as an external partner. However, Arcadis will not have access to raw interview data. Only anonymised and combined insights may be shared with Arcadis for the purpose of this research analysis. No individual participants or organisations will be identifiable in any information provided to Arcadis.

As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers in this study will remain confidential. We will minimize any risks by anonymizing all collected data and storing it in a password-protected cloud environment. No IP addresses or personally identifiable information will be collected or stored. Any references to organizations or individuals will be removed during transcription to ensure confidentiality. The interview data will not be made publicly available and will be used solely for academic purposes by the researcher and supervising faculty members.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to skip any questions. Participation will not affect your relationship with TU Delft, Arcadis, or your employer in any way.
Within two weeks after the interview a summary of the participants answers will be provided to the participants. After these two weeks, the interview answers can be deleted at the participants will.

The responsible researcher from the TU Delft is Dr. Johan Ninan.

Explicit Consent points

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [___/___/_____], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions, and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves: • Answering questions regarding my work and involvement on the timber construction project. • Being audio-recorded with the sole goal of transcribing the answers. This audio-recording will not be shared with anyone outside the interviewer. After the transcription is done, it will be shared with the participant. Modification can be done until two weeks after the interview.	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
4. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) such as a name and company role and associated personally identifiable research data (PIRD) with the potential risk of my identity being revealed.	☐	☐

Figure B.1: Informed consent form page 1

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
5. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: • Anonymous data collection • Secure data storage in password protected environment • Transcription of participants answers • Audio-recordings will be destroyed after transcription	☐	☐
6. I understand that personal information collected about me that can identify me, such as my name and the role in the company, will not be shared beyond the study team. This data will be de-identified (all socio-demographic factors such as name, age, income, gender, community ties, etcl	☐	☐
7. I understand that the (identifiable) personal data I provide will be destroyed after the data collection phase of the thesis has finished.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
8. I understand that after the research study the de-identified information, I provide will be used for the master's thesis report and published in the TU Delft repository.	☐	☐
9. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐	☐

Signatures

____________________ ____________________ ________

Name of participant [printed] Signature Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Sjors Hooijmaijers ____________________ ________

Researcher name Signature Date

Contact details for further information: [redacted]

Figure B.2: Informed consent form page 2