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BUILDING THE FUTURE:

PATHWAY TO PREFABRICATED HOUSING ADOPTION IN THE DUTCH MARKET

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by

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Preface

Around the world, more and more people are struggling to find affordable homes, while climate change reminds us that the way we build must also change. Prefabricated housing offers a way to build faster, smarter, and with less harm to our mother earth. In this research, I explore how this housing technology can grow in the Dutch market, what supports it, what holds it back, and how different sectors, stakeholders, and policies play a role.

This research is very close to my heart because it combines small parts of my life: my background as Bachelor of Civil Engineering, as civil engineer, and everything I have learned during my Master's in Engineering and Policy Analysis. I have always been curious about how technical ideas can be turned into real-world solutions. This research gave me the chance to do just that.

But beyond the research, this journey has been deeply personal.

- Alhamdulillah, praise to **Allah SWT** for guiding me through the highest high, and lowest low. I will not be here without His guidance.
- To the late **Bert Enserink**, the former director of Engineering & Policy Analysis at TU Delft who granted me the full scholarship. May you rest in peace.
- To my parents, **Bapak Wustiyo and Ibu Sunartuti**, thank you for the courage to let me leave home, to discover the world, and to learn how to find joy, love, adventures, and meaning far from everything I once knew. You showed me that even when I am far away, I can build a much better home surrounded by people who truly value, love, and genuinely wants me to grow.
- To my sister, **Mbak Tiya**, remember our bet in 2015 about who would go abroad first? I won, but that bet pushed me forward and kept my fire burning. Thank you for being my quiet source of motivation all along.
- To my nephew and niece, **Prabu, Gessa**, my cutie pies, my sources of happiness at home, and the reason why I start loving video calls once I am away, I hope I could be a good example for you both. Thank you for being my sources of happiness with your cuteness, and sorry but not sorry to often make you cry because that is the consequences of taking my own reign as the youngest one in the family, and that is how every uncle in this world should act; being as annoying as possible, and of course for the newly born, my second nephew, **Kaisar** who was born this June 2025, thanks for bringing happiness from afar.
- To my **whole family**, I dedicate this achievement to you. I am the first in our family to study masters abroad, but I will not be the last. The gate is open now. Let's keep walking forward and raise our family's pride even higher. Let's work hard and set the bar so high that the ones who come next will chase it with all their hearts.
- To my thesis supervisors, **Geerten and Linda**, thank you for guiding me throughout this thesis journey. Thank you for understanding my constraints and struggles as an international student, while also challenging me to do my best.
- To my **Indonesian and international friends**, you lit up my path during the darkest, stormiest days. Your kindness, your jokes, your presence. I will carry those memories forever.
- Finally, as cliché as it might sound, I want to thank myself for pushing myself forward no matter what the obstacles are. I got rejected by LPDP Scholarship twice but finally earned Bert Enserink Scholarship which made it possible to do my master at TU Delft. I also write this to appreciate myself for working hard, for always seeing something from the silver lining, and most importantly, for staying kind, witty, eccentric, cool, and sane during these unfamiliar situations.

Finally, I hope this thesis inspires future research and development in the market adoption of prefabricated housing both in the Netherlands and the world. May its findings contribute to the collective pursuit of sustainable buildings in the future.

Prima Sandy Yonanda

Delft, August 2025

Abstract

The Netherlands faces a critical housing shortage, estimated at over 400,000 homes in 2024, while simultaneously pursuing ambitious climate goals. Prefabricated housing offers a promising solution, as it enables faster construction, minimizes material waste, and improves energy efficiency. However, despite its technical and non-technical advantages and alignment with sustainability agendas, its market adoption remains limited and fragmented in the Dutch context. This study examines the key factors influencing the market adoption of prefabricated housing in the Netherlands, with a focus on the underlying misalignments among actors from diverse sectors.

To explore this issue, the study applied a mixed-methods research design. An extensive literature review was conducted to identify factors influencing adoption in the existing literature. Subsequently, three stages of expert interviews were conducted with 12 experts from academia, industry, and government, who represent the Triple Helix model. The Best-Worst Method (BWM) was then applied to rank nine consolidated adoption factors based on expert input systematically. The process was followed by a thematic analysis and triangulation with 25 international studies to explore the reasoning behind stakeholder preferences and variation in prioritization.

The nine key factors assessed were:
1. Financial and Economic Viability
2. Consumer Perception and Market Demand
3. Policy and Regulatory Support
4. Speed and Construction Efficiency
5. Sustainability and Environmental Impact
6. Industry Collaboration and Workforce Development
7. Structural Quality and Durability
8. Technological Advancements and Standardisation
9. Supply Chain and Logistics Efficiency

As seen above, financial and economic viability ranked highest, indicating that cost-effectiveness, profitability, and affordability are decisive for both public and private actors. Consumer perception and market demand followed closely, reflecting the role of public trust and design acceptability. Policy and regulatory support was also ranked highly, which emphasizes the need for efficient permits and consistent policies. Conversely, factors such as technological advancements and supply chain logistics, often emphasised in the literature, were deprioritised by experts, who saw them as either already developed or less influential in current decision-making contexts.

BWM analysis also revealed that prioritizations were not sectorally consistent: experts within the same sector often disagreed. Instead, through thematic analysis and triangulation, it is known that factor rankings were shaped by an individual's background, institutional mandate, and past project experience. For example, experts with experience in government focused on financial viability and regulatory support, while industry actors emphasized financial viability and sustainability. In the meantime, academic experts often stressed consumer perception, construction speed, and cross-sector collaboration.

This study presents a stakeholder-informed, decision-analytic framework for understanding the adoption of prefabricated housing. It emphasizes that accelerating adoption requires not only technical innovation but also coordinated cross-sectoral strategies, financial incentives, a shared narrative that enhances consumer perception, and policy support. The findings offer practical insights for policymakers, developers, and researchers seeking to mainstream prefabricated housing as a sustainable, scalable, and socially accepted housing solution in the Netherlands.

Keywords: Prefabricated housing, Market adoption, Best-Worst Method (BWM), Stakeholder analysis, Triple Helix model, Housing shortage, Sustainability, Construction efficiency, Consumer perception, Policy and regulation, Financial viability, Thematic analysis, Triangulation, Netherlands housing market

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“Innovation for holders of conventional wisdom is not novelty but annihilation.”

- Marshall McLuhan

1) Introduction

1.1 Research Background

The Netherlands is facing a housing shortage (Nijskens & Heeringa, 2017). By 2024, it is estimated that around 401,000 homes will still be needed (Nijskens et al., 2019). At the same time, the country is working ambitiously to achieve its climate goals and reduce pollution from various sectors, including the construction sector. Traditional building methods have been in use for a long time and are often regarded as the standard approach to construction. However, they are slow, require considerable labour, and generate a large amount of pollution and waste (Hill & Bowen, 1997; Lam et al., 2010; Hwang et al., 2018; Martin & Forsythe, 2019). These methods are no longer enough to meet the current urgent housing and environmental needs.

As a result, prefabricated housing has begun to gain attention as a more promising approach. With this method, large parts of a building are manufactured in a factory. It is even possible to construct the entire housing in the factory, then transport it to the building site and assemble it. This approach helps accelerate construction, minimize waste, and enhance quality. It can also lower the overall cost and energy used during construction (van Doren et al., 2020). For a country like the Netherlands, which is renowned for its strong environmental policies and thoughtful urban planning, prefabricated housing is a suitable match for future housing projects (London & Pablo, 2017).

Prefabricated housing, although it still requires energy, is more efficient and environmentally friendly than traditional construction (Ngo, 2023). Factory planning ensures precise material use, which reduces excess demand and saves energy. In contrast, traditional sites often encounter errors and changes that result in increased waste and resource consumption (Hu, 2024). Waste from prefabrication is also easier to recycle, while mixed on-site waste in traditional builds requires more energy to handle (Tavares et al., 2021). Prefabricated buildings are completed faster, which reduces machinery use and emissions, whereas conventional methods take longer and consume more energy (Zhou et al., 2023). They also feature better insulation and airtightness, which lowers heating and cooling needs, while traditional buildings often leak energy (Kumar et al., 2020). Lastly, transportation is more efficient with fewer large deliveries, which reduces emissions compared to the frequent small deliveries in traditional construction (Yi et al., 2019).

However, despite these advantages, the market adoption of prefabricated housing in the Netherlands remains limited and fragmented. While there is no shortage of technical innovation, the root causes lie in the lack of alignment within the Triple Helix, the three key actors shaping the development and diffusion of prefabricated housing: government, industry, and academia. Each of these sectors operates with different interests, objectives, and expectations. For instance, while governments focus on economic viability, and factors that relate to regulatory support, such as affordability, sustainability, and structural durability, the industry sector prioritizes profitability, speed, and consumer preferences. Meanwhile, academia tends to emphasize sustainability, collaboration, and systemic thinking (Lucena do Nascimento & Mazali, 2023; Harris, 2006; Steinhardt et al., 2013; Azeem et al., 2020).

Because these stakeholders rarely operate in sync, there is no shared roadmap or unified strategy for adoption. Instead, each group tends to define its own "ideal" adoption factors, which often diverge or even conflict with one another. This misalignment creates fragmented implementation, slows down coordination efforts, and ultimately prevents prefabricated housing from becoming a solution. As a result, the adoption of prefabricated housing in the Netherlands is not just a technical or engineering challenge; it is a market adoption problem, shaped by psychology, policy, economics, and institutional dynamics (European Commission, 2012; Oorschot et al., 2019). What is currently lacking is a clear, collective understanding of which factors matter most to accelerate adoption across all sectors.

This thesis aims to address that problem by answering the main research question:

"What key factors affect the market adoption of prefabricated houses in the Netherlands?".

To achieve this, the study employs a mixed-methods approach. It begins with an extensive literature review to identify adoption factors cited in academic and professional research. This is followed by expert interviews with actors from government, industry, and academia to integrate factors from practical and research fields that are not adequately captured in the current literature. Then, the Best-Worst Method (BWM) is used to quantify the importance of these factors, allowing for a structured comparison of factors derived from a comprehensive literature review and expert interviews.

Once the Best Worst Method (BWM) analysis is complete, the next step is to conduct thematic analysis and triangulation. Both could be achieved by performing the third-stage interview to understand how the background, mental framework, knowledge, expertise, and experience of the experts influence their logic for prioritising the factors. The result of this interview is then compared with the findings of existing literature.

By identifying and prioritising the most influential adoption factors while also understanding the reasons why certain factors are prioritised and some are not, this research provides a valuable foundation for better strategic decisions, more aligned multi-actor collaboration, and the broader adoption of prefabricated housing technologies in the Dutch market (Markard & Erlinghagen, 2017; Dastbaz et al., 2015; Liu et al., 2020).

1.2 Relevance to EPA Programme

This study aligns closely with the objectives of the Engineering and Policy Analysis (EPA) program. This program emphasises the combination of engineering mindset, stakeholder involvement, and multi-actor collaboration, which directly incorporates with the scope and methodology as explained below:

- This study aims to address the complex problem of the housing crisis by introducing housing technology, along with the factors that influence its adoption in the Netherlands, which also involve multi-actor perspectives (Triple Helix Model: Government, Academia, and Industry).
- Data-driven method, using the combination of the extensive literature review, three stages of expert interviews, and thematic analysis and triangulation.
- This study addresses significant societal challenges in sustainable housing and construction, which directly contribute to the EPA's vision of combining engineering and policy analysis to solve grand challenges.

Below are the EPA's courses that are aligned with this study:

- Policy Analysis for International Challenges (PAIC). This study aligns with PAIC in that it attempts to address a wicked problem that occurs in the Netherlands and globally, namely, housing shortages.
- Actor and Strategic Model (ASM). This study resonates with ASM because it acknowledges that actors share the same goals, but due to their differing priorities, this creates conflicting views on various matters. In this context, it is worth considering how actors from different sectors, and even those from the same industry but with different expertise, may hold different views on which factors should be prioritised if the Netherlands aims to achieve more sustainable housing while also reducing the number of housing shortage cases.
- Ethics of Large System Interventions. This course and study align with one another in a way that emphasises the consideration of ethical implications when adopting new technologies.
- Political Decision-Making, in a way that this study recognises, is that any new technology is likely to be successful if there is political will behind it.

1.3 Objectives

- To systematically identify key factors that contribute to the market adoption of prefabricated housing technologies in the Netherlands through an extensive literature review and expert interviews.
- To assess the relative importance of each identified factor through structured interviews with experts from academia, industry, and government.
- To apply the Best-Worst Method (BWM) to identify which factors of prefabricated housing technology market adoption should be prioritised to achieve widespread adoption in the Dutch market.
- To understand if any, the reasons why actors from different sectors prioritise different factors to achieve a collective understanding.

1.4 Research Questions

Considering the research objectives (see Section 1.3 Objectives), the focus of this research is to identify and analyse the factors that influence market adoption in the Netherlands, while also examining the reasons why these factors are ranked as they are. Understanding the importance of those two, the study poses this main research question:

"What key factors affect the market adoption of prefabricated houses in the Netherlands?"

To answer the main question, it is essential to break it down into three sub-research questions below:

a) Identification of Influencing Factors:

"What are the factors that influence the market adoption of prefabricated housing technologies, according to existing literature and expert interviews?"

Answering this first sub-research question involves combining the factors gained from both the extensive literature review and the initial stage of interviews. This means that factors from both existing literature and experts' experiences that have not been captured in the literature are gained. To ensure it is well-represented, experts should utilise the Triple Helix Model. That means experts should come from the government, academia, and industry sectors.

b) Evaluation of Importance and Determination of Key Factors:

"What is the importance of these identified factors, and which factors are likely to become major determinants based on expert interviews and BWM Analysis?"

Once the first sub-research question is answered, the study proceeds to the second stage, where the factors are ranked through an interview. At this stage, the interview questions will focus on Best-Worst Method (BWM) Analysis. This means that the questions would be about what the best and worst factors are, followed by ranking the factors placed in the middle (2nd through 8th rank). The questions also include identifying the objective reasons why the experts rank those certain factors. The objective reasons suggest that the experts' backgrounds should not be the reason for ranking those factors to avoid bias.

c) Analysis of variance, if any:

"What explains the variation, if any, in how experts prioritize factors for the market adoption of prefabricated housing?"

Once the BWM Analysis is complete, this study proceeds by conducting the third-stage interview to understand the subjective reasons why experts rank the factors. This third-stage interview is necessary, especially if the results of the BWM Analysis vary among the same sectors, which is likely to happen, considering the different research areas, backgrounds, and past experiences of experts, which would shape subjective reasons. Thus, objective reasons gained from the second-stage interview are not enough.

2) Theoretical Background

The theoretical background of this study includes the concept of prefabricated housing, including its market adoption, and the complexity on how stakeholders' strategies influence both as follow.

2.1 Prefabricated Housing

Prefabricated housing is an innovative construction method in which significant components are manufactured off-site and assembled on-site, allowing for faster and sometimes more cost-effective building compared to traditional methods (Jaillon & Poon, 2009; Bergdoll & Christensen, 2008; van Oorschot et al., 2021). Industry leaders such as Boxabl, Sustainer Homes, Prefab Homes Nederland, Livingstone, and Jan Snel are pioneering the use of prefabrication to transform the construction industry.

A significant benefit of prefabricated homes is their efficiency and reduced error rates, which accelerate construction and minimise waste, making them a more sustainable option (Malmqvist et al., 2018; Sadeghi et al., 2022; Lehmann, 2013; van Campen, 2024). Sustainer Homes emphasises eco-friendly materials and methods, while Livingstone combines luxury with environmental standards.

Despite these advantages, widespread adoption faces hurdles (Steinhardt et al., 2013). High initial investment in manufacturing and complex logistics for transporting modules raises costs (Grant et al., 2017). Additionally, industry resistance remains due to entrenched traditional practices (Nadim & Goulding, 2011). Jan Snel has mitigated these challenges by streamlining quality and speed, making them especially useful for rapid deployments in sectors such as healthcare and education.

Regulatory frameworks also shape adoption rates. In the Netherlands, stringent sustainability laws have supported the growth of firms like Prefab Homes Nederland (Wu et al., 2022; van Campen, 2024). Market demand, economic conditions, and consumer preferences further influence uptake (Mohamed et al., 2023). Boxabl exemplifies how innovation and affordability can appeal to a broad audience with its scalable modular homes. Additional research is essential to unlock the full potential of prefabrication, including regional adoption patterns and long-term cost-effectiveness (D'Oca et al., 2018; Svahn et al., 2017; Steinhardt et al., 2014).

In brief, prefabricated housing offers a rapid, efficient, and environmentally friendly alternative to traditional methods (Mandala & Nayaka, 2023). By overcoming resistance and aligning with favourable policies and market trends, companies like Boxabl and Sustainer Homes are setting new benchmarks. Continued research and innovation will be key to mainstreaming this construction model globally (Ferdous et al., 2019).

2.2 Theoretical Perspective on Innovation Adoption of Prefabricated Housing

2.2.1 Understanding Market Adoption of Prefabricated Housing

Market adoption refers to the extent to which new products or innovations are accepted by consumers or organizations (Bentsen & Pedersen, 2021). In the Netherlands, the adoption of prefabricated housing is driven by strong environmental policies and the urgent need for fast, efficient housing solutions (Herrera & Cardenas-Ramirez, 2023). Government support for eco-friendly building practices makes prefabrication a strategic fit (Shi et al., 2022). These homes reduce energy use and waste, resulting in lower environmental impact (Wij, 2023).

Dutch consumers are increasingly drawn to sustainable, quickly constructed homes, influenced by high housing demand and growing awareness of sustainability (Ebrahimighrarehbaghi et al., 2021). This trend benefits companies like Boxabl, Sustainer Homes, Prefab Homes Nederland, Livingstone, and Jan Snel, which are enhancing the quality, sustainability, and affordability of their offerings. They utilise advanced technologies in manufacturing and design to enhance efficiency and customisation.

Prefabricated homes are also cost-effective, as they require less labour and construction time (Agung et al., 2017; Phatak et al., 2011; Selvan & Jagannathan, 2015). This positions them as a competitive alternative to traditional methods that are typically slower and more expensive.

Nonetheless, challenges persist, including the transportation of large modules and public misconceptions about long-term durability. However, with ongoing improvements and robust regulatory and market support, the Netherlands is well-positioned to lead in the adoption of prefabricated housing (Oorschot et al., 2016, 2019).

2.2.2 Technology Dominance Framework to Prefabricated Housing

The diffusion of prefabricated housing in the Netherlands represents more than the introduction of a new construction method; it signals a paradigm shift in how buildings are designed, produced, procured, and regulated. This complexity makes the adoption process particularly sensitive to uncertainty, fragmentation, and misalignment between technological potential and institutional readiness. While many existing innovation theories categorise uncertainty into types such as technical, market, and institutional, Suarez (2004) offers a more dynamic and phase-based framework that emphasises how technologies compete and potentially achieve dominance over time. His model divides the technology adoption process into five sequential phases: R&D Build-Up, Technical Feasibility, Market Creation, Decisive Battle, and Post-Dominance, each governed by shifting weights of firm-level and environmental factors. Applying this process-oriented lens to prefabricated housing in the Netherlands allows us to explore not only why adoption has been uneven but also how certain actors have been better positioned than others to navigate each phase and overcome embedded uncertainties.

Phase I: R&D Build-Up – Anchored in Credibility and Appropriability

In the first phase of Suarez's framework, technology is in its infancy, and actors engage in exploratory research and development (R&D) activities. Credibility, complementary assets, and the ability to attract technical talent are critical. In the Netherlands, this phase was shaped by early efforts from forward-thinking architecture firms, technical universities such as TU Delft, and municipal innovation platforms like Amsterdam Institute for Advanced Metropolitan Solutions (AMS Institute). These institutions, often in partnership with larger developers (e.g., Heijmans or Van Wijnen), began experimenting with modular housing techniques as early as the 2010s, driven by sustainability goals and the need for urban densification.

The importance of complementary assets in this phase cannot be overstated. Developers with in-house engineering teams, BIM expertise, and access to pilot funding were better able to attract partners and talent. For instance, Van Wijnen's Fijn Wonen platform consolidated in-house design, manufacturing, and logistics capabilities, giving it a significant first-mover advantage. Meanwhile, minor housing associations and regional contractors, lacking these capabilities, were less able to engage in R&D despite recognising housing shortages. In terms of appropriability, the lack of industry-wide standards and unclear intellectual property protection for modular construction processes disincentivised smaller players from investing heavily in R&D, fearing that any innovation would be difficult to protect or scale.

Phase II: Technical Feasibility – Performance Validation and Regulatory Interference

Once working prototypes are developed, Suarez argues that technological superiority becomes a significant factor in the decision-making process. In the Dutch context, pilot projects in cities such as Almere's

“Houtwijken” and Amsterdam’s “Startblok Riekerhaven” have demonstrated that modular and prefabricated housing can meet or even exceed traditional building standards. Performance metrics in these pilots include faster build times (often 30–50% reduction), high energy efficiency (nearly zero-energy buildings, or NZEB), and improved indoor climate control.

Despite growing confidence in technical performance, regulatory frameworks have not evolved at the same pace. Suarez highlights the role of regulatory and institutional intervention as a potential determinant or barrier during this phase. In the Netherlands, building codes still primarily reference traditional construction methods, and there is no clear or harmonised pathway for certifying factory-produced housing components across municipalities. For example, a prefab project that complies in Amsterdam may encounter resistance in The Hague due to different interpretations of structural or fire safety codes. This kind of institutional inertia creates friction even when the technical case is strong, preventing feasible solutions from scaling uniformly.

Phase III: Market Creation – Strategic Manoeuvring and Perception Management

According to Suarez, the third phase marks the shift from technical performance to market positioning. Here, strategic manoeuvring, pricing, partnerships, marketing, and licensing become pivotal. This phase has proven particularly challenging in the Dutch housing market, especially in speculative, investor-driven segments. Developers and investors often remain unconvinced that prefabricated housing offers sufficient return on investment. They worry that these units may not retain value over time or may not attract tenants and buyers across varied socioeconomic groups.

Compounding this is the legacy perception of prefab housing as temporary, cheap, and aesthetically inflexible, a stigma rooted in post-war emergency housing or temporary student units. Very few firms have actively tried to reshape this narrative through public-facing campaigns. A rare exception is The Urban Modules project by DUS Architects in Amsterdam, which combined 3D printing and modularity to rebrand prefab as a customizable, eco-conscious solution. However, isolated cases are insufficient to change broad market perceptions.

Suarez emphasises that in this phase, early market creation is not only about selling units, but it is about building coalitions, forming consortia, and coordinating with municipalities, end-users, and suppliers. Strategic alliances, such as those between construction firms and technical universities, or between municipalities and prefabricated startup companies, can reduce perceived risk by pooling resources and spreading reputational credibility. The lack of such partnerships among smaller or mid-tier developers in the Netherlands partially explains their slower entry into the prefab market.

Phase IV: Decisive Battle – Installed Base and Network Effects

As front-runners emerge, Suarez’s fourth phase is characterised by increasing returns to adoption, primarily through installed base effects and network externalities. However, in the case of prefabricated housing in the Netherlands, this phase is still incomplete. A dominant system of modular components, logistics providers, or digital platforms has yet to emerge. This creates coordination failure: manufacturers do not scale because demand is uncertain, and developers are hesitant because manufacturing scale has not yet reduced costs.

In sectors with more substantial network effects (e.g., digital platforms), such self-reinforcing cycles lead to lock-in. In housing, these effects are weaker and more fragmented due to physical, geographic, and institutional complexity. For example, even when a firm like Van Wijnen achieves local success, other regions may not adopt similar systems due to local zoning rules, procurement biases, or supply chain differences. Without a nationally recognised certification system for prefab components, akin to CE marking in Europe for other products, interoperability remains low, and economies of scale are difficult to achieve.

This phase also sees a shift in buyer demographics. As Suarez notes, the “early adopter” segment gives way to more conservative, risk-averse market participants, such as banks, pension-backed developers, and regional housing corporations. These actors prefer proven technologies backed by established players, which reinforces the advantage of large firms with complementary assets and strong reputations. For smaller actors, even modest uncertainty about maintenance costs, long-term durability, or resale pricing can be enough to halt exploration altogether.

Phase V: Post-Dominance – Standardisation and Internal Process Innovation

In the final phase of Suarez's model, one technology achieves dominance, and the competitive focus shifts from gaining market share to optimising within the dominant design. While the Dutch prefab housing sector has not yet reached this stage, emerging signals are worth noting. Firms like Heijmans and Jan Snel are investing in proprietary modular platforms and factory-based delivery models with integrated design, build, and operate capacities. These firms are not just delivering houses but also building platform ecosystems where suppliers, municipalities, and tenants engage with a shared technical and operational architecture. If such platforms scale successfully and become widely adopted, we may see a shift into process innovation and cost competition, rather than architectural or technological experimentation.

Unequal Actor Capacities and Policy Implications

One of the most important contributions of Suarez's framework is the recognition that not all actors are equally positioned to navigate uncertainty across the technology adoption lifecycle. In the Dutch housing sector, large national developers, particularly those with integrated design and manufacturing units, can absorb risks, influence regulation, and influence market narratives. These firms are also able to engage in multi-site, multi-year scaling, allowing them to build up the installed base and standardise procurement and delivery models.

By contrast, municipal housing corporations, small cooperatives, and regional builders often lack the financial resilience, technical expertise, and political access needed to participate meaningfully. For these actors, even minor institutional or market uncertainties become insurmountable barriers. Their absence in early adoption phases risks producing a dual-track diffusion: one of progress led by a few dominant players, and one of exclusion for others, deepening housing inequality and undermining the social goals of modular innovation.

Toward Adaptive Diffusion Strategies

Ultimately, Suarez's (2004) framework encourages us to view prefabricated housing not as a static technology with a binary adoption outcome, but as a trajectory embedded in socio-technical and institutional dynamics. Success requires not only technical viability and regulatory approval but also strategic adaptability across multiple stages. Firms that recognise which levers to pull at each phase, whether building alliances, influencing regulation, launching public pilots, or accumulating installed base, are better poised to lead the shift toward modularity.

For policymakers, Suarez's insights imply that generic subsidies or innovation grants are insufficient. What is needed is targeted support across all five phases: funding for early R&D consortia, regulatory harmonisation for prototype approvals, public procurement mandates to create early markets, coordination platforms to grow installed bases, and digital standardisation tools to scale modular ecosystems. Without these deliberate interventions, prefabricated housing risks becoming another promising innovation stymied by structural inertia and uneven distribution of capabilities.

2.2.3 Individual-Level and Behavioral Theories

Rogers' Diffusion of Innovations (2003) provides a valuable lens for understanding how new technologies and practices, such as prefabricated housing, are adopted (or resisted) across a population. The theory identifies five core attributes that influence the rate and extent of innovation adoption: relative advantage, compatibility, complexity, trialability, and observability. These dimensions do not operate in isolation; instead, they interact dynamically within different stakeholder environments, shaping the perceived value and feasibility of adopting a given innovation.

In the context of prefabricated or modular housing, the perceived relative advantage plays a central role. If local governments, housing developers, or end consumers view prefab solutions as offering significant benefits, such as lower energy bills due to improved insulation, shorter construction times, reduced labour costs, or enhanced quality control, the innovation is more likely to gain traction. For example, in a country like the Netherlands, where sustainability and energy performance are high priorities, prefabrication's potential to reduce operational emissions may be viewed as a strategic asset.

However, even when an innovation offers clear benefits, adoption can be hampered by perceptions of complexity and incompatibility. In the Dutch housing context, complexity may arise from challenges in coordinating between design teams, suppliers, and logistics partners, particularly when modular components need to be integrated into diverse urban settings. Incompatibility may arise when prefabricated systems conflict with traditional building codes, zoning laws, or established architectural preferences. For instance, Dutch municipalities often have stringent spatial planning guidelines and aesthetic expectations that may not align easily with modular design templates. These barriers can discourage risk-averse actors from adopting the innovation.

This is where the concepts of trialability and observability become especially crucial. In the construction sector, known for its conservative, precedent-driven decision-making, trialability allows stakeholders to experiment with new approaches on a limited scale before fully committing. Small-scale pilot projects, such as a few units of modular housing in a new residential development, provide opportunities to evaluate performance, costs, and social acceptance. For instance, if a municipality like Almere initiates a pilot involving modular homes in a mixed-income neighbourhood, it serves not only as a testing ground but also as a visible demonstration model.

Such examples enhance the observability of prefabrication's benefits. When other municipalities, developers, or housing cooperatives observe successful implementations, especially those that have overcome regulatory hurdles or achieved high resident satisfaction, they are more likely to consider adopting the approach themselves. This visibility reduces the perceived risk, enhances trust in the innovation, and facilitates knowledge transfer across institutional boundaries. In this sense, pilot projects act as both learning platforms and marketing tools.

2.2.4 Technological Ecosystem and Adoption Readiness

Ortt et al. (2014) argue that innovations do not succeed solely on the basis of technical merit; instead, they depend on a supportive socio-technical ecosystem. In the context of prefabricated housing, this means that even if the technology is mature and the benefits are clear, adoption may stall without enabling conditions in the surrounding environment. For example, transporting large building modules across the Netherlands, a country with highly urbanized yet regionally distinct infrastructure, requires not only well-maintained roads but also logistical coordination, permissive traffic regulations, and available storage space near construction sites. Similarly, the availability of skilled labour who understand off-site manufacturing, just-in-time delivery, and on-site assembly is crucial. The absence of such workforce readiness, whether due to limited vocational training, a lack of industry exposure, or resistance among traditional contractors, can render prefabrication impractical, even if it is technically viable.

Moreover, the institutional and policy environment plays a pivotal role. Misalignments between the capabilities of municipalities and the requirements of modular construction frequently create friction. For instance, a technically sound modular solution may fail to scale if municipal planning departments are under-resourced or if procurement frameworks are rigid, favouring well-established traditional contractors over innovative suppliers. Ortt et al. describe this as the "scaling gap", a phase where promising innovations are validated in controlled pilots or niche markets but cannot cross over into the mainstream system due to systemic bottlenecks. In the Dutch case, this is evident in how modular housing projects often succeed in small experimental neighbourhoods or student housing, but rarely gain traction in large-scale public housing programs.

To further dissect the multi-dimensional challenges facing adoption, the framework developed by Van de Kaa et al. (2010) is particularly instructive. Their typology organizes the contextual factors into technical, economic, institutional, and actor-related dimensions. This structure enables a more granular analysis of how various forces converge or conflict in shaping the trajectory of prefabricated housing in the Netherlands.

- From a technical perspective, concerns may arise regarding the long-term durability of prefabricated materials, their resistance to Dutch climate conditions (such as moisture and wind), or the flexibility of modular designs in meeting diverse architectural norms.
- Economic factors include fluctuating costs of prefabricated components, higher upfront investments in manufacturing facilities, and scepticism from investors regarding the return on investment, especially in comparison to traditional construction methods that have more predictable risk profiles.
- On the institutional front, provincial and municipal zoning regulations, as well as building codes, differ widely across the Netherlands. Even with national-level endorsement for industrialised construction, local planning departments often retain discretion over approvals, resulting in institutional fragmentation that can delay or hinder modular housing proposals.
- Finally, actor-related factors such as stakeholder trust, risk aversion, and entrenched relationships between municipalities and traditional contractors shape decision-making. Developers and public officials may be reluctant to engage with modular suppliers without clear benchmarks or prior working relationships.

Applying this typology to the Dutch housing context reveals how intersecting pressures across these four dimensions create inertia in the system. Even when a municipality or developer is theoretically open to prefabrication, they must simultaneously navigate technical validation, economic justifications, institutional compliance, and stakeholder dynamics. This helps explain the uneven landscape of modular housing adoption across Dutch regions, where some areas, such as Almere or Groningen, embrace experimentation, while others remain entrenched in conventional practices.

By integrating Van de Kaa's typology with stakeholder prioritization methods, such as the Best-Worst Method (BWM), this study identifies not only which factors matter but also how they are perceived and weighed differently by various actors. For instance, a municipality may rank institutional flexibility as its most critical factor, while developers may prioritise technical standardisation and risk-sharing models. This dual-layered approach enables the study to move beyond binary adoption metrics, providing a nuanced understanding of how competing priorities and systemic frictions influence real-world decision-making regarding prefab housing.

2.2.5 Innovation Dynamics and Disruption

Pan et al. (2018) frame prefabrication not merely as a technological improvement, but as a disruptive innovation, one that challenges the foundational assumptions and operating logics of the construction industry. Unlike incremental innovations that improve existing practices, disruptive innovations introduce entirely new ways of organising production, shifting value chains, timelines, and relationships between stakeholders. In the case of prefabricated housing, this disruption is particularly profound, as it reshapes how buildings are conceived (design), financed (through funding models), sourced (via procurement), and delivered (through assembly and logistics).

For instance, traditional contractors, whose expertise lies in on-site project management and labour coordination, must now develop new competencies in off-site manufacturing, supply chain orchestration, and digital sequencing, the locus of control shifts upstream, requiring careful synchronisation with factory production schedules and early-stage procurement decisions. Architects, similarly, are no longer free to iterate on designs late in the process. Instead, they must co-design with suppliers and manufacturers from the outset, working within the material and dimensional constraints of modular systems. This calls for a more integrated and collaborative workflow, often facilitated through Building Information Modelling (BIM) and other digital tools.

However, as Goulding et al. (2010) highlight, this transformation does not occur in a vacuum, their research points to deep-rooted structural and cultural barriers that inhibit systemic change. The construction industry has historically been fragmented, risk-averse, and dominated by project-based thinking. Goulding et al.'s Strategic Implementation Framework outlines the multi-dimensional nature of these barriers, which include:

- Cultural resistance to change, particularly among firms accustomed to traditional linear processes and adversarial contracting norms;
- Limited digital capability, especially concerning BIM proficiency, which is essential for integrating design, manufacturing, and logistics;
- Fragmented supply chains, where low levels of vertical integration make it difficult to implement and scale modular systems across projects.

In the Dutch context, these barriers are particularly relevant. The construction sector is primarily composed of small- and medium-sized enterprises (SMEs), which often operate on thin margins and lack the financial and human capital to invest in new technologies or retrain their workforce. Retooling for prefabrication, whether through purchasing new machinery, adopting digital platforms, or forming new supplier relationships, requires a level of investment and strategic foresight that many SMEs are unable or unwilling to undertake independently.

As a result, despite growing policy interest in industrialised construction, the pace of transformation in the Dutch housing sector remains incremental and uneven. To overcome this inertia, Goulding et al. argue for systemic interventions that go beyond firm-level change. These include:

- Cross-sectoral learning platforms, where actors from different segments of the value chain, designers, contractors, suppliers, and policymakers, can experiment with modular methods and share knowledge;
- Living labs or test beds, where innovative construction methods are trialled in real-life projects under controlled conditions;
- Policy nudges and incentives, such as procurement reforms or tax credits, which reduce the perceived risk of innovation and reward early adopters.

In the Netherlands, some public-private partnerships and regional innovation hubs have begun to emerge to support such experimentation, for instance, initiatives that bring together municipalities, technical universities, and housing corporations to develop replicable modular housing models. However, these efforts remain disconnected and project-specific unless accompanied by national-level coordination and standardisation efforts. Without coherent governance structures and long-term investment in industry transformation, prefabrication risks remaining trapped in pilot projects, unable to disrupt the mainstream housing production system.

By combining Pan's notion of disruptive innovation with Goulding's strategic lens on industry inertia, we can gain a deeper understanding of the structural lock-ins that constrain the potential of prefabrication in the Dutch housing sector. This dual perspective emphasises that successful adoption requires not just technical feasibility or economic logic, but deep institutional and cultural transformation, enabled by collective action and strategic alignment across sectors.

2.2.6 Social and Institutional Influence Theories

Abrahamson and Rosenkopf (1993), along with Bronnenberg and Mela (2004), offer valuable insights into how social influence and network effects shape the diffusion of innovations, particularly in industries that are risk-averse and cost-sensitive. In such environments, decision-makers often rely not only on technical or financial evaluations but also on social cues and peer behavior. This is especially true in the construction sector, where projects involve long timelines, high sunk costs, and fragmented stakeholder groups. Firms, municipalities, and investors typically wait for others to act first, observing outcomes before committing to a new method.

This phenomenon is evident in the adoption of prefabricated housing in the Netherlands. For example, when a major city like Rotterdam successfully completes a large-scale modular social housing project, demonstrating reduced build times, high energy efficiency, or strong tenant satisfaction, other municipalities take notice. Smaller or more risk-averse cities, such as those in peripheral regions, may follow suit not because of direct incentives, but due to the reassurance gained from observing a peer's success. This "informational cascade" or bandwagon effect can help accelerate innovation diffusion, provided early adopters deliver visible, positive outcomes.

However, these network effects are not just social, they are also material and institutional, as highlighted by Actor-Network Theory (ANT), pioneered by Callon (1986). ANT argues that innovations succeed not because of their inherent superiority, but because a network of heterogeneous actors, both human and non-human, becomes aligned around the new practice. These actors include people (e.g., planners, architects, developers), tools (e.g., BIM software, logistics platforms), institutions (e.g., building codes, zoning authorities, insurance underwriters), and even physical objects (e.g., cranes, transport containers, prefab modules).

In this light, the adoption of a prefab housing system depends on much more than just proving technical feasibility. The system must be translated and accepted across an entire network:

- Municipalities must approve new modular designs within existing urban plans.
- Insurers and lenders must recognize prefabricated buildings as stable assets with manageable risks.
- Contractors and logistics firms must be willing and able to coordinate just-in-time deliveries, which may differ significantly from their established routines.
- Software platforms such as BIM must be interoperable across different stakeholder organizations and levels of expertise.
- End-users, including residents or housing cooperatives, must see value in modular designs and accept possible trade-offs in layout or aesthetic flexibility.

If even one of these nodes in the network fails to align, the entire system becomes fragile. For instance, if insurers remain skeptical of non-traditional construction methods, developers may be unable to secure financing, even if municipal approval has been granted. Or if logistics firms are not equipped to handle off-site manufactured components, delays or damages may occur, undermining confidence in the method. This fragility and interdependence help explain why innovation diffusion in construction is often uneven, stalled, or reversed, despite strong technical arguments or policy enthusiasm.

ANT thus complements the social diffusion perspective by revealing the hidden scaffolding of innovation adoption: it is not enough for people to be convinced; the infrastructure of trust, coordination, and shared standards must also be built. This is particularly relevant in the Dutch context, where the construction ecosystem is highly decentralized, with decision-making power spread across national, provincial, and municipal levels. Even if the Ministry of Housing supports industrialized building, municipalities retain significant autonomy, and alignment must still be achieved project by project.

Moreover, the presence (or absence) of "obligatory passage points", as described by Callon, becomes critical. These are nodes in the network that all actors must go through for a project to succeed, such as standardized regulatory frameworks or digital coordination platforms. In the absence of such stabilizing mechanisms, prefab housing remains vulnerable to local misalignments, preventing it from achieving widespread institutionalization.

In sum, combining social diffusion theories with Actor-Network Theory gives us a comprehensive view of innovation dynamics in construction. While social proof and peer emulation can jumpstart interest in prefab housing, deep, system-wide alignment is necessary to sustain it. The diffusion of modular housing is not simply about scaling a product, it is about constructing a durable network of belief, practice, and infrastructure that can hold the innovation together across diverse and often conflicting environments.

2.2.7 The Role of Perceived Innovation Characteristics

The theoretical foundation for understanding innovation adoption was laid by Everett Rogers (2003), who proposed five key attributes that shape an innovation's adoption rate. This concept is then implemented with the context of prefabricated housing as follows:

- **Relative Advantage**: The degree to which prefabricated housing is seen as better than conventional methods, for example, faster delivery, less on-site disruption, or improved sustainability.
- **Compatibility**: How well prefabrication aligns with existing values, workflows, or regulatory conditions. For instance, a municipality with a circular construction agenda may find prefab highly compatible with its goals.
- **Complexity**: Whether prefab is perceived as difficult to understand or implement. Misconceptions about design limitations or logistical hurdles may increase perceived complexity.
- **Trialability**: The ability to experiment on a small scale, such as through a pilot project. This lowers perceived risk and helps build confidence among stakeholders.
- **Observability**: The visibility of successful prefab applications. Seeing other actors complete projects successfully can influence hesitant adopters.

In the case of prefabricated housing, these five characteristics are highly interdependent. For example, a prefab system that demonstrates relative advantage through shorter construction times may still face low adoption if it is perceived as complex or incompatible with local building codes. Hence, understanding how different actors **perceive these attributes** is essential for mapping adoption dynamics.

2.2.8 Network Effects and the Bandwagon Dynamic

Market adoption does not occur in isolation (Bronnenberg & Mela, 2004). The value of specific innovations increases as **more market actors begin to adopt them**, a phenomenon known as **network effects** (Zwitter, n.d.). These are particularly relevant in contexts where supply chains, shared technologies, or complementary services are involved.

- **Direct network effects** may be less prominent in prefabricated housing, but the existence of shared knowledge networks or regional prefab clusters can increase collective value (Liu et al., 2024).
- **Indirect network effects** are more common. For instance, as more companies adopt prefab methods, suppliers, logistics firms, and labour markets adjust accordingly, making future adoption easier and more attractive for others (Blinken, 2003).

Once a critical mass of adopters is reached, **a bandwagon effect** may emerge, where stakeholders feel social or competitive pressure to adopt because others have done so (Abrahamson & Rosenkopf, 1993; Baum et al., 2024). In the Netherlands, this is evident in local governments that adopt prefabricated solutions after witnessing the successful implementation by peer municipalities. This effect can significantly accelerate market diffusion, especially when actors are risk-averse and prefer to “wait and see” before making a decision (Oren & Schwartz, 1988).

2.3 Stakeholder Strategies

In the Netherlands, the adoption of prefabricated housing is shaped by a dynamic interplay of actors (Scheller et al., 2020). The national government, especially the Ministry of the Interior and Kingdom Relations and the Ministry of Housing and Spatial Planning, supports prefabrication through regulations promoting energy-efficient and low-waste construction (Icibaci, 2019; Dakwale et al., 2011). Industry leaders like Jan Snel showcase the practical value of prefabrication by delivering high-quality, sustainable housing quickly, setting benchmarks that encourage sector-wide uptake (Bijman, 2019; Wallbaum et al., 2012; Li et al., 2019, 2020; Lu et al., 2018).

Academic institutions, particularly Delft University of Technology’s Faculty of Architecture and Built Environment, contribute by researching innovative building materials and methods that enhance adaptability and sustainability (Kamp, 2006; Chen et al., 2010). Meanwhile, growing consumer demand for affordable, sustainable, and fast housing continues to shape both market trends and policy responses (Ebrahimigharehbaghi et al., 2022).

Together, government, industry, academia, and consumers form a collaborative ecosystem that supports the growth of prefabricated housing (Chan et al., 2017), addressing urgent housing needs while laying the foundation for long-term sustainable construction in the Netherlands (Steinhardt et al., 2013; McCormick et al., 2013; de Wilde, 2019).

3) Literature Review & Research Gap

3.1 Key Papers Selection

In academic study, particularly in specialized areas like prefabricated housing, conducting a thorough literature review is crucial to understand the existing research landscape and pinpoint areas that may need further investigation. This process begins by identifying a few key topics that the research will cover, using specific keywords to ensure all relevant areas are included. For this thesis, the selected keywords to frame the investigation into modular construction are:

a) Modular Construction Adoption
b) Technological Competition in Housing
c) Network Effects in Building Technologies
d) Sustainability in Modular Housing
e) Prefabricated Construction Standards

After identifying the keywords, the literature review is started with using PRISMA guidelines with the processes as explained below:

a) Identification: This initial stage involves executing keyword searches in three major academic databases: Scopus, Web of Science, and ScienceDirect. Five separate search strings are used, each focusing on a different aspect of prefabricated construction technologies. The total number of results obtained from each database for each search string is recorded.

   The search string for the papers are as follows:

   - Modular Construction Adoption

     ("Modular Construction" OR "Prefabricated Construction" OR "Modular Housing") AND ("Adoption" OR "Market Adoption") AND "Netherlands"

   - Technological Competition in Housing

     ("Technological Competition" OR "Innovation Competition") AND ("Housing" OR "Residential Construction" OR "Building Industry") AND "Netherlands"

   - Network Effects in Building Technologies

     ("Network Effects" OR "Technology Diffusion") AND ("Building Technologies" OR "Construction Technologies" OR "Smart Buildings") AND "Netherlands"

   - Sustainability in Modular Housing

     ("Sustainability" OR "Eco-friendly" OR "Green Building") AND ("Modular Housing" OR "Prefabricated Housing") AND "Netherlands"

   - Prefabricated Construction Standards

     ("Prefabricated Construction" OR "Modular Construction") AND ("Standards" OR "Regulations" OR "Building Codes") AND "Netherlands".

However, **web of science** does not enable the paper identifications through those search string. Thus, **the paper identifications in web of science are done using the keywords.**

One thing to emphasize, although only the first search string explicitly includes the term “adoption”, the inclusion of the other four search strings was intentional and necessary to support a more comprehensive literature review. Adoption of modular or prefabricated housing is not a standalone issue. It is shaped by a wide range of influencing factors such as technological readiness, regulatory clarity, stakeholder networks, and sustainability concerns. Many of these factors may not be labeled directly under “adoption”, but they play a critical role in enabling or hindering it in practice.

Relying solely on the adoption-related search string would risk overlooking valuable literature that discusses important enablers or barriers using different terminology. For example, studies that examine technological competition, innovation systems, or the lack of standardization in building codes may not mention “adoption” specifically, but they provide essential insights into why adoption may be delayed or unsuccessful. Including broader terms allows for the identification of indirect yet relevant factors that shape the adoption landscape.

Moreover, the broader set of search strings helps reduce keyword bias and ensures a wider thematic coverage. Studies may use terms such as “diffusion,” “implementation,” or “market uptake” instead of “adoption,” and a narrow keyword focus might exclude such contributions. Including multiple search strings increases the chance of capturing a more diverse set of perspectives and findings from the literature.

This approach also aligns with the overall research design, which combines literature analysis with expert interviews. A wider literature base enables a stronger comparison between what is documented in academic studies and what is emphasized by experts from government, industry, and academia. It supports triangulation and provides a solid foundation for identifying both well-established and underexplored adoption factors.

In a nutshell, the decision to include multiple search strings, beyond the one directly mentioning “adoption” was made to ensure the literature review captured a broad, meaningful set of factors influencing modular construction uptake in the Netherlands. This approach supports a richer analysis and complements the qualitative data gathered through expert interviews.

b) Screening: The records retrieved are then limited to those published within a specified timeframe (2015-2024) to ensure the relevance and recency of the research. Further screening involves reading the title, abstract, and keywords of each study to determine if they meet the specific criteria for further analysis, significantly reducing the number of articles.

c) Eligibility: This step involves a more detailed review, where the introduction, results, and conclusion sections of the remaining studies are examined to assess their relevance and contribution to the research questions posed in the thesis. This stage further narrows down the number of studies.

d) Inclusion: Finally, the articles that fulfil all the specified criteria and are deemed to contribute meaningfully to the thesis are included for detailed analysis and discussion in the literature review section of the thesis.

The whole process of literature review can be seen in Figure 1.

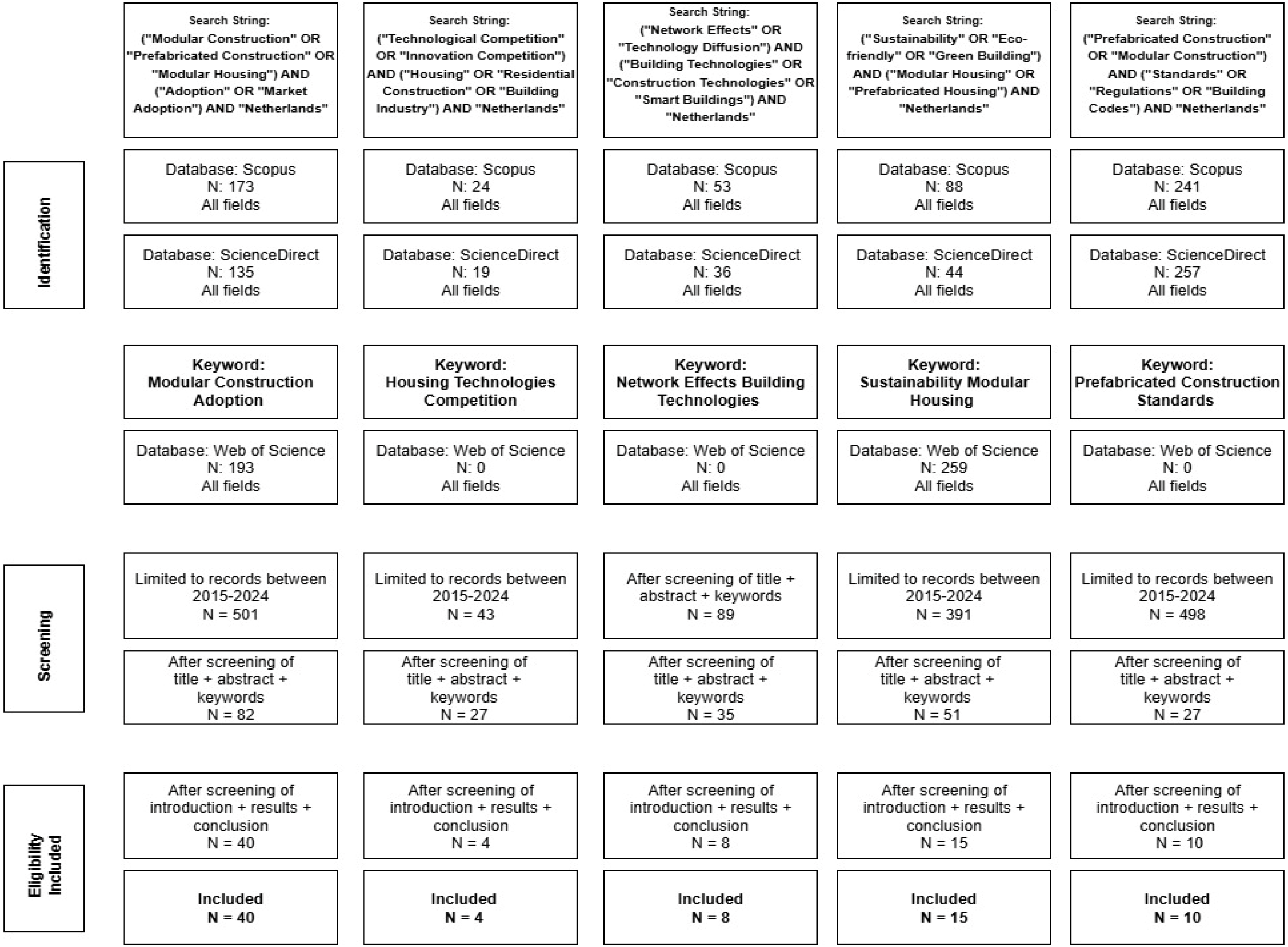

Figure 1 Key Papers Selection Process

3.2 Research Gap

Amid huge issues such as housing shortage that is happening along with the higher climate agenda, prefabricated housing has started to be seen as one promising solution, due to its advantages such as speed of construction, better quality control, minimized waste, and more efficient energy use (van Oorschot et al., 2021; Aruta et al., 2023; Olawumi et al., 2022). Those are the basic benefits. Now, the benefits increase with the emergence of innovations, such as digital design, automation, and modular production (Aziz et al., 2024; Olawumi et al., 2022). However, despite those benefits, market adoption of prefabricated housing in the Netherlands remains stagnant, especially when compared to its full technical potential.

Several studies worldwide have examined factors influencing the adoption of prefabricated housing from diverse perspectives. For instance, van Oorschot et al. (2021) and Navaratnam et al. (2022) emphasised the importance of aligned policy frameworks and regulatory clarity, while Widanage and Kim (2024) and Wu et al. (2024) emphasised the need for systemic, multi-actor collaboration and strategic stakeholder alignment. Meanwhile, Aruta et al. (2023), Pittau et al. (2017), and Graham et al. (2024) highlight the roles of consumer trust, affordability, spatial adaptability, and lifecycle value perception in shaping public acceptance. From a technical perspective, Olawumi et al. (2022), Aziz et al. (2024), and Thai et al. (2020) identify digital integration, automation readiness, and logistics coordination as essential enablers, while also acknowledging challenges to supply chain reliability. Papadonikolaki (2018) and Alnaser et al. (2024) further highlight the weak standardization of platforms and the oversight of social sustainability dimensions, such as worker safety, skills, and local acceptance, as barriers. According to the literature mentioned, it is evident that the adoption of prefabricated housing necessitates a multidimensional and interdisciplinary approach, as numerous factors must be taken into consideration. However, despite these insights, two key research gaps remain. First, there is a lack of structured prioritization across these factors, and second, an over-reliance on single-actor perspectives. Those will limit the ability to formulate coordinated and targeted strategies.

3.2.1 Lack of Clear Prioritization and the Need for a More Robust Method

First, it is acknowledged that the factors influencing the market adoption of prefabricated buildings have been identified in the literature across various regions. Factors such as construction cost, material availability, design flexibility, environmental impacts, regulatory conditions, and stakeholder trust are commonly found in the literature. However, studies that focus on prioritizing them and exploring how each factor interacts with the others across different decision-making levels are still scarce. This brings consequences. For instance, practitioners and policymakers often lack clear guidance on where to focus their attention and resources to accelerate adoption in multi-actor contexts.

According to methods, tools such as Social Network Analysis (SNA) and the Importance-Relative Index (IRI) have been applied to address this need, but each comes with significant limitations. For instance, Wu et al. (2024) used SNA to analyze 17 interrelated factors, including developer strategies, consumer trust, and government incentives, and identified those with the highest network centrality. Those are insightful, especially if there is an urgency to understand the systemic influence within each factor. However, SNA does not rank the factors, and it also overlooks the diverse preferences across stakeholder groups. A similar condition also occurs if IRI is used. Using IRI, Wu et al. (2019) aggregate expert perceptions of importance; however, IRI did not enable an internal consistency check, which subsequently undermined its reliability in complex and value-driven settings.

The importance of ranking the factor is vital for the context of the Netherlands, due to its decentralized governance model and strong normative considerations, such as preserving urban form, meeting climate ambitions, and ensuring citizen participation (de Jong et al., 2024; Mata et al., 2021). The fragmented institutional landscape, comprising municipalities, housing corporations, research institutions, and private developers, complicates the search for shared priorities if the method used for prioritizing the factors is not employed.

Some studies illustrated this complexity. For instance, Ferdous et al. (2019) identify how off-site modular construction must navigate logistical barriers, such as transportation limits, technical integration issues, and resistance from conventional contractors, all of which may be weighted differently by various actors, including government and academia. In another case, Shufrin et al. (2023) highlight the growing importance of composite materials, automation, and hybrid structures in green construction, while acknowledging that stakeholder priorities are not always aligned on issues such as demolition waste, life-cycle emissions, or innovative system integration.

From an institutional perspective, Enker and Morrison (2017) demonstrate that even when energy performance policies are adopted, their disruptive impact on traditional building codes and actor behaviours is uneven across jurisdictions. A similar point is also addressed by Ehrenhard et al. (2014), who note that Smart Home technologies, although highly relevant to ageing-in-place prefabricated housing, often fail in implementation due to fragmented value networks and misaligned expectations among firms, users, and regulators.

Even the existing studies that focus on enabling strategies highlight the multiplicity of relevant factors. For instance, Gao et al. (2022) demonstrate that the successful deployment of prefabricated hospitals, such as Huoshenshan, during COVID-19 was driven by optimised supply chains and BIM-assisted assembly. These factors may be perceived as unimportant or peripheral, depending on one's perspective. Additionally, de Jong et al. (2024) noted that when digital or modular housing solutions are primarily presented as technical or efficiency-driven innovations, they can divert attention from deeper issues, such as inequality, exclusion, and affordability. By framing housing challenges as neutral problems to be solved with technology, these approaches may overlook who benefits, who is left out, and how power and profit are distributed. In some cases, such solutions risk becoming tools for financial gain rather than addressing structural housing needs. Therefore, de Jong et al. (2024) emphasise the importance of critically examining the broader social and political implications of such innovations, rather than accepting them as purely objective or beneficial.

Given these layered insights and value conflicts, the Best-Worst Method (BWM), introduced by Rezaei (2015), emerges as a particularly fitting tool for stakeholder-based prioritisation. Unlike IRI or SNA, BWM enables the structured comparison of factors about the most and least important ones, thereby reducing the number of required comparisons while incorporating a consistency ratio to verify logical coherence. This feature is especially valuable in the Dutch context, where participant time is limited and consensus-building is often more important than statistical generalizability.

Moreover, BWM has been shown to perform well in settings with small, heterogeneous expert groups, precisely the kind of setting that characterises multi-stakeholder housing innovation platforms in the Netherlands (Shufrin et al., 2023; Ferdous et al., 2019). Crucially, BWM can accommodate context-specific segmentation, which allows researchers to compare how developers, academics, and municipal planners might prioritise factors such as cost, urban aesthetics, or energy performance differently.

In brief, while methods such as SNA and IRI have helped us understand the factors behind the adoption of prefabricated housing, they do not provide a clear or consistent way to rank these factors based on different stakeholder views. Amidst those limitations, the Best-Worst Method (BWM) emerges as a structured and reliable approach that is particularly well-suited for complex settings, such as the Dutch housing sector, where numerous actors are involved and values often diverge.

3.2.2 Over-Reliance on Single Actor Perspectives

The second research gap is the limited existing literatures that capture multi-actor perspectives in the adoption of prefabricated housing. Most studies are based on single-actor perspectives, particularly those of the government (Navaratnam et al., 2022), developers (Wu et al., 2024), or consumers (Aruta et al., 2023), which treat them individually and as isolated entities. However, the adoption of technology nationwide requires systemic alignment across governmental agencies, industry players, research institutions, and end-users (Wuni & Shen, 2020; Halman et al., 2008).

For example, in one case, Wu et al. (2024) used social network analysis to map 17 influencing factors from the developer's perspective, such as strategic goals, industry chain completeness, and investment risks, without reflecting how other actors perceive or prioritise these elements. While such studies are valuable, they often ignore how other stakeholders such as municipalities or end-users may interpret the same factors differently: what developers see as financial risk, consumers may view as compromised quality, and policymakers might interpret as long-term affordability or climate alignment (Wang et al., 2023; Steinhardt et al., 2013).

Recent literature increasingly emphasises the fragmented nature of housing innovation systems. Van Oorschot et al. (2021) highlighted that policy alignment alone is insufficient without improved collaboration among stakeholders. Similarly, Hofman et al. (2009) and Aziz et al. (2024) argue that supply chain structures, regulatory readiness, and design flexibility must be understood as interdependent phenomena among actors. Design for Manufacture and Assembly (DfMA) implementation, for instance, often fails not because of technological barriers, but due to mismatched expectations between clients, governments, and suppliers (Chen et al., 2024; Widanage & Kim, 2024).

Even in green modular innovations, studies show that developers may prioritise Return on Investment (RoI) and productivity, whereas municipalities stress spatial identity and social cohesion (Hoppe, 2012; Pittau et al., 2017). These misaligned priorities could act as a barrier to collaborative decision-making. Research from the UK, China, and Australia also confirms that multi-actor misalignments delay project timelines, inflate costs, and hinder the effort to create (Li et al., 2016; Arashpour et al., 2017; Manalo, 2013).

In the Dutch context, such dynamics are exacerbated by lengthy planning and decentralisation, which necessitate not only multi-level governance but also adaptive actor coordination (Halman et al., 2008; Hofman, 2010). However, very few studies attempt to map or compare factor prioritisation across different actor types empirically. This is a significant blind spot, as modular construction ecosystems rely on negotiated values rather than technical efficiency alone (Olawumi et al., 2022; Hwang et al., 2018).

To address this, this study implements the Best-Worst Method (BWM) framework, not only to rank adoption factors, but to do so based on the value perspectives of academia, industry, and government. This multi-actor-sensitive approach is necessary to reflect institutional logics, reduce actor misalignment, and offer strategic clarity for collaborative housing pathways (Rezaei, 2015; Zhang et al., 2024).

From these gaps, this thesis aims to provide a combination of research methods that integrate both qualitative and quantitative approaches, utilising a literature review, multi-industry expert interviews, and Best-Worst Method (BWM) analysis to identify factors influencing market adoption in the Netherlands. By doing so, it provides collective ranked factors that can help all sectors make more informed choices to support the future of prefabricated housing in the Netherlands.

4) Methodology

The methodology of this study is a mixture of both qualitative and quantitative. Qualitatively, this study will explore lots of literature studies, thematic analysis, and triangulation, while quantitatively, this study will focus on the Best-Worst Methods (BWM) Analysis as follows:

4.1 Extensive Literature Review

The extensive literature review is done with PRISMA guidelines as explained in the **3.1 Key Papers Selection** section. This process will focus on identifying the factors that are recognized as influential in the adoption of prefabricated housing technologies based on the existing literature. The literatures are gained together hand in hand with the identification of research gap. Which means, once the research gaps are identified, the same literatures are then used for identifying the factors.

4.2 Expert Interviews

Expert's interviews are done by interviewing ten experts from Triple Helix (Academia, Industry, and Government). The experts are chosen based on three main criteria by Marlini, 2019 as follows:

- **High Level of Competence**
  Experts are not solely those with years of experience, but rather those who have achieved a significant level of competence in their field. This involves not only acquiring knowledge but also effectively applying it to solve new problems within their area of expertise.

- **Disciplinary or Sub-disciplinary Focus**
  Expertise is typically confined to specific disciplines or sub-disciplines. This means that experts usually have deep, specialized knowledge in a narrowly defined area, although there is also room for expertise in communicating across disciplines.

- **Social Recognition and Influence**
  Expertise is described as a social concept, implying that it involves recognition by peers and society.

Table 1 Overview of experts

Expert	Background	Position	Education	Years of Experiences	Interview Participations
Expert 1	Government	Project Manager	Master of Law	30 years	First & Second Stage Interview
Expert 2	Government	Housing Policy Advisor	Master of Economic & Governance	7 years	First, Second, and Third Stage Interview
Expert 3	Academia	Professor of Climate Design & Sustainability	PhD in Climate Design	30 years	First & Second Stage Interview
Expert 4	Academia	Professor of Housing Institution & Governance	PhD in Housing & Governance	20 years	Second Stage Interview
Expert 5	Academia	Assistant Professor of Innovative and Industrial Construction	PhD in Civil & Environmental Engineering	8 years	Second Stage Interview
Expert 6	Academia	PhD in Civil Engineering	PhD in Civil Engineering	6 years	Second Stage Interview

Expert 7	Academia	PhD Researcher at Real Estate Management	PhD Researcher at Real Estate Management	5 years	Second Stage Interview
Expert 8	Academia	Professor of Complex Project	PhD in Complex Project	29 years	Additional Insights about the idea of prefabricated housing.
Expert 9	Industry	Circular Economic Advisor	Master of Science	5 years	First & Second Stage Interview
Expert 10	Industry & Academia	Researcher	Master of Science	5 years	Second & Third Stage Interview
Expert 11	Industry	Site Engineering & Standardization Officer (BIM)	Master of Science	9 years	Second & Third Stage Interview
Expert 12	Industry	Project Engineer	Master of Science	28 years	Third Stage Interview

Table 1 presents an overview of ten experts who participated in the interviews for this research. The participants are those who come from a diverse range of backgrounds, including academia, industry, and government. That is done purposefully and intentionally to ensure that the representation of Triple Helix Model, are well-executed. However, even though they have diverse background, they have one thing in common: the interest and experience in prefabricated housing.

Their professional backgrounds range from professors, PhD students, and policy advisors to project and circular economy managers. They have interest in prefabricated housing, and have been exploring the field through the angle of climate design, law, economics, and governance, with professional experience varying from 5 to 30 years. The interview process was conducted in three stages, with some experts contributing to all, and some contributing partially.

a) First Stage Interview

Once extensive literature review is done, the process of factor identification is continued through first stage of expert interview (See Appendix A). As people who have been working in the prefabricated housing fields for years, those experts must have gained lots of insights and practical experiences which make them know the factors that are recognized as influential in the adoption of prefabricated housing technologies that have not been captured in the literatures. Thus, continuing the factor identification through expert interview is very important.

As seen on Table 1, there are four experts who join the first stage interviews, such as **Expert 1, 2, 3, 4,** and **9**, with **Experts 1 & 2** are from government sector, **Expert 3 & 4** from academia, and **Expert 9** from the industry sector. Ideally, the interviews are done online through **Microsoft Teams** with the informed consents must be sent prior to the interview. However, in case there is circumstance where the experts are **not eligible or able to do online interviews**, it is still acceptable to **answer interview questions written** with the informed consent sent prior to that. For instance, **Expert 3** answer interview questions written due to health circumstances.

b) Second Stage Interview

Once the interview is done, the interview results are then be analysed for approximately 3-7 days to combine the factors from both extensive literature review and the result of interview (See Appendix B). However, the process could take much longer since the second stage interview will be done after first stage interview of Triple Helix (Academia, Industry, and Government Sector) is finished. The process of finding the right experts, asking their availability, matching to their schedule, and many things behind the screen process might take more times.

To integrate factors from both the literature review and expert interviews, a combined **open and axial coding** method was used. This two-step qualitative analysis begins with **open coding**, where relevant factors are identified and labeled. In the **axial coding** phase, similar items are grouped, redundancies removed, and categories clearly defined. This ensures a structured and transparent list of adoption factors.

After coding, a **second stage of interviews** is conducted. In the second stage of interview, **ten experts participate**, with five remaining experts who join since the first stage interview (Expert 1, 2, 3, 4, and 9), added with the new experts such as **Expert 5, 6, 7, 9, 10,** and **11**. **Expert 5, 6,** and **7** are from academic sector, while Expert 9, 10, and 11 are from industry.

Ideally, same as the first stage interview, the second-stage interview is ideally conducted online through **Microsoft Teams**. However, in case there is circumstance where the experts are **not eligible or able to do online interviews**, it is still acceptable to **answer interview questions written**. For instance, **Expert 1** answer interview questions written due to health circumstances, while Experts 5, 6, 7, 8, and 10 answer written due to schedule and work tight schedule.

Similarly, while interviews are preferably conducted one-on-one, it is acceptable for experts to attend jointly as long as they reach a shared consensus. This was the case for **Experts 1** and **2**, who participated together in both stage of interview. The outcomes of these second-stage interviews serve as the basis for the **Best-Worst Method (BWM)** analysis (see Appendix B).

c) Third Stage Interview

Once the BWM analysis is completed, the factors rank will also be identified. However, there is potential that the results would vary since the various background of experts such as academia, industry, and government. Thus, it is very important to conduct the third-stage interview to obtain more in-depth analysis by understanding how background, objectives, interests, knowledges, mental frameworks, and experiences shape the expert’s perception towards which factors that should be prioritized and not and how that impacts the market adoption of prefabricated housing in the Netherlands (see Appendix C).

Ideally, the interview is conducted with the same experts. However, due to some reasons, most of experts withdraw their participations. It is only **Expert 2, 9,** and **10** who still have willingness to do the interview. In this third-stage interview, one new Expert is added, which is **Expert 11** who come from industry sector.

Similarly, the interview is ideally conducted one-on-one online through **Microsoft Teams**. However, if the expert is unable to join online meeting, written answer is also accepted. For instance, due to conflicting schedule of work and interview, **Expert 9** answer written.

d) Semi-structured conversation to gain additional insights

This is not an official interview. It is more like a semi-structured, and semi-casual conversation that is done to gain more insights about prefabricated housing conceptually, and its application in the Netherlands. This conversation is done with **Expert 8**, a Professor of Complex Project, and an owner of architectural firm that has been working in the industry for more than 20 years. The result of the conversation will be used for enriching the discussion, and future research of this study.

4.3 The Best-Worst Method (BWM)

The Best-Worst Method (BWM) is a multi-criteria decision-making technique that identifies the relative importance of different decision criteria based on expert judgment. It is widely used due to its ability to produce consistent and reliable weights with fewer comparisons than traditional methods, such as the Analytic Hierarchy Process (AHP). This method is suitable for this study because it reduces cognitive overload among experts during the process. The BWM consists of six main steps, including a mathematical consistency check to ensure logical coherence in expert responses.

a) Determine the Set of Decision Criteria

The first step is to identify the relevant decision criteria (denoted as c_1, c_2, ..., c_n). These criteria form the basis for evaluating alternatives. The criteria are usually selected through expert interviews or literature review. To keep the evaluation practical and manageable, the number of criteria is typically limited to a maximum of 9. In this study, the criteria comprise 9 factors derived from a combined review of existing literature and expert interviews (see **Section 4). Analysis**).

b) Identify the Best and Worst Criteria

From the set of criteria, the decision-maker identifies the most important criterion, referred to as the 'Best' (B), and the least important criterion, referred to as the 'Worst' (W). This step is purely based on subjective judgment and does not involve any numerical rating yet. The decision-makers in this study context are experts involved in the second-stage interview.

c) Determine the Preference of the Best Criterion Over Others

In this step, the decision-maker rates how much more important the best criterion (B) is compared to each of the other criteria. The ratings are given on a scale from 1 to 9, where 1 indicates equal importance and 9 indicates strongly less important. Let a_Bj represent the preference of Best over criterion j. This is calculated using the formula:

$$a_{Bj} = a_B - a_j + 1$$

Equation 1: The best criterion over others

Where:

- a_B is the expert's importance score for the best criterion
- a_j is the score for criterion j
- a_{Bj} is the calculated preference of the best criterion over criterion j

This step results in the Best-to-Others vector: A_B = (a_B1, a_B2, ..., a_Bj).

d) Determine the Preference of All Criteria Over the Worst Criterion

Next, the decision-maker assesses how much more important each criterion is compared to the Worst criterion (W), again using a 1–9 scale. Let a_jW represent the preference of criterion j over the Worst. The formula used is:

$$a\_jW = a\_j - a\_W + 1$$

Equation 2: All criteria over the worst criterion

Where:

- a_j is the expert's score for criterion j
- a_W is the score for the Worst criterion
- a_jW represents the preference of criterion j over the Worst

This results in the Others-to-Worst vector: A_W = (a_1W, a_2W, ..., a_jW).

e) Calculate the Optimal Weights

The next step is to compute the optimal weights (w_1, w_2, ..., w_n) for each criterion such that the deviations between the derived weights and the preference scores are minimized. The following optimization model is used:

$$Minimize\ \xi$$

Equation 3: Minimized weight

Subject to:

$$|w\_B\ /\ w\_j\ -\ a\_Bj|\ \leq\ \xi\ for\ all\ j$$

Equation 4: Best-to-Others constraint

$$|w\_j\ /\ w\_W\ -\ a\_jW|\ \leq\ \xi\ for\ all\ j$$

Equation 5: Others-to-Worst constraint

$$\sum w\_j\ =\ 1$$

Equation 6: Normalization constraint

$$w\_j\ \geq\ 0\ for\ all\ j$$

Equation 7: Non-negativity constraint

Where:

- w_B is the weight of the best criterion
- w_W is the weight of the Worst criterion
- a_Bj and a_jW are the preference values provided by the expert
- ξ (xi) is the maximum absolute deviation, also called the consistency indicator

The objective is to minimize ξ, meaning the model seeks to find weights that are as consistent as possible with the expert's input.

f) Perform the Consistency Check

After computing the weights, the final step is to assess the consistency of the expert's judgments using the consistency ratio (CR). This ratio measures whether the preferences follow a logically coherent pattern. The ideal condition is:

$$a\_Bj\ \times\ a\_jW\ =\ a\_BW$$

Equation 8: The implied preference of Best over Worst

Where:

- a_Bj is the preference of Best over criterion j
- a_jW is the preference of criterion j over Worst
- a_BW is the implied preference of Best over Worst

The individual consistency index for each criterion is then calculated as:

$$CR'_j = \frac{|a_{Bj} \times a_{jW} - a_{BW}|}{1} \left(a_{BW} \times (a_{BW} - 1)\right), if\ a_{BW} > 1 = 0, if\ a\_BW = 1$$ *Equation 9: Individual consistency index*

The overall consistency ratio is:

$$CR' = max\_j\ (CR'\_j)$$ *Equation 10: Overall consistency ratio*

A CR′ value close to 0 indicates high consistency, while a large CR′ value may indicate contradictory inputs. In such cases, experts may need to revisit and revise their ratings. Generally, a CR′ value below 0.1 or 0.2 is considered acceptable.

4.4 Thematic Analysis & Triangulation

This is the stage that follows the third-stage interview. **Thematic analysis** involves carefully reading and coding the interview transcripts to identify common themes or patterns in how experts explain their prioritizations. For example, professional background, sector-specific experiences, personal values, or mental frameworks (such as short-term practicality versus long-term sustainability) will be examined to understand how these factors influence how experts prioritise their decisions. These themes will help understand the different logics behind each expert's thinking. Ideally, all experts who participated in the first- and second-stage interviews should also be invited to participate in the third-stage interview. However, due to personal constraints, some experts withdraw their participation and should be replaced by other experts. For instance, the experts involved in the third-stage interviews consist of four experts: **Expert 2, 9, 10,** and **11**. **Expert 2** has participated since the first-stage interviews, while the others joined only for the third-stage interview.

As consequences, before the third-stage interview begins, the first 15-30 minutes are allocated to explain about the first, and second stage interview, and also what BWM analysis is to **Expert 9, 10,** and **11** to make sure that they are well-informed on the current stage of research, so that they are understand enough to continue giving more insights on the current existing insights from previous interviews by previous experts. Once they know, the third-stage interview begins.

After the third-stage interview is conducted, the next stage involves analysing the data more deeply to identify the themes that emerge. After determining the themes, they will then be compared with the findings from the existing literature review through **triangulation**. This step involves checking whether the expert explanations align with, differ from, or provide new insights into existing academic research. By doing this, this research aims to build a deeper and more validated understanding of the reasons behind the variation in expert prioritisation and identify action steps that should be taken to widen the market adoption of prefabricated housing in the Netherlands.

4.5 Research Flow Diagram

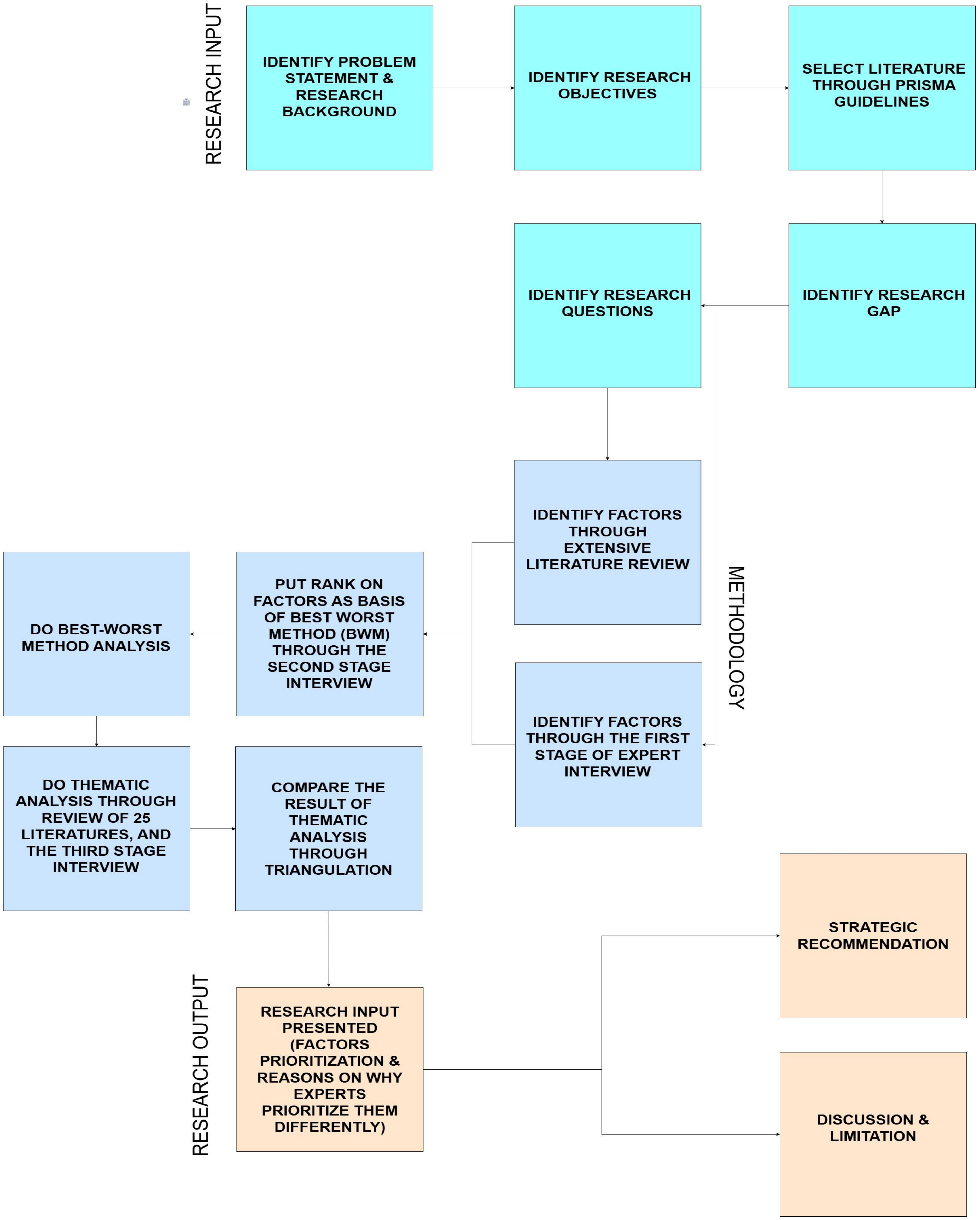

Figure 2 Research Flow Diagram

Figure 2 shows the step-by-step process of this research about the adoption of prefabricated housing in the Netherlands. It starts by explaining the main problems: the country has a big housing shortage (more than 240,000 homes are needed), there's pressure to build more sustainably, and different groups (academia, industry, and government) do not always agree on what's most important. These problems are the reason this research is needed.

The research has three main goals. First, it wants to find out what factors are important for adopting prefabricated housing. Second, it wants to know how important each factor is, based on what experts from different groups think. Third, it uses a method called Best-Worst Method (BWM) to rank these factors and predict which ones matter most for successful adoption. To do this, the researcher starts by reviewing existing studies using specific keywords from trusted databases, and then selects the most relevant articles.

Even though there isalready research on this topic, most of it only looks at it from one point of view, like just the industry or just the government. There islittle comparison across all three groups. This is the research gap. That is why this study asks three questions: What are the key factors? How do different people rank them? And why do they rank them that way?

To answer these questions, the research follows several steps. First, the researcher reviews the literature and collects factors that have been discussed before (like network effects or modular systems). Then, in the first round of expert interviews, people from academia, industry, and government are asked what factors they think are important. This helps to catch anything the literature might have missed.

Next is the second round of interviews, where experts are asked to rank the factors using the Best-Worst Method. They choose which factor they think is most important and which is least, and these rankings are turned into numbers. These scores are then compared across the three groups to see where they agree or disagree.

After that, there is a third round of interviews. This one is more about understanding *why* experts ranked the factors the way they did. The researcher reads through their answers carefully and looks for patterns in how they think, what experiences they bring, and how they explain their decisions.

In the final step, called triangulation, the researcher compares everything: what the literature says, what the experts ranked, and what they explained in the third interview. This helps paint a full picture and shows where everyone agrees and where they do not. It also helps figure out what steps can be taken next to improve adoption.

In the end, the research gives two main things: results and recommendations. The results show the ranked list of important factors and explain how different groups think about them. The recommendations give advice to key sectors such as government, academia, and industry on what they should focus on if they want their products to be more widely accepted. There is also a section discussing the limits of this research, like what was not covered or what could be improved in future studies.

5) Analysis

5.1 Factor Identification Through Extensive Literature Review

The first stage of this analysis involves identifying the factors influencing the market adoption of prefabricated housing in the Netherlands through a comprehensive literature review. This review is conducted after **selecting key research papers** that provide relevant insights into the topic using 5 different search strings. By analysing these papers, critical factors such as cost, regulatory frameworks, public perception, technological advancements, and other related factors are identified (See Table 2 – 6). One thing to note, those factors are already sorted through Open & Axial Code. The actual factors could be seen on “Breakdown” column, and they are classified into one factor on “Factor” column.

Search String 1 - ("Modular Construction" OR "Prefabricated Construction" OR "Modular Housing") AND ("Adoption" OR "Market Adoption") AND "Netherlands"

Table 2 Identified Factors from Search String 1

Factor	Definition of Factor	Breakdown	Definition of Breakdown	Citations
Building Information Modeling (BIM) Integration	The extent to which digital tools like BIM can facilitate collaboration, coordination, and decision-making in prefab housing projects.	Enhances collaboration	Enables real-time communication and coordination across teams involved in prefab projects.	Kordestani et al., 2024; Evans et al., 2021; Bortolini et al., 2019
		Reduces errors	Minimizes design clashes and human error through detailed digital visualization.	
		Improves decision-making	Provides data-driven insights to support effective project planning and execution.	
		Supports prefabrication logistics	Assists in managing and optimizing the production and delivery workflows of prefab elements.	
Supply Chain and Logistics Optimization	The ability to ensure efficient, reliable, and timely delivery of prefabricated components through an optimized supply chain.	Just-in-time (JIT) delivery	Delivering components exactly when needed to minimize inventory and holding costs.	Chen et al., 2023; Ayalp & Ay, 2021; Liew et al., 2018; Ter Haar et al., 2023
		Better material tracking	Using real-time monitoring to trace the location and status of materials throughout supply.	
		Reduced waste	Minimizing surplus materials and unnecessary handling through precise logistics.	
Sustainability and Circular Economy	The incorporation of environmentally conscious practices and circular principles in prefab construction processes.	Reduced construction waste	Prefab processes generate less on-site waste compared to traditional methods.	Ferdous et al., 2019; Chen et al., 2024; Wuni & Shen, 2020; Navaratnam et al., 2022
		Enable material reuse	Supports reuse and recycling of materials across building life cycles.	
		Alignment with sustainability goals	Integrates green design and low-carbon strategies aligned with climate policy.	
Construction Speed and Efficiency	The ability to complete construction projects faster and more efficiently through streamlined prefab workflows.	Precise timelines	Defined project milestones supported by factory-controlled schedules.	Ferdous et al., 2019; Liew et al., 2018; Zhu et al., 2021; Ter Haar et al., 2023
		Parallel construction workflows	Simultaneous off-site manufacturing and on-site preparation to reduce build time.	
Cost Efficiency and Financial Incentives	The financial feasibility of prefab housing, including the ability to reduce costs and leverage economic support.	Upfront investment	Initial capital required for setting up prefab production and logistics.	Goh & Goh, 2019; Wuni & Shen, 2020; Ayalp & Ay, 2021; Kordestani et al., 2024
		Financial incentives	Tax benefits, subsidies, or other governmental support to lower cost barriers.	

Regulatory and Policy Support	The regulatory environment and public policies that affect the ease of implementing prefab housing.	Tax incentives	Government-provided deductions or exemptions to promote prefab adoption.	van Oorschot et al., 2021; Kordestani et al., 2024; Ayalp & Ay, 2021; Evans et al., 2021
		Regulatory frameworks	Clear legal guidelines that support safe and consistent prefab construction.	
		Sustainability mandates	Policies requiring or encouraging green construction methods.	
Structural Innovations and Material Advancements	The use of new structural designs and materials to improve prefab performance and versatility.	Lightweight materials use	Reduces structural load, transport cost, and facilitates faster installation.	Liew et al., 2018; Ferdous et al., 2019; Ter Haar et al., 2023; Bortolini et al., 2019
		High-performance modular joints	Enhances structural integrity and flexibility during module assembly.	
Workforce Training and Digital Skill Development	The availability of a skilled labor force trained in digital construction methods and prefab techniques.	BIM, digital fabrication, modular training	Workforce development programs to upskill for digital design and manufacturing.	Evans et al., 2021; Kordestani et al., 2024; Wuni & Shen, 2020
		Upskilling construction workers for new methods	Transitioning traditional labor to adopt industrialized building techniques.	
Public Perception and Market Readiness	The social acceptance and readiness of the market to adopt prefab housing solutions.	Public perception	General societal views, trust, and openness toward prefab housing as a quality solution.	Ayalp & Ay, 2021; Wuni & Shen, 2020; Navaratnam et al., 2022
Automation and Robotics in Prefabrication	The integration of automation technologies to streamline and scale prefab manufacturing processes.	Automation in modular manufacturing	Use of robotics and AI in prefab production lines for consistency and speed.	Zhu et al., 2021; Ter Haar et al., 2023; Bortolini et al., 2019
		Reduced labor reliance	Shifting from manual labor to machine-based tasks to address labor shortages.	
		Efficiency	Improvement in productivity and reduction in error through automated systems.	
Challenges in Prefabrication Adoption	The barriers and obstacles preventing widespread implementation of prefab housing.	Initial investment	High startup costs for factories and logistics infrastructure.	Kordestani et al., 2024; Evans et al., 2021; Wuni & Shen, 2020
		Regulatory fragmentation	Inconsistencies in local codes that complicate prefab adoption across jurisdictions.	
		Resistance from traditional stakeholders	Reluctance of developers, contractors, or officials used to conventional construction.	

Search String 2 - ("Technological Competition" OR "Innovation Competition") AND ("Housing" OR "Residential Construction" OR "Building Industry") AND "Netherlands"

Table 3 Identified Factors from Search String 2

Factor	Definition of Factor	Breakdown	Definition of Breakdown	Citations
Digitalization and Smart Construction Technologies	The integration of digital tools and smart systems such as BIM, digital twins, and AI that enhance productivity, automation, and decision-making in prefab housing.	Integration of BIM, digital twins, AI, and automation	Use of advanced digital platforms to model, simulate, and manage construction processes.	Çetin et al., 2021; de Jong et al., 2024
		Efficiency	Optimizing time, resources, and labor use in prefab production.	
		Reduced construction time	Shortening project timelines through off-site manufacturing and planning.	
		Reduced construction cost	Cutting expenses via automation, standardization, and minimized waste.	
Sustainability and Circular Economy	Adoption of environmentally sustainable practices and circular principles to reduce resource use and waste across the prefab lifecycle.	Alignment with sustainability goals	Ensuring that prefab practices comply with environmental and climate-related targets.	Çetin et al., 2021; Jensen, 2017
		Energy efficiency	Reducing energy consumption through smart designs and energy-saving materials.	
		Material reuse	Encouraging reuse and recycling of components to support circularity.	

		Low carbon construction	Using low-emission processes and materials to minimize environmental impact.	
Regulatory and Policy Support	The role of government regulations and planning policies in facilitating prefab adoption.	Government policies	National or regional policies that incentivize or ease prefab construction.	de Jong et al., 2024; Çetin et al., 2021
		Building regulations	Legal requirements that govern building safety, design, and efficiency.	
		Urban planning incentives	Zoning or land-use benefits to encourage prefab adoption in urban areas.	
Financial and Investment Incentives	The availability of funding and economic programs that support prefab adoption and scaling.	Availability of funding	Public or private financial support for prefab businesses or developments.	de Jong et al., 2024; Jensen, 2017
		Public-private partnerships	Collaborative financial arrangements between government and industry.	
		Financial support for prefabrication businesses	Direct financial incentives (e.g., grants, tax benefits) to develop prefab enterprises.	
Knowledge Transfer and Industry Adoption	The dissemination of know-how, practices, and success stories to encourage industry-wide prefab adoption.	Sharing best practices	Communication of effective methods and case studies across the industry.	Jensen, 2017; Çetin et al., 2021
		Competition-driven knowledge diffusion	Adoption of innovations sparked by industry competition.	
		Collaboration across industries	Cooperative efforts between sectors to improve prefab integration and standards.	
Innovation through Competitive Demonstrations	The impact of public competitions and showcases in driving innovation and awareness in prefab housing.	Solar Decathlon and similar competitions	Events that demonstrate innovative prefab technologies and help normalize their market perception.	Jensen, 2017
Urban Densification and Housing Shortages	The pressure of increasing urban populations and land scarcity as drivers for efficient housing solutions like prefab.	High demand for housing	Rising housing needs push for faster and scalable construction methods.	de Jong et al., 2024
		Land scarcity in urban areas	Limited land availability necessitating compact, fast-deployable housing systems.	
Supply Chain and Manufacturing Efficiency	The improvement of manufacturing and supply operations to ensure cost-effective and timely prefab delivery.	Efficient manufacturing processes	Streamlining factory workflows to maximize productivity and quality.	Çetin et al., 2021
		Logistics optimization	Enhancing transportation and delivery systems to reduce cost and delay.	
		Supply chain resilience	Building robust systems that can adapt to shocks and ensure continuity.	
Consumer Awareness and Market Perception	The level of public knowledge, trust, and attitudes toward prefab housing.	Public perception	People's views and willingness to live in or invest in prefab homes.	Jensen, 2017
		Awareness campaigns	Outreach and educational initiatives to promote prefab benefits.	

Search String 3 - ("Network Effects" OR "Technology Diffusion") AND ("Building Technologies" OR "Construction Technologies" OR "Smart Buildings") AND "Netherlands"

Table 4 Identified Factors from Search String 3

Factor	Definition of Factor	Breakdown	Definition of Breakdown	Citations
Economic Factors	Financial structures that enable investment in prefab through subsidies, microloans, or tax support.	Financial incentives such as subsidies and microloans support adoption	Monetary tools such as direct subsidies or loans that lower the cost barrier for stakeholders.	Mata et al., 2021; Ehrenhard et al., 2014; Wang et al., 2023

Government and Policy Support	To what extend the institutional frameworks and administrative systems that regulate, permit, or incentivize prefab adoption become influential in the adoption of prefabricated housing technologies.	Regulatory frameworks	Laws and codes that define prefab permissions, standards, and procedures.	Iqbal et al., 2021; Mata et al., 2021; Ehrenhard et al., 2014
		Tax incentives and subsidies	Fiscal benefits that reduce upfront costs for builders or buyers.	
		Bureaucracy	The complexity and time-consuming nature of permitting processes.	
		Consistent policies	Long-term stable regulations to avoid uncertainty.	
Consumer Awareness and Information Access	To what extend the public understanding and accessibility to information regarding prefab housing influence the adoption of prefabricated housing.	Public awareness	General familiarity with prefab concepts and availability.	Mata et al., 2021; Wang et al., 2023
		Information about energy savings	Awareness of long-term utility savings from energy-efficient prefab.	
		Information about prefabricated housing benefits	Understanding of prefab benefits like speed, quality, or cost.	
Technological Advancements and Standardization	Use of new technologies and consistent standards in prefab design and integration.	Standardization of prefabricated components	Ensuring parts and modules follow shared dimensions or specs.	Singh et al., 2024; Owens et al., 2024; Ehrenhard et al., 2014
		Standardization of smart integration	Shared rules for how smart systems are added to prefab housing.	
		Interoperability	Seamless functioning of prefab components and tech across systems.	
Sustainability and Circular Economy Practices	To what extend environmentally responsible building approaches that promote reuse and reduce emissions.	Low-carbon goals	Targets for reducing carbon output in prefab processes.	Iqbal et al., 2021; Ehrenhard et al., 2014; Mata et al., 2021
		Reduced waste	Minimizing scrap, errors, and unused materials through precision.	
		Supports the circular economy	Prefab design that enables reuse, recycling, and material recovery.	
Market Demand and Consumer Preferences	How consumer-driven demand and expectations influencing prefab product-market fit.	Urbanization trends	Urban growth that demands faster and denser housing solutions.	van Oschot et al., 2020; Mata et al., 2021; Ehrenhard et al., 2014
		The need for affordable housing	Public pressure for cost-effective housing alternatives.	
		Skepticism about quality and design flexibility	Consumer concerns over aesthetics or perceived prefab limitations.	
Integration with Smart Technologies	How the integration of digital, automated, and IoT-based systems in prefab units influence the adoption of prefabricated housing.	Smart metering, automation, and IoT-based solutions	Integration of intelligent devices to monitor, control, or optimize home performance.	Singh et al., 2024; Ehrenhard et al., 2014; Mata et al., 2021
		Efficiency and usability	Ensuring tech is user-friendly and contributes to performance.	

Workforce and Construction Industry Challenges	Labor shortages and resistance from traditional construction industries.	Number of skilled labor	Availability of trained workers to carry out prefab design and assembly.	Wang et al., 2023; Ehrenhard et al., 2014
		Support from traditional construction	The extent to which conventional firms are willing to adapt or collaborate.	
Stakeholder Collaboration and Value Network Efficiency	The coordination between governments, suppliers, builders, and users to streamline prefab value chains.	Collaboration among government bodies, developers, and consumers	Multistakeholder cooperation to reduce friction and promote efficiency.	Ehrenhard et al., 2014; van Oorschot et al., 2020
Financial Incentives and Cost Management	Financial planning and incentives that control cost risk in prefab investment.	Financial incentives and interest-free loans	Accessible financial instruments to make prefab projects bankable.	Wang et al., 2021; Ehrenhard et al., 2014
Customization and Design Flexibility	Ability to adapt prefab designs to meet user preferences or contextual needs.	Customization	Tailoring prefab housing to social, cultural, or functional needs.	van Oorschot et al., 2020; Wang et al., 2023
Security, Privacy, and Data Protection Concerns	Data and privacy risks associated with integrated smart systems in prefab housing.	Concerns about cybersecurity and data privacy in smart-integrated prefabricated housing impact consumer trust.	Worries about data leaks, misuse, or surveillance undermining buyer confidence.	Owens et al., 2024; Ehrenhard et al., 2014

Search String 4 - ("Sustainability" OR "Eco-friendly" OR "Green Building") AND ("Modular Housing" OR "Prefabricated Housing") AND "Netherlands"

Table 5 Identified Factors from Keyword 4

Factor	Definition of Factor	Breakdown	Definition of Breakdown	Citations
Policy & Regulatory Support	Government policies and regulations that facilitate prefab housing adoption through incentives, zoning, and standards.	Government incentives	Financial or strategic support from government to encourage prefab construction.	Steinhardt & Manley, 2016; van Oorschot et al., 2021; Wuni & Shen, 2020
		Standardized building codes	Consistent technical requirements for design and safety.	
		Energy efficiency mandates	Legal requirement to meet energy-saving benchmarks.	
		Zoning laws	Urban land use regulations that enable prefab development.	
Financial & Economic Factors	The financial viability and economic advantages that encourage prefab investment and scaling.	Investment costs	Upfront capital required for prefab projects.	Ferdous et al., 2019; Aruta et al., 2023
		Financial feasibility	Ability to recover costs and generate acceptable return.	
		Economies of scale	Cost reduction from mass production of prefab modules.	
		Cost of materials	Price of building inputs used in prefab production.	

Sustainability & Environmental Benefits	The environmental advantages of prefab such as energy efficiency, low-carbon emissions, and material reuse.	Low carbon footprint	Reduced greenhouse gas emissions from prefab methods.	Shufrin et al., 2023; Mayouf et al., 2024; Xu et al., 2024
		Waste reduction	Minimizing material waste during off-site production.	
		Energy-efficient designs	Use of insulation, passive heating, or smart systems to lower energy use.	
		Use of sustainable materials	Preference for recycled or low-impact building components.	
		Integration with smart city initiatives	Aligning prefab developments with broader smart, green infrastructure.	
Technological Advancements	The adoption of digital tools and automation to improve precision and efficiency in prefab.	Integration of BIM, automation, digital fabrication, robotics, and 3D printing	Use of digital design and manufacturing tools to increase productivity and reduce error.	Hwang et al., 2022; Gao et al., 2024; Widanage & Kim, 2024
Supply Chain & Logistics Optimization	Strategies to improve the transportation, delivery, and coordination of prefab components.	Standardization of modular components	Uniformity in dimensions and systems to ease logistics.	Gao et al., 2024; Ferdous et al., 2019
		Transportation logistics	Efficient movement of modules from factory to site.	
		On-site assembly	Seamless installation of delivered components.	
Consumer Perception & Market Demand	Public acceptance, understanding, and desire for prefab housing.	Local material sourcing	Use of regionally available materials to improve perception.	Seymour et al., 2024; van Oorschot et al., 2021
		Public awareness campaigns	Educational efforts to promote prefab benefits.	
		Demand estimation models	Forecasting demand to support strategic planning.	
Customization & Flexibility	The ability to personalize prefab design to user and site needs.	Design freedom	Freedom to modify layouts, finishes, or sizes.	Raymundo et al., 2024; Wuni & Shen, 2020
		Mass customization	Offering variety without losing manufacturing efficiency.	
		Legal background on contract living spaces	Regulations or frameworks to support flexible housing contracts.	
Cost & Time Efficiency	The potential of prefab to reduce construction duration and lifecycle costs.	Reduction in construction time	Faster building through parallel site/factory work.	Hwang et al., 2022; Ferdous et al., 2019
		Punctual modular installation	Reliable, timely delivery and placement of modules.	
		Additional cost savings	Total economic benefit over traditional construction.	
Industry Readiness & Workforce Development	The availability of trained labor and organizational support for prefab deployment.	Training programs for skilled professionals	Formal courses to equip labor with prefab-specific skills.	Wuni & Shen, 2020; Widanage & Kim, 2024
		Organizational adaptation	Firms' readiness to adopt new prefab workflows and tools.	

		Adaptation of workforce to modular construction techniques	Upskilling and retraining construction workers.	

Search String 5 - ("Prefabricated Construction" OR "Modular Construction") AND ("Standards" OR "Regulations" OR "Building Codes") AND "Netherlands".

Table 6 Identified Factors from Search String 5

Factor	Definition of Factor	Breakdown	Definition of Breakdown	Citations
Construction Speed & Efficiency	The ability of prefab to significantly reduce construction timelines through off-site parallel production.	Faster construction, reducing project timelines by 50–60% compared to traditional methods	Accelerated build process due to controlled factory settings and pre-assembly.	Ferdous et al., 2024; Zhu et al., 2023; Navaratnam et al., 2022
Sustainability & Environmental Impact	The ecological benefits of prefab construction through lower emissions, material savings, and energy efficiency.	Reduced material waste	Less leftover or unused materials through precision manufacturing.	Ivaniuk et al., 2024; Sajid et al., 2024; Widanage & Kim, 2024
		Lower carbon footprint	Reduction of GHG emissions due to efficient transport and construction.	
		Supports energy-efficient building solutions	Use of prefab in buildings designed to conserve energy.	
Cost Reduction & Economic Viability	The potential to lower material, labor, and time-related costs while increasing project feasibility.	Minimizes material and labor costs	Efficiency reduces resource consumption and wages.	Wu et al., 2019; Navaratnam et al., 2022
		Shorter project duration	Less time on-site reduces labor hours and overhead.	
		Long-term financial viability	Sustainable ROI and low maintenance cost over building lifecycle.	
Regulatory & Policy Support	Public policy and administrative measures that facilitate prefab adoption.	Tax benefits and incentives	Financial tools provided by governments to lower entry barriers.	Wu et al., 2019; Widanage & Kim, 2024; Ferdous et al., 2024
		Government incentives	Grants or financial assistance encouraging prefab uptake.	
		Zoning regulations	Legal frameworks that allow or encourage modular developments.	
Supply Chain & Logistics	Optimization and coordination of prefab material delivery and site readiness.	Challenges in transporting large prefab components	Limitations due to road access, weight, or modular size.	Zhu et al., 2023; Navaratnam et al., 2022
		On-site installation logistics	Ensuring the timely arrival, placement, and assembly of prefab units.	
Technological Integration (BIM, IoT, DMA)	Integration of Building Information Modeling (BIM), Internet of Things (IoT), and Design for Manufacture and Assembly (DfMA) to enhance prefab accuracy and efficiency.	BIM, IoT, and DMA	Technologies used for digital design, real-time monitoring, and efficient modular assembly.	Ferdous et al., 2024; Widanage & Kim, 2024
Workforce & Labor Market	Issues concerning skilled labor availability and the need to retrain workers for modular construction practices.	Need for retraining construction workers	Upskilling existing labor for factory-based prefab roles.	Navaratnam et al., 2022; Wu et al., 2022
		Concerns from unions regarding job displacement	Resistance from traditional labor organizations due to role shifts.	
Structural Performance & Durability	The ability of prefab structures to meet or exceed conventional standards for safety and longevity.	High structural integrity	Prefab modules must withstand loads, transport, and weathering.	Zhu et al., 2023; Ivaniuk et al., 2024
		Design adaptability under various conditions	Structural flexibility to accommodate site- or climate-specific challenges.	
Market Demand & Consumer Perception	Public acceptance and growing need for prefab housing options.	Public perception of prefab homes	Trust and willingness to adopt prefab as high-quality housing.	Navaratnam et al., 2022; Sajid et al., 2024
		Accurate education is necessary for wider adoption	Need for awareness and communication campaigns.	
High Initial Capital & Investment Costs	The large financial input required for setting up prefab manufacturing systems.	Modular manufacturing plants set up	Upfront infrastructure costs for production facilities.	Navaratnam et al., 2022; Wu et al., 2022

Eventhough the application of Open & Axial Coding has been done, it is done separately among each search string. As results, some factors might still overlap if being compared across 5 search strings, which still lead to redundancy. Therefore, it is essential to re-apply **Open and Axial Coding** to refine and consolidate these factors into a more structured and concise framework (See Table 7).

Table 7 Refinement of Identified Factors from Literature Reviews Through Open and Axial Coding

Factor Category	**Definition**	**Factor Breakdown**	**Definition of Each Breakdown**	**Source Tables**	**Original Factors Combined**	**Reason for Grouping**
Policy & Regulatory Support	Government actions, rules, and incentives that enable or constrain the adoption of prefab housing.	Government policies	Policies issued to promote prefab adoption via planning, zoning, and incentives.	2, 3, 4, 5, 6	Regulatory and Policy Support, Government and Policy Support, Policy & Regulatory Support	All relate to enabling prefab via public authority structures.
		Tax benefits	Financial deductions or exemptions to reduce prefab investment barriers.			
		Standardized building codes	Consistent construction and safety standards to enable prefab scalability.			
		Regulatory consistency	Stability and clarity in prefab approval and policy environments.			
Financial & Economic Factors	Economic feasibility of prefab housing through cost efficiency and accessible financial support.	Upfront investment costs	Capital needed for prefab factory and setup.	2, 3, 4, 5, 6	Cost Efficiency and Financial Incentives, Financial and Investment Incentives, Economic Factors	All emphasize affordability and finance in prefab adoption.
		Tax incentives	Fiscal tools provided to ease prefab adoption.			
		Economies of scale	Cost savings through mass production and standardization.			
Sustainability & Environmental Benefits	Environmentally friendly features of prefab including waste reduction, energy efficiency, and carbon mitigation.	Reduced material waste	Less surplus due to precision manufacturing.	2, 3, 4, 5, 6	Sustainability and Circular Economy, Sustainability and Circular Economy Practices	All refer to prefab's environmental advantages.
		Low carbon construction	Building with reduced GHG emissions.			
		Energy-efficient design	Design that minimizes energy use via insulation and tech.			
		Circular economy support	Use of recyclable materials and reusable components.			

Technological Advancements & Integration	Adoption of digital tools and automation to improve accuracy, flexibility, and productivity in prefab.	BIM, IoT, robotics, 3D printing	Digital and smart technologies used for modeling, production, and monitoring.	2, 3, 5, 6	BIM Integration, Technological Advancements, Digitalization and Smart Construction Technologies	All relate to how tech improves prefab production and decision-making.
		Automation	Replacing labor-intensive processes with machines.			
		Interoperability	Compatibility of digital systems and prefab elements.			
		Digital fabrication scalability	Extending digital production to serve broader prefab use.			
Construction Speed & Efficiency	The ability to reduce timelines and construction inefficiencies through controlled, modular workflows.	Off-site parallel workflows	Simultaneous manufacturing and site prep to reduce timelines.	2, 3, 5, 6	Construction Speed and Efficiency, Cost and Time Efficiency	All refer to time reduction benefits of prefab.
		Punctual module installation	Accurate, on-time module delivery and assembly.			
		Reduced site labor	Less need for on-site work due to prefab completion.			
Supply Chain & Logistics Optimization	Improvement of transport, delivery, and coordination for prefab components.	Just-in-time delivery	Modules delivered exactly when needed.	2, 3, 5, 6	Supply Chain and Logistics Optimization, Supply Chain & Manufacturing Efficiency	All relate to making prefab supply chains lean and effective.
		Transport logistics	Coordinated transport from factory to site.			
		On-site installation planning	Ensuring prefab units are ready to install upon arrival.			
Consumer Awareness & Market Demand	Public understanding, trust, and acceptance of prefab as a viable housing solution.	Public awareness	Knowledge about prefab options and benefits.	2, 3, 4, 5, 6	Public Perception and Market Readiness, Consumer Perception & Market Demand	All focus on social and market-side drivers.
		Affordability need	Demand from middle/low-income groups for affordable homes.			
		Quality perception	Trust in prefab as aesthetically and technically equal to traditional builds.			
Customization & Design Flexibility	Ability to personalize prefab design for local, functional, or cultural preferences.	Mass customization	Offering variations without sacrificing efficiency.	4, 5	Customization and Design Flexibility	All refer to variation within standardized prefab.
		Adaptability	Design that can change over time or meet site needs.			
		Contractual flexibility	Legal mechanisms for flexible housing contracts.			
	Availability of skilled workers and industry	Upskilling	Training in digital and modular	2, 4, 5, 6		

Workforce Readiness & Labor Market	support for prefab transitions.		construction methods.		Workforce Training, Industry Readiness & Labor Market	All focus on labor transformation for prefab.
		Industry support	Willingness of firms to invest in new prefab methods.			
		Union adaptation	Addressing labor concerns from traditional unions.			
Structural Performance & Durability	Technical robustness and flexibility of prefab to meet site-specific and climate challenges.	Structural integrity	Ability to withstand load, weather, and transport stress.	2, 5, 6	Structural Innovations and Material Advancements	Focuses on prefab safety, load-bearing, and resilience.
		Design adaptability	Modularity that fits various topographies and climate conditions.			
Security, Privacy & Data Protection	Concerns related to data privacy in digitally connected prefab homes.	Cybersecurity	Preventing data breaches or misuse in smart prefab.	4	Security, Privacy, and Data Protection Concerns	Directly relates to smart prefab's digital vulnerability.
		Privacy in smart prefab systems	Ensuring trust in home surveillance and data control.			
Stakeholder Collaboration & Value Network Efficiency	Cross-sectoral partnerships and shared learning to streamline prefab integration.	Inter-industry collaboration	Coordination between sectors to reduce redundancy and conflict.	3, 4	Knowledge Transfer, Industry Adoption, Stakeholder Collaboration	Emphasizes collaborative governance and industry alignment.
		Knowledge sharing	Spreading best practices across actors.			
		Public-private innovation	Co-created innovation from competitions or showcases.			

5.2 Expert Interview

As explained in **Methodology** section, the second stage of this thesis analysis involves **conducting expert interviews from Triple Helix (Academia, Industry, and Government Sector)**. This stage is essential for adding more insights about factors that influence the market adoption of prefabricated housing in the Netherlands that are not captured by the existing literatures (See Table 8 – 10).

These stage also helps answer first sub-research question:

"What are the factors that influence the market adoption of prefabricated housing technologies, according to existing literature and expert interview?".

While also as baseline to answer second sub-research question:

"What is the importance of these identified factors, and which factors are likely to become major determinant based on expert interview and BWM Analysis?"

This also answers third sub-research question:

"What explains the variation, if any, in how experts prioritize factors for the market adoption of prefabricated housing?"

Table 8 Identified factors from academia sector

Factor	Description
Cost, Speed, and Quick Assembly	Prefab housing offers faster construction with potential cost savings, driving market interest.
Nitrogen Crisis & Bio-based Materials	Environmental pressures and bio-based alternatives have increased attention on prefabrication.
Lower Carbon Emissions	Prefab construction has a smaller carbon footprint than traditional methods, appealing to regulators.
Easier Environmental Compliance	Prefabrication helps meet environmental regulations more easily, aiding market adoption.
Construction Industry Tradition	Established practices and resistance to change slow prefab adoption in the Dutch market.
Higher Cost of Bio-based Materials	Wood, aluminum, and steel are more expensive than concrete, limiting prefab's cost competitiveness.
Regulatory Bias	Policy preferences favor traditional materials due to concrete industry influence.
Negative Consumer Perceptions	Prefab is seen as lower quality and less safe, particularly in fire resistance, deterring adoption.
Sustainability Benefits	Reduced emissions and faster builds make prefab more sustainable and market-attractive.
Cost Concerns for Bio-based Prefab	Though sustainable, bio-based options are still perceived as costly, affecting adoption decisions.
Local Materials Usage	Sourcing locally reduces carbon footprint and supports sustainable adoption in the market.
Prefabrication as Future Norm	Trend toward off-site construction aligns with prefab adoption, likened to car manufacturing norms.
Carbon & Nitrogen Policy Integration	Aligning with emission policies promotes prefab's role in sustainable development strategies.
Carbon Pricing System	Making concrete and steel costlier through carbon pricing could make prefab more competitive.
Consumer Awareness Campaigns	Educating consumers on prefab's benefits can boost acceptance and drive market growth.

Table 9 Identified factors from industry sector

Factor	Description
Housing Demand	Prefabrication helps address urgent housing shortages, especially for temporary housing needs.
Spatial Planning Policy	Government zoning and planning policies affect where and how prefab housing can be built.
Customization & Design Value	The ability to customize prefab homes improves appeal and increases adoption potential.
Fast Assembly Time	Quicker construction speeds up housing availability, meeting urgent demand efficiently.
Cost Considerations	Prefab can be cost-effective, but savings depend on local labor and material taxation policies.
Environmental Compliance	Strict environmental regulations drive adoption by favoring prefab methods that are compliant.
Sustainable Materials Use	Preference for wood and bio-based materials boosts sustainability appeal but may raise costs.
Lack of Circularity Knowledge	Limited awareness and unclear standards for circular construction hinder wider prefab adoption.

Consumer Perception Issues	Prefab housing is often viewed as low-quality and visually unappealing, limiting market acceptance.
Material Choice Impact	Continued reliance on concrete limits prefab's environmental advantages, reducing adoption drivers.
Bio-based Material Adoption	Switching to sustainable, bio-based materials enhances prefab's market appeal and environmental role.
Circularity Awareness	Industry understanding of circular practices promotes innovation and strengthens prefab adoption.
Better Visualization	Demonstrating aesthetic, customizable designs can shift public perception and attract buyers.
Sustainable Logistics	Efficient transport and assembly methods reduce CO2 emissions, supporting green construction goals.
Design Quality Improvement	High-quality, attractive prefab designs challenge negative stereotypes and boost consumer interest.

Table 10 Identified factors from government sector

Factor	**Description**
Policy and Government Support	Government aims to increase industrialized housing to 50%. Policies include subsidies for flexible housing and 'industrial fast lanes' for streamlined permits.
Housing Crisis and Demand	Housing shortage of 100,000 homes per year drives demand for faster construction solutions like prefabrication.
Technical Barriers & Standardization	Rigid municipal design requirements and lack of standardization make it difficult for prefabricated housing to be universally accepted.
Financial and Market Structure Challenges	High capital investment needed for factories; companies require a steady order flow to maintain profitability. Vulnerability to economic shocks.
Image and Public Perception	Negative perception due to historical use in post-war housing and refugee accommodations. Government is rebranding prefabrication as 'modular housing'.
Sustainability and Environmental Concerns	Prefabricated housing uses bio-based materials and is seen as a sustainable option, attracting large investors like pension funds and BlackRock.
Labour Shortages in Traditional Construction	Labour shortages in traditional construction push for more automation and robotic manufacturing in prefabrication factories.
International Trends & Export Potential	The Netherlands has one of the highest prefabrication market shares (~20%) in Europe. Growing demand for export, for example, Ukraine, Turkey.
Industry Organization & Collaboration	Lack of industry association for prefabricated builders. Need for better collaboration between municipalities, developers, and architects to align processes.

5.3 Combined Insights from Literature and Expert Interviews

While new factors were identified through expert interviews, many of the factors also found in the extensive literature review remained the same. This overlap suggests that several factors are widely recognised and commonly acknowledged in both academic studies and practical experiences by the industry and government sectors. To organise and simplify these overlapping factors, open coding and axial coding were applied again. These methods helped group similar factors and develop a more precise and more structured set of key points. Since the outcome of this process will serve as the basis for the Best-Worst Method Analysis, the main factors should be nine, as shown in Table 11.

Table 11 Consolidated factors from both literature review and expert interview

Main Factor	Definition	Accumulated Factor	Definition of Accumulated Factor	Sources	Original Factors Combined	Reason for Grouping
Policy & Regulatory Support	The extent to which government regulation, permits, and support make it easier and faster to build prefab homes.	Government policies & incentives	Government initiatives that provide financial or strategic support to encourage prefab housing.	Academia, Government, Literature	Regulatory bias, Spatial Planning Policy, Regulatory and Policy Support, Government and Policy Support, Spatial Planning, Carbon & Nitrogen Policy Integration, Carbon Pricing System	All relate to enabling prefab via institutional regulation and support.
		Spatial Planning policies	Policies that guide land use and zoning to facilitate prefab housing development.	Industry		
		Standardized building codes	Uniform construction standards that ensure prefab buildings meet safety and quality requirements.	Academia, Government, Literature		
		Regulatory consistency	Stable and predictable regulations that reduce uncertainty for prefab developers.	Literature, Government		
		Industrial fast lanes for prefab permits	Faster government approval for prefab projects.	Literature, Industry		
Financial & Economic Viability	The extent to which prefab housing is affordable to build and can make a profit.	Upfront investment costs	Initial capital needed to start prefab housing projects.	Industry, Government, Literature	Cost Consideration, Higher Cost of Bio-based Materials, Cost Efficiency, Financial Incentives, Financial Stability, International Trends & Export Potential	Unified by economic viability as key adoption driver.
		Tax incentives & material/labor taxes	Tax reductions or benefits for using certain materials or labor in prefab construction.	Academia, Industry, Government, Literature		
		Economies of scale	Cost advantages gained by producing prefab components in large quantities.	Government, Industry		
		Financial stability for prefab factories	Consistent financial resources to maintain and operate prefab production facilities.	Academia, Industry		
		Cost reduction potential	Opportunities to lower overall project costs through prefab methods.	Academia, Industry, Literature		
Technological Advancements & Standardization	The extent to which smart tools and common building designs help make prefab homes better.	BIM, IoT, robotics, digital fabrication	Technologies that improve planning, monitoring, and automation in prefab construction.	Academia, Industry	Construction Industry Tradition, Customization & Design Value, Design Quality Improvement, Technical Barriers & Standardization, Technological Advancement & Integration,	All relate to prefab's green advantages and environmental regulation.
		3D printing	Use of 3D printing to create prefab components efficiently.	Literature, Industry		

		Scalability & automation	Ability to expand production and automate tasks to improve efficiency.	Academia, Industry	Customization & Design Flexibility, Prefabrication as future norms.	
		Certification & industrial fast lanes	Official recognition of prefab standards and expedited processes for certified methods.	Government, Academia		
		Prefab standardization	Development of common prefab designs and modules to simplify production.	Literature, Academia, Industry		
Supply Chain & Logistics Efficiency	The extent to which prefab materials can be delivered on time, in the right place, and in a smooth way.	Just-in-time (JIT) delivery	Delivering prefab components exactly when needed to reduce storage costs.	Academia	Tech Integration, 3D Printing, Smart Construction, Local Material Usage, Sustainable Logistics, Supply Chain & Logistics Optimization.	Unified by the role of technology in efficiency, quality, and repeatability.
		Real-time material tracking	Monitoring materials in real time to improve coordination and reduce delays.	Industry, Literature		
		Sustainable logistics & CO_2 reduction	Eco-friendly transport methods to reduce carbon emissions in the supply chain.	Government		
		Effective coordination among suppliers	Collaboration between suppliers to ensure smooth and timely delivery of materials.	Academia, Government		
Sustainability & Environmental Impact	The extent to which prefab housing helps the environment by using less energy, creating less waste, and using eco-friendly materials.	Carbon footprint reduction	Decreasing greenhouse gas emissions from prefab construction activities.	Industry, Literature	Nitrogen Crisis & Bio-Based Material, Lower Carbon Emission, Logistics, Delivery Coordination, Sustainability Benefit, Environmental Compliance, Sustainable Material Use, Sustainability & Environmental Concerns	All deal with prefab flow from factory to site.
		Circular economy & material reuse	Reusing materials to minimize waste and promote sustainable practices.	Industry, Academia		
		Energy efficiency	Reducing energy consumption in prefab building and operation.	Industry, Academia		
		Bio-based materials preference	Using materials derived from natural sources to reduce environmental impact.	Government, Industry		
		Climate resilience & sustainability policies	Designing prefab homes to withstand climate impacts and align with green policies.	Academia, Government, Literature		
Speed & Construction Efficiency	The extent to which prefab housing can be built faster and with fewer delays than normal building.	Faster timelines & parallel workflows	Completing projects quicker by working on multiple tasks simultaneously.	Government	Time Reduction, Parallel Workflows, Cost, Speed, and Quick Assembly, Local Material Usage, Fast Assembly Time.	All related to how speed and efficiency influence on how people would choose certain construction technology.
		Prefab extensions instead of demolitions	Adding prefab parts to existing buildings without full demolition.	Industry, Academia		
		Modular Design for quicker assembly	Using prefabricated modules to speed up the construction process.	Academia, Government, Literature		
Consumer Perception & Market Demand	The extent to which people like prefab housing and want to live in it.	Public perception & awareness	How the public views and understands prefab housing.	Industry, Literature	Market Readiness, Consumer Awareness Campaigns, Consumer Perception Issues, Material Choice Impact, Negative Consumer Perception, Image & Public Perception, Security, Privacy, and Protection	Driven by social acceptance and understanding.
		Prefab housing aesthetics	Visual appeal and design quality of prefab homes.	Industry, Government		
		Customization & design flexibility	Ability for buyers to personalize prefab homes to their needs.	Academia, Government		
		Addressing prefab misconceptions	Correcting false beliefs about prefab quality or durability.	Government, Academia		

Industry Collaboration & Workforce Development	The extent to which companies, workers, and the government work well together and have the right skills to build prefab housing.	Industry-wide standardization efforts	Collaboration to set common standards across the prefab sector.	Academia, Industry	Lack of circularity knowledge, circularity awareness, Labor shortages, industry organization & collaboration, Workforce readiness & labour market, Stakeholder Collaboration & Value Network Efficiency	Aligns training, collaboration among sector, and regulation.
		Workforce retraining programs	Programs to teach workers skills for prefab construction.	Government		
		Union & stakeholder cooperation	Working with labor unions and stakeholders to support prefab adoption.	Government		
		Collaboration with municipalities	Partnering with local governments to promote prefab housing.	Literature, Industry		
Structural Quality & Durability	The extent to which prefab homes are strong, safe, and long-lasting.	High structural integrity	Strength and stability of prefab buildings under normal use.	Academia, Literature	Structural Performance & Design Flexibility	Unified by performance under environmental and structural load.
		Prefab's resilience under environmental conditions	Prefab's ability to withstand weather and other environmental factors.	Industry, Literature		
		Design & material improvements for longevity	Using better materials and designs to extend the life of prefab homes.	Industry, Literature		

Table 11 shows 9 main factors that will be used as baseline for the second stage interview. Thus, it is crucial to provide definitions of each both main and accumulated factor to create more clarity for the experts. However, during the second stage interview, experts only need to focus on main factors and only take accumulated factors as consideration when ranking 9 main factors.

5.4 Best-Worst Method (BWM)

As explained in the **Methodology** section, after gathering input from experts through two stages of interviews and combining their inputs with the extensive literature review, the next step was to analyse their responses using the **Best-Worst Method (BWM)**, a tool used to compare and rank different factors. BWM is part of a group of methods called **Multi-Criteria Decision Analysis (MCDA)**, which helps in making decisions when multiple factors need to be considered.

In this case, BWM was used to determine which factors (See Table 11) experts believe are **most important**, which are **least significant,** and which are **placed in the middle**, supporting the market adoption of prefabricated housing in the Netherlands. Experts first selected the factor they considered the most important and the one they considered the least important. Then, they compared all other aspects to these two. Although experts are considered individually, they are still classified into three sectors: academia, industry, and government (see Table 12).

Table 12 Result of Best-Worst Method (BWM) Analysis

No	Categories & Factors	Government		Academia					Industry			Global Average Weight	Rank
		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 9	Expert 10	Expert 11		
1	Policy & Regulatory Support	0,1915	0,1915	0,0766	0,0479	0,1915	0,0766	0,0638	0,1442	0,1915	0,1277	0,1303	3
2	Financial & Economic Viability	0,3146	0,3146	0,0274	0,0547	0,3146	0,0958	0,0958	0,0721	0,3146	0,3146	0,1919	1
3	Technological Advancements & Standardization	0,0547	0,0547	0,0958	0,0274	0,0547	0,0638	0,1915	0,0206	0,0766	0,0274	0,0667	8
4	Supply Chain & Logistics Efficiency	0,0274	0,0274	0,0479	0,0958	0,0638	0,0547	0,0274	0,0412	0,1277	0,0958	0,0609	9
5	Sustainability & Environmental Impact	0,0766	0,0766	0,1915	0,0766	0,0766	0,1277	0,0547	0,2368	0,0274	0,0547	0,0999	5
6	Speed & Construction Efficiency	0,0479	0,0479	0,3146	0,0638	0,0958	0,1915	0,1277	0,0721	0,0958	0,0766	0,1134	4
7	Consumer Perception & Market Demand	0,1277	0,1277	0,1277	0,1915	0,1277	0,3146	0,3146	0,2368	0,0479	0,1915	0,1808	2
8	Industry Collaboration & Workforce Development	0,0958	0,0958	0,0547	0,3146	0,0274	0,0274	0,0766	0,0320	0,0547	0,0479	0,0827	6
9	Structural Quality & Durability	0,0638	0,0638	0,0638	0,1277	0,0479	0,0479	0,0479	0,1442	0,0638	0,0638	0,0735	7

Table 13 Input-based consistency ratios and the associated thresholds.

Experts	Input-Based Consistency Ratio	Threshold
Expert 1	0,2083	0,3662
Expert 2	0,2083	0,3662
Expert 3	0,2083	0,3662
Expert 4	0,1667	0,3662
Expert 5	0,0972	0,3662
Expert 6	0,0972	0,3662
Expert 7	0,0972	0,3662
Expert 9	0,0972	0,3662
Expert 10	0,2083	0,3662
Expert 11	0,2083	0,3662

Table 12 presents the rankings of ten experts from government (Experts 1 and 2), academia (Experts 3, 4, 5, 6, and 7), and industry (Experts 9, 10, and 11) on the importance of nine factors influencing the adoption of prefabricated housing in the Netherlands. Each expert assigned a weight to each factor, and the average of these weights produced a global average weight, giving a general picture of what factors are considered **most and least important overall**. While the global averages help identify common priorities, the individual rankings reveal more profound differences in perspectives based on professional background, role, and experience.

Based on the global average weight, **Financial and Economic Viability** emerged as the most critical factor (0.1919). This reflects a widespread belief that if prefabricated housing is not affordable for buyers and cost-effective for developers, it will not be adopted. Experts across sectors agreed that pricing, return on investment, and financial viability are essential to driving market interest. Without economic viability, even the most innovative or sustainable prefab solution would struggle to compete with traditional construction. As noted by multiple experts, strong business cases and cost competitiveness are necessary to gain adoption from both public and private actors.

The second most crucial factor was **Consumer Perception and Market Demand** (0.1808). This factor highlights how the success of prefabricated housing depends not only on performance and price but also on whether people trust, desire, and are willing to live in these homes. Negative perceptions, such as associating prefabricated housing with temporary or low-quality housing, can act as a significant barrier. At the same time, strong consumer interest can accelerate adoption by attracting investment and political support. Experts emphasised that public acceptance shapes everything from sales to policy attention and plays a significant role in scaling up new housing methods.

In third place was **Policy and Regulatory Support** (0.1303). This factor refers to government involvement in enabling adoption through zoning policies, permitting procedures, subsidies, pilot projects, and building codes. While it received lower weight than financial and market factors, it was still considered crucial, particularly in terms of unlocking land, reducing risks, and sending clear signals to the market. Several experts emphasised that outdated or rigid policies frequently hinder the growth of prefab housing, and smoother bureaucratic processes could make a significant difference in its adoption.

Ranked fourth is **Speed and Construction Efficiency** (0.1134). One of the commonly cited benefits of prefabricated housing is its ability to reduce on-site construction time through off-site manufacturing. This speed is particularly valuable in addressing urgent housing shortages or post-disaster reconstruction. Experts who prioritised this factor argued that the ability to build faster without sacrificing quality is one of prefab's key competitive advantages. However, some experts noted that this benefit only matters if financial and regulatory hurdles are also addressed.

Fifth in the ranking is **Sustainability and Environmental Impact** (0.0999). This factor captures prefab's potential to contribute to climate goals through lower emissions, material efficiency, and less waste. While not ranked at the top, several experts, particularly from government and industry, argued that sustainability will grow in importance due to environmental regulations, rising awareness of carbon footprints, and the shift toward circular construction. Prefab systems that utilise biobased or recyclable materials are increasingly viewed as part of the future of sustainable housing.

Industry Collaboration and Workforce Development ranked sixth (0.0827). This factor refers to the need for better coordination between different actors in the housing sector, such as construction firms, municipalities, housing associations, and prefabrication manufacturers, as well as a skilled workforce that can support prefabricated production and assembly. Experts with hands-on experience stressed that a lack of collaboration leads to delays, misaligned expectations, and wasted resources. While not initially viewed as the primary driver of adoption, this factor is considered essential for effective and scalable implementation.

In seventh place is **Structural Quality and Durability** (0.0735). While important, this factor was ranked relatively low in part because experts believed that prefab systems in the Netherlands already meet high quality standards. Several participants stated that once minimum legal and technical standards are met, improving quality has a less significant impact on adoption compared to factors such as cost, perception, or demand. That said, maintaining a strong reputation for quality remains essential to establish trust and acceptance in the long term.

Technological Advancements and Standardisation ranked eighth (0.0667). This includes innovations such as Building Information Modelling (BIM), automation, digital design, and standard construction modules. Some experts, especially those from academia, argued that technology is already available and not the main bottleneck. They felt that institutional readiness and market demand were more important. However, a few also noted that as the prefab industry grows, better standardisation could improve efficiency, reduce costs, and allow companies to scale more easily.

Finally, the lowest-ranked factor is **Supply Chain and Logistics Efficiency** (0.0609). This factor involves the transportation, storage, and delivery of prefab components from factories to construction sites. Although it is a technical concern, most experts do not view it as a significant barrier at the current stage of adoption. Some mentioned that supply chains in the Netherlands are already well-developed, and improving logistics would only yield marginal benefits unless more critical issues, such as cost, regulation, or public trust, are addressed first. Others noted that in emergency scenarios, logistics may take on even greater importance.

However, despite the aggregated results, a closer examination of individual expert responses reveals considerable variation, even among experts from the same sector. Their rankings were not only shaped by professional affiliation but also by personal experience, daily responsibilities, and their views on what is most urgent in the Dutch housing context.

Government Sector (Experts 1 and 2)

The government experts were very clear about what matters most to them: **money**. Financial and economic viability was at the top of their list. From their perspective, if a prefabricated housing project does not make financial sense, it will not survive, no matter how good the other benefits are. Innovation, speed, and sustainability all sound great, but without a solid financial case, they simply don't matter.

Expert 1 summed this up in a straightforward way.

"If building prefabricated homes is not financially possible or profitable,"

he said,

“Then it does not matter how good the other factors are; people and companies will not adopt it.”

Expert 2 agreed, but put it even more bluntly.

“It is stupid. But still the economy at the end”.

These quotes are not just about cost, they reflect how **the government system works**. Projects that use public money have to be justified. Officials have to show that they are spending wisely. If a project seems too risky, too expensive, or too uncertain, it will not get approved, no matter how innovative it is.

And that thinking matches what many studies have been saying for years. Lu (2019) pointed out that high upfront costs are one of the biggest barriers for prefab housing. Yang et al. (2022) added that even though prefab might save money in the long run, many developers still avoid it because they can’t wait for those savings. They need short-term results. Abioye et al. (2024) explained that unless there are subsidies or policy support, developers, especially in the public sector, see prefab as too risky. On top of that, Shah et al. (2024) found that regular people also worry about the cost. Most said they wouldn’t buy a prefab home unless there was financial support.

In other words, **money is not just one issue, it is the main filter**. If a project is not financially viable, it will not even make it to the discussion table. That is especially true for public officials, who have to answer to voters, auditors, and political stakeholders. They are not just thinking about what’s possible, they are thinking about what’s safe, explainable, and likely to be approved.

And there’s another difference between how government experts and academics view money. Academics often look at cost using formulas and models. They talk about ROI, net present value, and other metrics. But the experts think in terms of real-life decisions: **will this project get funded? will people support it? will it survive the budget meetings?** That is a very different kind of logic.

The experts also agreed that **supply chain and logistics efficiency** is not a big deal in their world. Expert 1 explained it this way:

“If a housing project already takes two years to complete,”

he said,

“Making the supply chain a little faster does not make a big difference.”

For them, the real delays come from zoning, paperwork, and approvals, not from how fast materials move. That is why they don’t see logistics as a game-changer, even though it gets a lot of attention in academic research.

One last point they raised was how **priorities can shift quickly in a crisis**. Expert 2 gave an example:

“In the case of a natural disaster or war,”

he said,

“Building homes quickly becomes the top priority, and things like cost and regulations become less important.”

This is something that is not frequently seen in research papers, which usually assume that priorities are fixed. But in real life, **context matters**. During emergencies, governments are willing to take more risks and move faster. That is something only people inside the system truly understand.

So overall, the government experts are **not against prefab**. They just know how the system works. Their thinking is shaped by public responsibility, tight budgets, and the pressure to justify every project. That does not mean they reject innovation, it just means they need it to fit within what's possible right now.

Academic Sector (Experts 3 to 7)

The academic experts gave a much more varied set of responses, reflecting their different research backgrounds and long-term thinking. Their priorities were not all the same, but many of them shared a broader, more future-oriented view of what would help prefabricated housing succeed in the Netherlands.

Expert 3 focused most of his attention on two things: sustainability and construction speed. He saw these as deeply connected, especially in the current environmental and policy landscape.

"Speed has always been a traditional driver for prefabrication,"

he explained.

"And prefab and biobased construction methods offer significantly lower emissions."

He also believed that even though some sustainable building materials are expensive now, that could change soon, depending on policy.

"While biobased materials may currently be more expensive,"

he said,

"That may change if carbon pricing or emissions taxation is introduced."

He pointed to the Netherlands' current nitrogen crisis as an example of how environmental issues are already pushing change:

"The nitrogen crisis in the Netherlands is already pushing us to rethink traditional construction methods."

What made his comments stand out was how he did not treat sustainability as something that just automatically matters to everyone. Instead, he argued that sustainability becomes important **when it gets linked to financial systems and policy frameworks**, for example, through carbon taxes or emission penalties. This view feels more grounded than what we usually see in academic literature, which often assumes that the environmental benefits of prefab alone are enough to convince people. Many studies describe prefab as cleaner, quieter, and less wasteful, and act like those points should be obvious reasons for adoption.

For example, Alnusairat and Qadourah (2024) argue that prefab leads to less construction waste and better material efficiency because everything is built in controlled factory conditions. Radziszewska-Zielina and Gleń (2025) highlight how prefab reduces emissions and causes less disruption to surrounding neighborhoods, especially in cities. These studies tend to assume that if something is more sustainable, people will automatically choose it. But Expert 3 challenged that assumption.

His thinking was more policy-aware. He made it clear that sustainability only becomes powerful when it affects decisions through **money, laws, or social pressure**. Without those forces, people may agree that prefab is greener, but still choose other options because they are cheaper, easier, or more familiar. This more realistic view helps explain why prefab has not taken off yet, even though the technology is already available.

Expert 4 focused on something else entirely: the importance of collaboration. For her, the key to success wasn't just tools or methods, it was how people and institutions work together. She said:

"Collaboration among housing associations, municipal governments, and modular construction companies is essential for success."

Then she added:

“The tools and systems are already available. The issue lies in adapting institutional structures and workflows to deploy them effectively.”

What she meant was that technical solutions already exist. The problem is getting everyone to use them in a way that fits the current system. This goes beyond coordination, it is about changing how organizations think, decide, and operate. This view connects with earlier research from Pan et al. (2008) and Goh and Loosemore (2017), who describe how fragmented the construction industry can be. But while those studies focus more on communication and teamwork, Expert 4 went deeper. She was saying that prefab success depends on **reorganizing how things are done**, not just holding more meetings.

Expert 5 brought the conversation back to money, echoing what the government experts said. He believed that unless prefab is financially attractive for both companies and consumers, it will not be adopted widely.

“Even if a prefabricated building is fast to build or environmentally friendly,”

he said,

“People and companies will not use it unless it is affordable for the consumer, while also profitable for the companies.”

His view underlined the same hard truth: **finance drives decision-making**, and good intentions will not carry a project unless the economics are strong enough to back it up.

Experts 6 and 7 shifted the focus to the people who actually live in the houses, consumers. They both felt that **public perception and user demand** would be critical to making prefab work. Expert 6 pointed out:

“Public acceptance ultimately drives the adoption of prefabricated housing. Without strong consumer interest and demand, even the most advanced or efficient prefab solutions may struggle to attract the market.”

Expert 7 added a similar thought, but emphasized how supply-side thinking has taken over the conversation:

“An innovation in housing will be more likely perceived by the users,”

he said,

“And seeing from the demand-side perspective is more relevant than the supply-side.”

He also criticized how much attention goes to technical improvements when other things might matter more:

“A technical factor, which is not as urgent as understanding broader market dynamics.”

Their opinions are backed by Shah et al. (2024), who showed that many consumers still don’t trust prefab homes. Some people think they are unattractive or unfamiliar. Others simply don’t know enough about them to make a confident choice. But the academics went a step further. They did not just say that perception matters, they argued that it **shapes everything**, from political support to investor interest. That is a powerful point. It means that even great technologies can fail if people don’t feel good about them.

Looking across all five experts, a strong pattern is seen: they are focused on **systems, future pressures, and social change**. They talked about sustainability, policy signals, institutional reform, consumer trust, and cross-sector partnerships. Compared to the government experts, who are grounded in current rules and constraints, the academics think more about what needs to change in the long run. They are not naive, most of them still emphasized that finance matters. But they also see opportunities to change the game by improving rules, coordination, and awareness.

Industry Sector (Experts 9 to 11)

The industry experts focused firmly on the practical realities of finance, risk, and policy. Their primary concern was whether prefabricated housing can offer a solid business case. Expert 10 expressed this directly, saying,

"If prefab does not make financial sense, whether That is the upfront investment or the ability to scale, it is hard to attract developers, investors, or even clients."

This indicates that for those working in the private sector, decisions are not based solely on long-term potential or innovation. Projects must be financially sound in the short term, able to scale up efficiently, and predictable in terms of returns. Expert 11 took a slightly broader approach but emphasised the same logic:

"Affordability, streamlined bureaucracy, and consumer demands should be the primary focus."

He also recognised that the industry is evolving, noting that,

"Future development, for example, a sustainability focus, might become more prominent in the future."

These views align well with several studies. Wu et al. (2024) emphasise that developers are unlikely to adopt prefabrication unless there is strong regulatory support, reduced risk, and clear financial benefits. Similarly, Xue et al. (2018) argue that in the absence of stable and supportive policies, investors tend to view prefab as too uncertain, especially when compared to conventional construction. These studies, like the experts, highlight the importance of low-risk environments where policies are predictable, regulations are aligned, and sudden shifts in building codes, approval processes, or cost structures do not threaten profit margins.

The experts also brought attention to how these priorities could shift over time. They accepted sustainability, but viewed it as a factor that is becoming increasingly important, especially as governments and consumers demand greener buildings. In this sense, the experts were not resistant to change. Instead, they are waiting for the right conditions, such as policy incentives, stable regulations, and consumer demand, to make sustainability a viable business priority. This view suggests a practical, not ideological, approach to prefab adoption. Sustainability matters, but it must align with a business's logic.

Expert 9 was the exception who placed sustainability front and centre. He said,

"The construction industry needs to reduce CO_2 emissions urgently, and prefab offers a strong opportunity for that."

He also emphasised design as a factor in public acceptance, stating,

"Many homes today lack strong visual appeal. Good architecture design could help make prefab more accepted."

Most notably, he downplayed the importance of technical limitations, saying,

"The technology is already developed enough. The real challenge is in regulations and how people view prefab housing."

These statements highlight a significant difference between expert experience and what is still emphasised in much of the academic literature. A large number of papers continue to focus on technical innovation as the primary area for improvement. For example, Bertram et al. (2023), Mao et al. (2015), and even Jaillon and Poon (2008) discuss ways to make prefab components lighter, brighter, more standardised, or better integrated. These studies assume that if the technology is improved, adoption will follow.

However, industry experts have differing perspectives. For them, technical solutions already exist. The bigger problems lie in policy barriers, unclear regulations, negative public perception, and lack of investor confidence. From their day-to-day experience, it is not engineering gaps that slow things down. It is the environment around the project: whether the market wants it, whether the local government supports it, and whether the return is worth the risk. Expert 9's emphasis on aesthetics also adds something that is rarely discussed in literature: how a building *looks* can influence how people perceive its quality and acceptability.

This makes lots of sense. Industry actors are under pressure to deliver results, manage budgets, satisfy clients, and respond to shifting consumer demands. They cannot afford to chase new trends unless a clear path to profitability, low risk, and regulatory approval backs those trends. However, their statements also reveal that they are not resistant to change. They are closely monitoring the policy environment and are prepared to adjust their priorities, particularly toward sustainability and design, if conditions become more favourable.

5.5 Thematic Analysis & Triangulation

As explained in the **Methodology** section, this research follows a multi-stage approach to understand the key factors influencing the adoption of prefabricated housing in the Netherlands. The second-stage interview involved ranking the factors as the basis for the **Best-Worst Method (BWM) Analysis** based on their perceived importance. However, identifying *the prioritized factors* is only part of the picture. To fully understand the reasoning *behind* these prioritizations, one of the questions of the second stage interview is as follows:

"Based on the ranking you've provided, what are the reasons behind your choice of the most and least important factors? Are there any emerging trends or future developments that might change the importance of any of these factors?"

The above question was designed to encourage experts to reflect on their decision-making process and provide an objective explanation for their rankings. However, the responses revealed a more complex and fragmented picture. For instance, even among experts from the same sector, such as academia, there were apparent differences:

- **Expert 3** emphasized *Speed & Construction Efficiency*,
- **Expert 4** highlighted *Industry Collaboration & Workforce Development*,
- **Expert 5** emphasized *Economic & Financial Viability*, and
- **Experts 6 and 7** prioritized consumer perception and market demand.

These differences show that experts within the same sector do not always share the same priorities. This lack of alignment suggests that factor prioritization is shaped by individual perspectives, areas of expertise, or institutional contexts, rather than a sectoral perspective. This has important **implications**. Without a shared understanding or agreement on which factors matter most, efforts to promote prefabricated housing may face challenges such as misaligned and fragmented communication strategies or ineffective cross-sector collaboration. For example, suppose the academia sector promotes innovation internally, with one focus on consumer perception and others on technical efficiency or workforce development. In such cases, it can result in inconsistent recommendations for policymakers, developers, and industry stakeholders. Such divergence can delay decision-making, reduce stakeholder buy-in, or lead to the prioritisation of interventions that do not comprehensively address the root causes of the challenges.

Because of these findings, a **third stage of interviews** is essential to explore deeper, subjective, and context-specific reasons for prioritization. This stage aims to uncover the underlying motivations and assumptions that may not have surfaced during the earlier phases. Once the third-stage interview is completed, transcripts will be coded and analyzed using **Thematic Analysis** to identify recurring patterns and themes. These findings will then be compared with insights from the **literature review** through **Triangulation**, which helps verify consistency between expert opinions and established knowledge.

a) Thematic Analysis

In this thesis, **thematic analysis** was used to help answer the third sub-research question:

"What explains the variation, if any, in how experts prioritize factors for the market adoption of prefabricated housing?" While the Best-Worst Method (BWM) provided structured data that showed which factors were considered most and least important by different stakeholder groups, it did not explain why those priorities differed among them. To explore the reasoning behind those rankings, thematic analysis was used to examine both the expert interview responses and the 25 existing literatures previously reviewed.

Thematic analysis is a qualitative method used to identify and interpret patterns or recurring themes in non-numerical data, such as interview transcripts or written texts. In this study, thematic analysis was applied in two ways. First, it was used to analyze the third-stage expert interviews. These interviews asked experts from government, industry, and academia to reflect on how they ranked factors in the BWM exercise and why they made those decisions. Their answers were carefully reviewed to identify common patterns in how they explained their thought processes, concerns, and interpretations. Themes such as "people prioritise what they know," "experience shapes judgment," "organisational roles influence perception," and "people prefer to focus on what they can control" were found across multiple interviews.

Second, thematic analysis was also applied to the 25 academic articles summarised in Appendix E. These papers originated from a range of countries and disciplines, discussing stakeholder behaviour in the context of prefabricated housing adoption. By analysing these publications, the thesis identified common themes across the literature, including the typical priorities of different stakeholder groups. For example, industry stakeholders often focused on speed, cost, and market demand; government actors emphasised public accountability and policy feasibility; and academic researchers prioritised long-term innovation, collaboration, and systemic change. The literature also showed how regional context, policy environments, and stage of adoption influence what each group values.

By combining insights from both the third-stage interviews and academic literature, thematic analysis enabled this study to go beyond merely the "what" of prioritization and uncover the underlying "why." It became clear that the differences in factor rankings were not random. Instead, they were shaped by each expert's professional background, practical experiences, institutional role, and their interpretation of abstract or unfamiliar concepts. For example, some experts rated certain factors lower simply because they hadn't encountered them directly in their work, or found them too vague to evaluate confidently (see Table 14). The details can be seen in Appendix D.

Table 14 Thematic Analysis from Expert Interviews

Theme	Government Expert (Expert 2)	Industry Experts (Expert 11, and 12)	Academic Expert (Expert 10)	Insights
What shapes their priorities?	They prioritize things they can regulate, fund, or justify to taxpayers. For example, they care deeply about financial viability and policy feasibility, because every decision must survive audits, political pushback, and implementation challenges.	They care about factors that directly impact business performance. Market demand, consumer trust, and delivery speed are crucial , not because they are trendy, but because they decide whether the company sinks or swims. If the product can't sell or be delivered on time, it is a risk.	They focus on the bigger picture: how to create change across systems. They want to enable innovation, improve training, and support collaboration. They think long-term , about climate, knowledge transfer, and institutional improvement.	**Each sector has its own "survival logic".** Government wants defensible public impact, industry wants profitability and control, academia wants transformation and insight. The same factor (e.g., sustainability) might be valued by all , but for very different reasons. That is why cross-sector disagreement is not just about preference , it is about purpose.
How does their job influence how they think?	They are trained to think at the level of systems and public programs, not individual projects. They see prefab housing not as a construction technique, but as a solution (or problem) in housing policy.	Their mental model is shaped by real-world delivery. They think in cost, logistics, workforce, and deadlines , because That is what they are paid to manage. Strategic innovation does not matter if the building fails to complete.	Their thinking is academic, policy-facing, or research-driven. They break problems into root causes and look for long-term solutions. A poor-skilled labor force is not just a problem , it is a sign of a structural skills gap.	**How people define the "housing problem" depends on where they stand.** For government, it is a public governance problem. For business, it is a product and logistics problem. For academia, it is a systemic design and knowledge problem. The factors each group chooses are symptoms of the version of the problem they are solving.
What part of the process do they feel responsible for?	They feel responsible for what happens *across* actors , not inside one company. They care about aligning policy, budgets, and actors so prefab can scale.	They feel responsible for making projects work , that means getting it built, on budget, on time. That is their zone of control.	They feel responsible for generating knowledge and influencing future practice. They can't build homes , but they can influence how others understand and design the system.	**People focus on what they can act on.** That is why many experts ignore or downplay important factors, if it lies outside their responsibility or influence, it becomes invisible. Adoption strategies must work with, not against, this logic of ownership.
How does past experience change their views?	They are influenced by past failures , like policies that did not scale, or programs that ran over budget. These failures make them cautious and push them to value feasibility.	Bad projects stay burned in their brain. If a workforce shortage caused delays last year, they'll put that at the top of their list today. Experience creates fast, instinctive judgment.	Their insights are shaped by research outcomes and field collaborations. If they've seen policy fail due to poor intersectoral coordination, they'll rank collaboration higher.	**Nothing shapes judgment more than lived experience.** Experts do not just think with theory , they think with scars. Every failure leaves a "mental shortcut" that tells them, "do not mess this up again." That is why understanding past projects is crucial to understanding current priorities.
Are their views shaped by their organization's goals?	Yes , even unconsciously. Their decisions must reflect fairness, public value, and political visibility. These institutional values limit how bold or risky they can be.	Absolutely , they think in terms of what the company wants: growth, margins, reputation. If innovation did not pay off last time, they'll avoid it. If marketing drives success, they'll focus on consumers.	Yes , their discipline (engineering, sustainability, public policy) defines what they look for. Their funding also shapes what they care about.	**Nobody is "neutral." Everyone speaks through their organizational filters.** When someone ranks a factor, they are not just expressing their opinion , they are reflecting what their job, institution, and field tell them matters. That is why you need to read expert judgments *as institutional behaviors*, not just personal preferences.
How do they feel about the BWM method?	They think BWM is helpful for comparisons , but not for understanding. It shows "what people picked" but not "why they picked it." They recommend combining it with interviews or focus groups.	They like how BWM makes people think through trade-offs. But they say it oversimplifies reality , people often have to rank things they see as equally important.	They find BWM too limiting. It forces artificial rankings and ignores context. They prefer mixed methods that allow for layered reasoning, storytelling, and nuance.	**BWM is seen as a useful map , but not the territory.** It captures the structure of opinions, but not the substance. All experts agree that **without context, BWM is misleading**. You must combine it with narrative methods to uncover what really drives choices.
Which factors are too broad or misunderstood?	They say factors like "market demand" or "collaboration" are often misunderstood because people interpret them differently , leading to inconsistent results.	They say factors like "workforce" or "logistics" look simple in theory but are deeply complex in practice. People outside the field often underestimate their difficulty.	They say factors like "innovation" or "sustainability" are flattened into buzzwords. These need unpacking , what kind of sustainability? For whom? How?	**Vague factor labels create confusion, distortion, and disagreement.** Many disagreements in ranking exercises do not come from real differences , they come from people talking about *different things using the same word*. Adoption frameworks must define factors clearly or break them into components.
Would group discussion change results?	Yes , they've seen that when people talk across sectors, they often find shared ground. A policymaker and a builder may start with different goals but discover aligned interests when they talk through constraints.	Maybe. They say discussions can reveal interdependencies, but there isa risk that powerful voices dominate or groupthink kicks in. Skilled facilitation is key.	Mixed. They value learning from others but say deep-rooted identities and training can block change. Still, they see discussion as helpful for surfacing assumptions.	**Discussion changes understanding, not necessarily preferences.** Experts may not revise their rankings, but they gain respect and clarity about why others think differently. This is crucial for multi-stakeholder decision-making , even if compromise is not always possible.
Do their priorities change with external conditions?	Yes , policy and public opinion shift priorities fast. For example, during a housing shortage, construction speed may become top priority; during a climate crisis, it is sustainability.	Yes , rising material costs, labor shortages, or customer expectations shift what matters most. The environment changes, so do the priorities.	Yes , but they frame shifts in terms of structural change. For example, a war or trade dispute shows the need for supply chain resilience or regulatory reform.	**No factor is always the most important. Context rules all.** What's critical today may be secondary tomorrow. Strategies must remain flexible and scenario-aware. Static rankings are blind to the world's instability.
What do they think will be more important in the future?	Sustainability, workforce development, and system coordination , but only if these are supported by realistic policies and budgets. They stress the need for balancing ambition with fairness.	Sustainability, skilled labor, and building consumer trust. As expectations rise, firms that can deliver "green, fast, and reliable" will lead the market.	Geopolitical change, climate adaptation, and social resilience. They believe prefab housing will need to evolve into a system that can flex with global disruptions.	**All experts converge on key rising priorities , but for different reasons.** They all mention sustainability and workforce as future essentials. But government sees them as regulatory and system challenges; ind

Table 14 presents the findings from the third stage of expert interviews, in which participants from government, industry, and academia reflected on how they prioritized key factors using the Best-Worst Method (BWM). The government sector is represented by Expert 2, academia by Experts 8, 9, and 10, and industry by Experts 11 and 12. The interviews helped explain the reasoning behind their rankings and uncovered how professional roles, responsibilities, and experiences shape decision-making.

A key insight from the expert responses is that people tend to prioritize factors that directly relate to their professional roles and responsibilities. Across all sectors, including government, academia, and industry, experts consistently emphasise the parts of the system with which they interact most frequently. As Expert 2 noted,

“People tend to value the things that affect them the most in their work.”

Expert 2 also reflected this, saying,

“I, as someone from the government sector, am more focused on things like financial viability and policy, because we must make sure public money is used wisely.”

Similarly, Expert 10 explained that people often use familiar thinking patterns, adding,

“People tend to focus on what they know best… An expert’s professional background, work experience, and personal interests all shape how they see the world.”

This pattern is not a sign of bias, but rather a reflection of practical focus. As Expert 9 observed,

“In construction, we’re constantly dealing with budgets, timelines, labour, and client satisfaction. So naturally, we focus on things like cost, speed, sustainability, and market demand because those directly impact the success of our projects.”

What matters most to experts is often what they are responsible for, what they are measured against, and where they feel they have control or influence. Expert 11 added,

“We’re trained to solve problems in our field. Also, we’re accountable for those results… so if you’re a site manager, for example, structural quality and workforce reliability are top of mind.”

These perspectives reinforce the idea that prioritisation reflects practical experience and accountability, rather than just abstract theory.

Another strong theme is that expert judgments are shaped by their **backgrounds, worldviews, and personal experience**. Experts from various fields, including civil service, business, engineering, and policy, bring multiple perspectives to the table. For example, Expert 2 explained,

“I see the whole housing system, where the bottlenecks are and what slows things down.”

This systemic perspective leads to a focus on financial viability and regulatory frameworks. On the other hand, industry professionals may be more concerned with consumer perception or speed, as they view these as key factors in achieving profitability and market success. Expert 9 summarised it:

“People’s jobs and fields of study shape how they rank things.”

Worldview also plays a role. For example, Expert 10 noted that

“Values like social equity or systems thinking can shape what people prioritize, not just their job.”

An academic researcher might prioritise sustainability or collaboration because they are considering the long-term societal impact, while a business-oriented expert might focus on what delivers immediate results. Expert 9 explained that even within the industry, different teams emphasize different things:

"Clients and consumers are also starting to expect this… so building public trust will be just as important as building homes."

These diverse perspectives show that expert opinions are shaped not only by organizational roles but also by personal beliefs and disciplinary training.

Experience, especially from past projects, also has a significant impact on how experts prioritize tasks. Many experts shared how specific failures or successes have left a lasting impression. As Expert 11 shared,

"If you've worked on a project where delays happened because the components did not arrive on time, supply chain efficiency will probably stick out as a key issue for you."

Similarly, another expert explained,

"We tend to remember what went wrong and what went well. These experiences shape what we think matters most, even if we do not realize it at the time."

These reflections point to the idea that personal experience creates new "mental patterns," as Expert 10 described it:

"Once you've 'felt' a failure, you never see that issue the same way again."

Once someone has experienced the real impact of a factor, good or bad, it becomes impossible to ignore in future decisions.

This also explains why different experts may rank the same factor differently, even if they come from the same sector. For example, someone who has worked on a successful collaborative pilot project may rank "industry collaboration" higher. In contrast, another expert from the same organization who worked on a failed project may be more sceptical. As Expert 10 put it,

"These lessons shape how experts recalibrate their judgment based on what worked, or did not, in similar contexts."

Organizational culture and priorities also shape expert perspectives. Experts often act as representatives, consciously or unconsciously, of the institutions they work for. Expert 10 said this clearly:

"People almost 'speak for' their institutions, even unconsciously."

For example, an expert from the private sector may emphasise profitability and consumer trends because those align with their company's goals. At the same time, someone from a nonprofit or government agency might focus more on social impact, regulation, or equity. Expert 2 explained that.

"Personal and professional bias explain smaller differences in rankings. But some of the big differences, like how sectors view financial viability or sustainability, come from deeper differences in how each sector sees its role."

This means that what experts say is often shaped by the expectations, mandates, and norms of their workplace. It is not just personal opinion. It is embedded in organisational thinking.

Many experts also reflected on the **limitations of ranking methods**, such as the Best-Worst Method (BWM). While they appreciated its clarity and structure, they agreed that it could oversimplify how people think. Expert 10 was especially critical, stating that,

"BWM oversimplifies real reasoning and forces unfair tradeoffs," such as choosing between two equally important factors.

Expert 11 added, *"People might rank a factor low not because it is unimportant, but because it is hard to measure or control… BWM does not capture the reasons behind the choices."*

Experts suggested combining BWM with interviews, which have already been done in this research, workshops, or open-ended questions to capture more nuanced thinking. Expert 2 also supported this idea, saying,

"BWM gives a simple way to compare rankings, but it does not show what's going on underneath."

Another important insight was that **some factors are too broad or under-defined**, making them difficult to rank consistently. For instance, "consumer perception and market demand" was seen as a vague term that can mean very different things depending on the expert's background. Expert 10 pointed out that,

"Consumer trust includes values, experience, and marketing," not just market size or willingness to buy. Similarly, "industry collaboration" is more than just partnerships; it involves deep coordination, trust, and shared incentives across multiple actors. Experts noted that these broad labels risk oversimplifying complex, real-world issues. As Expert 9 noted from experience,

"Having a skilled and reliable workforce is one of the biggest challenges in construction, especially with new technologies like prefabrication. But this factor is sometimes treated as a background issue, rather than a top priority."

Experts also agreed that **group discussions could help reveal common ground**, even if individual rankings suggest disagreement. Expert 2 reflected,

"In real-life meetings between industry and academia, people often agree on many things after talking them through."

However, others warned that discussions might not alter core priorities, but could still foster a shared understanding. Expert 10 was sceptical, stating,

"Group talks might reinforce existing beliefs rather than change them."

Meanwhile, Expert 11 raised a valid concern about dominant voices influencing others, noting, *"Some participants are less confident or more deferential."*

Finally, all experts agreed that **priorities are not fixed. They shift when external conditions change**. Expert 9 pointed out that,

"In construction, we have to adapt fast when conditions change… if there were a housing shortage, speed and supply chain efficiency would jump to the top."

Expert 11 gave a clear example from industry, saying,

"If stricter climate policies were introduced, sustainability would become a bigger priority."

Expert 10 added that,

"War or geopolitical instability could shift the focus toward supply chain resilience and basic structural durability."

Expert 2 captured the government view, noting that,

"External conditions change what people think is important… policies should be strong enough to encourage better practices, but not so strict that only a few companies can meet them."

Looking to the future, most experts anticipate that **sustainability, workforce development, and consumer trust** will continue to grow in importance. Expert 9 emphasised the growing role of climate goals:

"As regulations around carbon emissions are tightened, we will need to build in greener ways, using better materials and reducing waste."

Expert 11 added,

"Workforce development is also critical… prefabrication requires a different set of skills, so we will need to invest more in training."

Lastly, Expert 10 concluded that, *"Public trust in prefabricated housing will determine how fast the market grows. People must feel confident in buying and living in prefab homes."*

Tables 15 explain the thematic analysis based on the literature findings.

Table 15 Thematic Analysis from 25 Literatures

Theme	Government Experts (Municipal Housing Officers, National-Level Policy Advisors, And Officials Working in Public Infrastructure, and Urban Development)	Industry Experts (Modular Housing Developers, Architecture and Engineering Consultants, Prefabricated System Manufacturers, And Construction Firm Directors)	Academic Experts (University Professors, PhD Researchers, And Built Environment Scholars from Fields Like Architecture, Sustainable Construction, and Housing Policy)	Overall Insight
What shapes their priorities?	Priorities are shaped by public accountability, political feasibility, and budget restrictions. Government actors operate under political constraints and must ensure any adoption decision is publicly defensible, legally compliant, and feasible across national and municipal levels.	Priorities are driven by cost-efficiency, delivery speed, and client satisfaction. The sector focuses on immediate performance indicators like demand, logistics, and reputation, as these are critical for winning contracts and staying competitive.	Priorities are guided by systemic insight, interdisciplinary collaboration, and long-term impact. Academic experts aim to uncover root causes of inefficiencies and design interventions that are scalable and sustainable beyond short-term metrics.	Each sector has its own “survival logic.” Government seeks public legitimacy and system feasibility, industry seeks short-term success and delivery control, and academia seeks long-term transformation and knowledge generation. A shared factor like “sustainability” is interpreted differently by each: as a regulatory constraint (gov), a market opportunity (industry), or a systemic goal (acad).
How does their job influence how they think?	Government roles train experts to think in terms of inter-institutional alignment and governance bottlenecks. They tend to emphasize legality, administrative continuity, and accountability to national goals.	Industry roles shape a mindset focused on resource management, execution, and deliverability. Business leaders think through risk, consumer expectations, and operational stability.	Academic roles are grounded in research and theory, with a focus on diagnostics and system reform. Academics think in pathways, variables, and complex causality.	Experts interpret the adoption problem through the lens of their professional roles. This lens functions like a filter: it directs attention toward sector-relevant constraints and away from others. Without accounting for this lens, stakeholder expectations may appear incompatible.
What part of the process do they feel responsible for?	Government experts are responsible for coordination and policy frameworks that enable large-scale adoption. They focus on regulation, incentives, and public programs.	Industry experts feel directly responsible for building delivery, market fit, and operational success. They work within the boundary of their control: workforce, logistics, and contracts.	Academic experts contribute through producing knowledge and shaping discourse. They influence visions, diagnostics, and policy discussions, even if they do not control implementation.	Each sector emphasizes the part of the adoption pipeline it can influence. This shapes its factor rankings. The government pushes enablers, industry prioritizes executional reliability, and academia proposes systemic correctives.
How does past experience change their views?	Past implementation failures , like underused pilot programs , shape their caution and focus on feasibility. They fear repeating misaligned policy designs.	Negative outcomes , such as delivery delays or unmet promises , create strong aversion to complexity or untested approaches. Prior experience makes reliability central.	Academics reflect on past research and policy trials to shape future designs. When a factor failed to show impact in past literature, it is down-ranked.	Experts are highly influenced by institutional memory , especially negative experience. Risk aversion stems not from conservatism, but from real consequences. Rankings are not theoretical , they are protective reactions to perceived threat based on what did not work.
Are their views shaped by their organization’s goals?	Their perspective reflects state logics: ensure legality, protect equity, manage tax money responsibly. Organizational mandates encourage conservative, scalable approaches.	They respond to market and internal goals: reduce risk, maximize return, and protect reputation. Culture and client feedback shape how new approaches are judged.	Organizational values around independence, originality, and theory steer priorities toward structural interventions rather than delivery issues.	Sectoral mandates shape what actors think is “rational.” Choices reflect institutional survival rather than personal opinion. For example, workforce development is top-ranked by industry not due to ideology but because of delivery risk.
How do they feel about the BWM method?	BWM is useful but requires context. Government experts value comparisons but emphasize that ranking is meaningless without narrative justification.	Industry sees BWM as practical for simplifying decisions. However, they warn that factors treated as equal in real life are forced into a hierarchy that does not reflect execution realities.	Academics view BWM as an oversimplification of reasoning. They advocate mixed methods, warning that such rankings risk de-contextualizing judgment.	BWM is a structured method, but not a full method of understanding. All sectors agree: it cannot reveal the “why” without qualitative explanation. Interpretations must go beyond number tables.
Which factors are too broad or misunderstood?	Terms like “market demand” or “policy support” are vague and context-dependent. Some factors were misranked due to different interpretations.	“Workforce” or “logistics” are seen as underexplored. Industry finds these factors to be multi-dimensional and more fragile than outsiders realize.	Abstract terms like “sustainability” or “collaboration” lack operational clarity. These need to be unpacked into specific forms.	Experts often assign different meanings to the same term. Rankings of a factor may reflect different versions of it. Without shared understanding, comparison becomes unstable.
Would group discussion change results?	Yes , they believe shared assumptions and bottlenecks would emerge through inter-sectoral dialogue. Group dialogue reveals mutual constraints.	Possibly , they acknowledge it may foster shared understanding but fear power dynamics and dominant voices could distort consensus.	Maybe , they expect it to surface contradictions and prompt reflection, but disciplinary loyalty may still prevent convergence.	Discussion changes the **understanding** of disagreement, even if it does not change the rankings. Dialogue fosters mutual learning, context exchange, and realistic mapping of cross-sector tensions.
Do their priorities change with external conditions?	Yes , shifts in public demand or political momentum can reprioritize what is feasible. Example: housing crises elevate speed and workforce.	Yes , disruptions like inflation or material shortage quickly change delivery risk, reshuffling priorities.	Yes , but the interpretation is broader. Crises are seen as signals of structural imbalance that reinforce the need for deeper reform.	All sectors agree that priorities are **fluid**, not static. External shocks reconfigure what matters. Hence, any adoption model must allow dynamic factor weighting.
What do they think will be more important in the future?	Labor capacity, workforce digital skills, and sustainability are seen as key future issues. These must be framed with fairness and equity for public adoption.	Labor availability, sustainability, and reputation risks are future threats. Companies will need to market trust and manage green transitions.	Geopolitical disruptions and structural resilience will drive the need for modular, flexible, and systemically sustainable solutions.	There is **convergence on future themes**: labor force, trust, and sustainability. But each sector links these to different mechanisms: compliance (gov), delivery (industry), transformation (acad). Strategies must tailor entry points per actor.

Table 15 summarises findings from the thematic analysis of 25 existing studies on the adoption of modular and prefabricated housing. The tables classify experts into government, industry, and academia, which aim to make the triangulation process simpler. What it means by government experts are those working in government sectors such as municipalities, policy analysts, and those related jobs. Meanwhile, industry experts include contractor, developer, engineering consultant, and other housing provider jobs. Last, academia experts are those who involve in research and development within the universities (see **Appendix E**). The table compares common themes across different countries, stakeholders, and study methods. The goal is to understand what factors are valued, why, and how these views vary depending on roles, experiences, and regions.

Understanding Why Different Stakeholders Value Different Things

In the adoption of prefabricated housing, stakeholder groups, including industry, government, and academia, prioritise different factors based on their institutional roles and objectives. Industry actors, including developers, contractors, and manufacturers, tend to focus on cost reduction, construction speed, and return on investment. Market dynamics, resource efficiency, and project-specific performance indicators often drive their decisions. Government stakeholders, meanwhile, are expected to provide enabling frameworks through supportive policies, financial incentives, and public housing programs. However, the extent and consistency of government involvement vary significantly by region. Academic researchers typically prioritise innovation, systemic design, and the use of models to analyse long-term impacts and adoption patterns of new technologies.

Regional context further shapes which factors are considered essential. For example, strong central planning and state support in China have accelerated the adoption of prefabrication, while countries like the UK have faced more policy fragmentation and uncertainty. In Japan, prefabrication is treated as a high-tech sector with a strong emphasis on quality and branding. These international cases illustrate that local governance structures, regulatory environments, and cultural expectations strongly influence stakeholder priorities.

The Role of Professional Background and Past Experience

Stakeholders' perspectives are not only shaped by their sector but also by their specific roles and experiences. For instance, developers who manage timelines and budgets emphasise cost control and construction risk mitigation. Government officials may focus more on regulatory compliance, social equity, and public accountability. Academics, in contrast, are oriented toward diagnostic thinking, research impact, and innovation potential. Moreover, these viewpoints are dynamic and can change across the lifecycle of a project. At early stages, technical feasibility may dominate, while at later stages, public perception or regulatory approvals may take precedence. External triggers, such as political shifts or housing shortages, can also reconfigure stakeholder priorities in real time.

Resistance to change is often cited in the literature as a significant barrier to the adoption of prefabrication, frequently more so than technical limitations. Even when viable prefab technologies exist, actors often revert to familiar practices due to institutional inertia, risk aversion, or limited exposure to alternative methods. This highlights the importance of addressing behavioural organisational change, not just technological readiness.

Invisible and Undervalued Factors in Decision-Making

Another consistent theme across the literature is that many “invisible” or qualitative factors, such as public trust, design quality, and user satisfaction, are often undervalued in formal decision-making processes. Because they are challenging to measure and standardise, these elements tend to be deprioritised in favour of easily quantifiable metrics, such as cost, speed, or emissions. However, researchers argue that these softer factors are essential to long-term adoption success. For example, if residents perceive prefab housing as unattractive or inferior, uptake will remain low regardless of technical merits. In many countries, prefabrication is still associated with temporary or low-income housing, which undermines consumer confidence and limits market demand.

The lack of attention to these aspects also explains why some well-designed prefab projects fail to scale. Without strategic efforts to improve public perception, enhance design aesthetics, and build community acceptance, even technically sound solutions can be met with resistance or indifference due to organisational Bias and Fragmented Perspectives.

The literature emphasises that each stakeholder group brings its own institutional bias or "lens" when evaluating prefab housing. Industry prioritises operational feasibility and project delivery, government actors assess policy compliance and budget constraints, and academics seek to identify systemic patterns and long-term improvements. These differences often lead to fragmented planning, poor coordination, and misaligned expectations. In some cases, such fragmentation occurs even within the organisation, for example, between technical engineers and project managers, or between design teams and financial planners.

Improved communication across stakeholder groups is frequently cited as a necessary step toward better alignment. While many studies advocate for integrated planning and intersectoral dialogue, real-world implementation remains limited. The lack of structured opportunities for cross-sector engagement often perpetuates misunderstandings about what each actor values or perceives as barriers.

Commonly Overlooked but Critical Issues

Numerous studies identify important factors that are often mentioned in theory but neglected in practice. These include training programs for prefab-specific skills, coordination between factory production and on-site assembly, and design choices that reflect user preferences or local identity. Other under-discussed issues include insurance coverage for prefab buildings, financing mechanisms tailored to modular construction, and the adoption of digital tools such as Building Information Modelling (BIM). The absence of these components can create hidden barriers to adoption, even when other foundational elements, such as cost and policy alignment, are in place.

This literature gap highlights the importance of approaching prefabricated housing not only as a construction innovation but also as a socio-technical system. Without addressing these enabling conditions, adoption efforts may falter regardless of technological readiness or market potential.

Impact of Changing External Conditions

The priorities of stakeholders are also shown to be highly sensitive to external changes. Events such as natural disasters, pandemics, shifts in climate policy, or housing crises can rapidly change what stakeholders consider essential. For instance, during emergencies, speed of delivery becomes a top concern. When environmental policy gains momentum, sustainability-related factors are reprioritised. Yet external incentives alone are not always sufficient. A lack of stakeholder readiness, trust, or institutional capacity can quickly reverse progress if not carefully managed.

Different studies emphasise different triggers, ranging from disaster recovery to affordability and climate targets. Still, they all point to the same conclusion: external conditions play a decisive role in shaping adoption pathways, and any prefab strategy must be flexible enough to accommodate evolving priorities.

Looking Ahead: Shared Needs, Diverse Entry Points

Despite their differences, most studies converge on what is needed to support prefabricated housing in the long term: consistent policies, stronger public engagement, skilled labour development, and better integration of digital planning tools. While some argue that rebuilding public trust is the most urgent challenge, others highlight access to financing or regulatory reform as key priorities. What is clear across the literature is that the adoption of prefabrication requires a coordinated effort from government, industry, and academia.

Countries like Japan, for instance, have successfully combined high-quality design, consumer branding, and strong industry standards. Others, such as the UK, are working to reverse the stigma associated with prefabricated housing. China's rapid growth in the sector illustrates that centralised policy support can act as a catalyst.

Ultimately, the literature frames prefabrication not just as a technical innovation but as a complex social process that must align with user values, institutional capacities, and evolving societal goals.

a) Triangulation

In this study, triangulation was used to compare and connect findings from two different sources: the **third-stage expert interviews** and the **analysis of 25 existing academic studies**. The goal was to gain a deeper understanding of why experts from government, industry, and academia prioritise certain factors differently when it comes to adopting prefabricated housing. While the interviews provided real-world insights based on personal experiences and job responsibilities, the literature review offered a broader view from published research across different countries and contexts. By placing these two perspectives side by side, triangulation helped identify the similarities between those two sources, while also identifying the differences between the existing literatures, and new insights gained from the third stage interview.

Table 16 Triangulation between the existing literatures & expert interviews

Theme	Literature Insights	Interview Insights	Triangulated Insights
What shapes their priorities?	Each group (government, industry, academia) focuses on what matters most to them. Government cares about rules and accountability, industry about getting things done, and academia about long-term effects. Even common terms like "sustainability" mean different things depending on who you ask.	Experts confirmed this. Government wants visible and reportable results, industry wants smooth delivery and sales, and academia wants to generate new knowledge. Even when they use the same words, they mean different things. All experts also agree that they tend to devalue factors that are considered vague and not familiar with their job description.	Even though the factors in the literature and interview are different, **both agree** that people prioritize what helps them succeed in their own jobs. Differences are not because they disagree, they just have different goals. Same words, different meanings.
How does their job influence how they think?	People's roles shape how they see the world. Government uses a policy lens, industry focuses on time and cost, academia looks at systems and causes.	Experts talked only about things in their job scope. Government people discussed financial & programs, industry talked about workers and delivery, academics focused on root problems.	What people do every day shapes what they notice or ignore. They don't just have different opinions, they see different parts of the puzzle.
What part of the process do they feel responsible for?	Government works on support systems (like rules and funding), industry builds and delivers, academia studies and advises. People focus on their own part and ignore others.	Experts admitted they tend to care only about what's under their control. If something is not their job, they do not pay much attention to it.	People focus on what they are responsible for. This explains why collaboration is hard, everyone is looking at different pieces.
How does past experience change their views?	Past mistakes (like bad policies or failed projects) make people more careful. Experience teaches them what to avoid.	Experts shared emotional stories: delayed projects, tough audits, or ignored research. These stories clearly shaped what they now see as most important.	Both confirm that experience matters a lot. People learn from mistakes and will never forget it.
Are their views shaped by their organization's goals?	People often follow what their organization cares about. Government focuses on public good, industry on profit, academia on research and funding.	Experts said they sometimes chose factors not because they believed in them, but because "That is what my boss or organization wants me to care about."	What people say they value often reflects what their workplace values. It is not just personal opinion, it is also about fitting into the system.

How do they feel about the BWM method?	None of literatures have used BWM Analysis.	Experts like BWM for forcing decisions, but say it can't show the reasoning behind choices. They all said follow up questions in the interviews were needed alongside it.	Solely from the expert interview because none of the existing literatures have used BWM for prefabricated housing context, BWM is useful for ranking things, but it does not tell the whole story. Everyone agrees it should be used with interviews to explain the rankings.
Which factors are too broad or misunderstood?	Terms like "collaboration" or "sustainability" are vague. People interpret them in different ways depending on their background.	Experts gave examples: "collaboration" could mean government teamwork, industry partnerships, or academic networking. Same word, different idea.	**Both agree.** The problem is not disagreement, it is different definitions. People rank the same factor differently because they think it means something else.
Would group discussion change results?	Literature suggests that talking across sectors could help people understand each other better, but warns that it may not be easy.	Experts liked the idea but worried that louder voices might dominate. Some said real discussion would need a skilled moderator.	**Both agree.** Talking helps, but only if done right. Without good facilitation, power imbalances and misunderstandings could get worse instead of better.
Do their priorities change with external conditions?	Yes. Events like inflation, COVID, or climate policy shifts can change what people focus on.	Experts said their focus shifts too, government responds to public pressure, industry to costs and delays, academia to big structural risks.	**Both agree:** Everyone adapts when things change, but they respond in their own way. Understanding these patterns helps make policies that work for all sides.
What do they think will be more important in the future?	Literature points to labor shortages, sustainability, and resilience as rising concerns. These issues are becoming urgent worldwide.	Experts agreed. Everyone mentioned labor and sustainability. Government wants to meet regulations, industry needs reliable workers, academia wants long-term solutions.	**Both agree:** The same big issues matter to everyone, but for different reasons. Planning for the future means understanding why each group cares, not just what they care about.

Table 16 presents triangulation, a comparison between insights gathered from the literature and those obtained through the third stage interviews, focusing on how Triple Helix, government, industry, and academia, view and prioritize various factors related to the adoption of prefabricated housing in the Netherlands. The findings highlight both similarities and differences across sectors, which offers a more complete understanding of how theoretical knowledge aligns (or does not align) with real-world practice.

a) Understanding Why Some Factors Are Valued More

The academic literature widely agrees that professionals tend to prioritise factors that align with their functional roles and institutional interests. Wu et al. (2024) mapped this trend using network analysis, showing that developers emphasised input costs, economic returns, and market scalability, whereas government actors prioritised regulation and policy incentives. Financial experts are drawn to cost efficiency and profitability, and construction professionals focus on technical feasibility and logistics (Wu et al., 2024).

Shah et al. (2023) added that public perception remains poorly understood and often underestimated; only 54% of surveyed UK citizens could identify a prefabricated house, suggesting widespread unfamiliarity (Shah et al., 2023). Adeyemi et al. (2024) also observed that while regulatory barriers and quality control receive considerable attention in design-focused studies, factors such as social trust and community acceptance are less emphasised due to their subjective nature (Adeyemi et al., 2024).

The interviews confirmed that people indeed prioritise what they are accountable for. Financial officers discussed financial risk, while delivery specialists focused on logistics and timeliness. Interviewees also tended to devalue vague or unfamiliar concepts such as "collaboration," unless they were directly engaged in cross-sector work. In this way, the interviews validate literature insights, but also reveal a more profound logic: people trust their intuition and professional experience over abstract constructs.

It is understandable. Naturally, people tend to be selfish. In this context, they will choose or prioritise things that are familiar and closely aligned with their job description and institutions. This then confirms the importance of involving more people from different sectors in this study, so that all perspectives are gained.

b) Sectoral Influence: Background, Worldview, and Role

The literature clearly outlines how stakeholder affiliation shapes prioritisation. Sobolewski and Zatyrb (2024) emphasised that public-sector actors focus on affordability and compliance, seeing prefabrication as a tool to meet national housing targets. In contrast, industry actors prioritise speed and cost, as evidenced by studies from India and Pakistan, where prefabrication was pursued for cost-saving efficiency (Masood et al., 2021). Park (2017) documented that academic evaluations leaned toward design quality, identity, and innovation, focusing on systemic impact rather than near-term deliverability (Park, 2017).

The interviews reaffirmed this sectoral divergence. Government experts were highly focused on budgeting and accountability. Industry actors often mentioned supply chain management and profitability, while academic participants spoke more frequently about systems thinking, long-term impact, and cross-disciplinary collaboration. However, the interviews also introduced nuance: several experts reflected on how their priorities evolved across career stages, particularly when transitioning from research to policy or practice, and their judgment of “what matters most” shifted accordingly.

It is also very common in human nature. Job focus and role would shape the identity of people, and then influence the way they think, prioritise, and also affect their judgments.

c) How Experience Shapes Judgment

Literature frequently references the importance of institutional memory and project history in shaping decisions. Masood et al. (2021) and Li et al. (2020) found that previous project delays, defects, or regulatory hold-ups often lead practitioners to repeat those same issues in future decision-making. Deka et al. (2022) similarly highlighted that failed prefab implementations in India shaped how regulators now view customisation and quality assurance (Masood et al., 2021; Li et al., 2020; Deka et al., 2022).

Interviews strongly supported this theme. Several participants ranked issues such as site disruptions, misaligned regulations, or unclear stakeholder roles as critical, often because they had previously encountered those exact failures. This experiential lens helped them form cognitive shortcuts or “red flag” indicators. Interviewees did not necessarily rely on the literature to inform these priorities; instead, their scars from previous projects served as primary guides.

Experience is indeed the best teacher. It is natural for people to be more cautious with things associated with past bad experiences. However, each expert from a different sector experienced different hardships related to the implementation of prefabricated housing, which tends to focus on that aspect without considering other factors.

d) Undervaluing Abstract or Cross-Cutting Factors

Many studies highlight that abstract factors, such as “trust,” “collaboration,” or “public image,” are often acknowledged but rarely operationalised. Wu et al. (2024) and Steinhardt and Manley (2016) found that while industry chain alignment and stakeholder engagement are theoretically important, they are inconsistently interpreted and challenging to measure (Wu et al., 2024; Steinhardt & Manley, 2016). Gorgolewski (2005) and Shah et al. (2023) both argued that public trust in prefab housing is limited, due in part to historical failures and visual stigma (Gorgolewski, 2005; Shah et al., 2023).

Interviewees echoed this concern. Some admitted skipping “public perception” in rankings because they “never worked with it” or “did not know how to evaluate it.” Others confused collaboration with procurement or wrongly assumed trust was irrelevant in technical roles. These insights confirm that vagueness and lack of personal experience both contribute to the underweighting of important abstract dimensions.

Ultimately, it is also common for people to overlook things they do not fully understand, due to bounded rationality. They will be more confident if they know things, and they will focus on the areas with which they have the highest familiarity.

e) Organisational Bias and Sectoral Echo Chambers

Tam et al. (2007) and the Canadian Manufactured Housing Institute (2011) emphasised that institutional mandates significantly influence individual prioritisation. Profit-driven firms prioritise scalability and client appeal, while public agencies focus on social impact and compliance (Tam et al., 2007; Canadian Manufactured Housing Institute, 2011). West (2008) described how organisational inertia can prevent consideration of broader sustainability or community-oriented goals (West, 2008).

Interviews brought this into sharp relief. Some experts acknowledged that their rankings aligned with their employer’s mission or KPIs. A private-sector interviewee admitted that “if it does not touch the bottom line, it will not rank high.” Conversely, a policymaker stated that “profitability is not relevant if the project does not serve the community.” These responses illustrate how institutional identity often overrides personal opinion, even if the individual believes they are being objective.

Yes, that makes sense. We as individuals are associated with the places we belong: home, office, and school. That shapes us. That shapes the way we think.

f) Shifting Priorities Through Context and External Shocks

The literature affirms that priorities shift under external pressure. The COVID-19 pandemic is described by Sobolewski and Zatyrb (2024) as a tipping point that redefined buyer needs in Central and Eastern Europe, elevating themes like health, speed, and resilience (Sobolewski & Zatyrb, 2024). Adeyemi et al. (2024) demonstrated that evolving climate policy has compelled sustainability to become a mainstream component of industry agendas, while geopolitical concerns are driving the need for more domestic sourcing and circular supply chains (Adeyemi et al., 2024).

Interviewees also observed that external shocks such as housing crises, environmental disasters, or political reform can override traditional priorities. A few noted that events like wildfires or wars made sustainability and resilience unavoidable, even for cost-focused actors. This adaptive thinking suggests that prioritisation is not static; it is elastic, especially under real-world stress.

g) Prospective Shifts: Looking Forward

Literature suggests an impending pivot toward long-term, systemic factors. Wu et al. (2024) and P.Z. & E.N.F. (2024) predict growing importance of workforce development, inclusivity, and sustainability, especially as housing demands and labour shortages increase (Wu et al., 2024; P.Z. & E.N.F., 2024). Social acceptance, trust, and consumer willingness are no longer peripheral; they are becoming central metrics of success.

Interviewees generally agreed. Many anticipated that energy policy, green certifications, and workforce re-skilling would dominate the prefab housing agenda within five years. Some worried about trade instability or talent gaps affecting supply chains. Others emphasised that consumer trust would shape public procurement and market demand alike. These forward-looking views from practitioners reinforce the trajectory set by academic literature

6) Conclusion, Recommendation, and Implications

6.1 Conclusion

This study identifies key factors influencing the market adoption of prefabricated housing in the Netherlands, a pressing issue given the country's housing shortage and climate goals. While prefabricated construction methods promise faster, cleaner, and more sustainable housing solutions, adoption remains limited and inconsistent. To understand this, the study combined an extensive literature review with expert interviews from government, industry, and academia (Triple Helix). It applied the Best-Worst Method (BWM) to rank the importance of various factors and followed this with thematic analysis and triangulation to explain why different experts prioritize different factors, even within the same sector.

The results show that **(1) Financial and Economic Viability (0.1919)** is the most influential factor across all sectors. Experts agreed that without affordability for consumers and profitability for developers, the benefits of speed, sustainability, or design flexibility lose significance. Key issues include high upfront investment costs, taxes on materials and labor, and the need for stable demand to justify factory-scale production.

(2) Consumer Perception and Market Demand (0.1808) was the second-highest factor. Experts highlighted that although prefabricated housing has many technical benefits, public perceptions often lag behind. In the Netherlands, some still associate prefab housing with being temporary, unattractive, or lower quality. This perception gap limits demand and investor interest. To address this, experts emphasized the importance of aesthetics, personalization, and trust-building to normalize prefab as a desirable housing option.

In third place is **(3) Policy and Regulatory Support (0.1303)**. Experts pointed out that adoption is smoother when regulations are clear, permitting is fast, and the government actively supports industrial-scale construction. Suggestions included standardizing building codes, offering subsidies, and creating “fast-track” pathways for prefab projects to get approved more quickly.

(4) Speed and Construction Efficiency (0.1134) follows next. This factor reflects one of the strongest selling points of prefabrication, faster delivery times thanks to off-site construction and parallel workflows. This advantage is especially important for tackling emergency housing needs and long waitlists. Still, its real impact depends on whether developers and buyers have the right incentives to choose prefab over traditional methods.

(5) Sustainability and Environmental Impact (0.0999) was ranked fifth. While prefabrication offers strong potential to reduce waste, use eco-friendly materials, and support circular construction goals, experts noted that these benefits usually only gain importance when tied to regulations or financial rewards, such as green investment policies or carbon taxes.

Next, **(6) Industry Collaboration and Workforce Development (0.0827)** was highlighted as a bottleneck. The prefab ecosystem struggles when architects, builders, policymakers, and suppliers work in silos. Experts called for more coordination across the value chain and better training for workers in digital tools (like BIM), modular techniques, and industrial processes. Without this collaboration, it is hard to scale production or ensure smooth implementation.

(7) Structural Quality and Durability (0.0735) was seen as less critical for adoption today, even though it remains an important factor. Experts agreed that modern prefab systems are usually code-compliant and technically sound. The bigger challenge is public confidence, ensuring people believe these homes can last, perform well, and provide long-term value.

Ranked eighth is **(8) Technological Advancements and Standardization (0.0667)**. While often emphasized in literature, experts felt the key technologies (e.g., BIM, 3D printing, digital fabrication) are already available and not the main issue. The problem is applying them consistently across different projects and sectors, not inventing new tools.

Finally, **(9) Supply Chain and Logistics Efficiency (0.0609)** was ranked lowest. While logistics, such as just-in-time deliveries or low-emission transport, are important, experts felt they are not major barriers in the Dutch context. The country's strong infrastructure makes logistics challenges relatively manageable compared to more pressing issues like cost or consumer trust.

From the thematic analysis and triangulation, the study also found that factor prioritization is shaped not only by sector but also by individual expert roles and experiences. For instance, an academic working on circular economy may focus on financial viability, while another expert in housing policy may emphasize collaboration. These differences show that people often prioritize what they directly work on and what they are held accountable for.

Because of this, some factors, like Consumer Perception or Industry Collaboration, tend to be underestimated. These are difficult to measure, fall outside the responsibility of any one institution, and don't easily fit into economic models. Yet they are essential. A house is not just a physical product, it represents culture, lifestyle, and identity. If these human dimensions are ignored, prefab housing may continue to be seen as temporary or inferior, no matter how technically advanced it is.

Finally, the study highlights a disconnect between literature and practice. While research often promotes innovation, sustainability, and system change, practitioners tend to focus on what's practical now, costs, returns, risks. Bridging this gap will require more integrative thinking that connects long-term vision with on-the-ground constraints.

In conclusion, adoption of prefabricated housing in the Netherlands depends on a complex mix of financial, social, policy, technical, and institutional factors. Addressing one factor in isolation is not enough. Real progress requires shared priorities, better incentives, and a shift in how value is defined, one that includes not just cost and speed, but also trust, social acceptance, and resilience. With the right alignment, prefabrication can grow from a niche innovation into a mainstream solution for sustainable and inclusive housing.

6.2 Recommendation

To increase the adoption of prefabricated housing in the Netherlands, several practical steps need to be taken. The findings of this study indicate that **economic and financial viability, public perception, market demand,** and **policy and regulatory support** are the key factors influencing the success of this initiative. Therefore, the priority should be to reduce the financial risks for developers and housing providers. This means making it easier to cover the upfront investment costs needed to build factories, purchase equipment, and maintain a steady production line. The government can help by offering tax breaks on prefabricated materials and labour, providing financial guarantees, and offering public housing projects a longer-term commitment to purchase prefabricated homes. These measures would help stabilise the market and encourage more companies to invest.

Another important recommendation is to improve the public's perception of prefabricated housing. Many people still associate it with low-quality or temporary buildings. Changing this view is essential to increasing demand. One way to do this is by building pilot projects or demonstration homes that show the comfort, design quality, and sustainability of prefab units. Offering future homeowners the chance to customise or co-design parts of their homes could also help make prefabricated housing feel more personal and appealing.

Policies and regulations also need to be adjusted. Currently, developers often face unclear rules and lengthy approval processes, which can delay construction. A faster and more consistent approval path is needed, especially for industrialised housing methods. National and local governments should collaborate to establish standardised procedures and update zoning regulations to accommodate prefabricated housing. Municipalities could also test quicker permit processes for prefabricated housing under special housing programs or sustainability initiatives.

It is also essential that public buyers, such as social housing agencies or municipalities, recognise the value of speed and low disruption that prefabrication can offer. They can include these benefits in their procurement requirements, which makes it more likely that prefab suppliers will be chosen. At the same time, sustainability goals should be linked with tangible rewards, such as access to special funding or higher scores in housing tenders, so that builders have a reason to choose prefab as a greener option.

For prefab to grow, it is not just the houses that need to be ready. It is also the people. More collaboration is required across companies, designers, builders, and local governments. Industry groups and partnerships can help share lessons, establish standards, and mitigate confusion. Additionally, training programs are necessary to prepare workers for the various skills required in modular construction, both in factories and on-site.

Although structural quality is generally no longer a concern, it remains essential to ensure that prefab housing offers a good experience for its users, particularly in terms of privacy, comfort, and attractive design. These elements influence whether people accept prefab housing as a real, long-term solution. More data about durability and long-term performance can also help convince investors and landlords.

In terms of innovation, the focus should shift from creating new technologies to better using the ones we already have. Many tools, such as Building Information Modelling (BIM) and automated systems, already exist. The key is to make them work together more smoothly, for example, by improving how they connect with permit systems or logistics planning.

While logistics is not the most significant barrier right now, in the future, if prefab housing becomes more common and happens at a larger scale, transporting all those parts could become more complicated and time-consuming. One way to avoid this is by building **smaller factories that are closer to the construction sites**. This would mean **shorter transport distances**, **faster delivery, and fewer trucks on the road**, which will reduce traffic, fuel use, and pollution. Additionally, the factory and the building site must collaborate **closely** and maintain effective communication. If the prefab parts arrive too early or too late, it can cause problems like storage issues or construction delays. With better planning, everything can run more smoothly.

Finally, the biggest challenge is that each sector, government, industry, and academia, tends to focus on different goals. This study reveals that individuals have diverse priorities, influenced by their respective roles and responsibilities. To move forward, there needs to be a shared direction. Policymakers, builders, and researchers should collaborate to establish common goals and convey a straightforward narrative about how prefabricated housing can contribute to solving the housing crisis. This shared effort should include not only measurable outcomes, such as cost and time, but also harder-to-measure values, like public trust, aesthetics, and long-term social acceptance.

By following these recommendations, the Netherlands can make significant progress in integrating prefabricated housing into its housing system as a more widely used and accepted option.

6.3 Theoretical Implications

This study advances theoretical understanding across multiple intersecting domains, innovation adoption, sociotechnical transitions, institutional governance, and decision science, by analyzing the adoption of prefabricated housing in the Netherlands through a multi-method, stakeholder-informed lens. By integrating expert interviews and the Best-Worst Method (BWM), the study offers both **conceptual refinements** and **methodological innovations**, while applying and extending **Suarez's (2004) phase-based framework on technology dominance**. Together, these contributions offer a multidimensional understanding of how innovation adoption unfolds under conditions of persistent uncertainty, fragmented governance, and uneven actor capabilities.

1. Reframing Stakeholder Theory through Intra-Sectoral Heterogeneity

The first contribution lies in refining stakeholder theory, particularly the Triple Helix model, by revealing that stakeholder preferences are shaped less by sectoral affiliation (government, industry, academia) and more by actor roles, decision contexts, and institutional mandates. Unlike conventional stakeholder mappings that assume intra-sector alignment, this study demonstrates intra-sectoral heterogeneity. For instance, while professor who also affiliates with housing association prioritized industry collaboration and workforce development, professor of climate design & sustainability emphasized sustainability and environmental impact, and its alignment with climate goals. This divergence, observable within the same sector, suggests that stakeholder analysis must move from sectoral generalization to role-based positionality, which recognize the influence of role and organizational culture, regulatory exposure, and professional incentives on how innovation is interpreted. The implication is a need for more granular stakeholder engagement frameworks that foreground actor-specific constraints and leverage points, particularly in complex governance environments.

2. Moving Beyond Technical Readiness: Toward System Innovation

Second, the study challenges the dominant focus on technical readiness in classic innovation theories such as the Technology Acceptance Model (TAM) and Rogers' Diffusion of Innovations (DOI). While technical maturity, demonstrated by BIM tools, logistical platforms, and modular design systems, is necessary, it is not sufficient to ensure large-scale adoption in high-income, regulated markets like the Netherlands. Instead, the research shows that post-readiness bottlenecks, including financial viability, shifting political mandates, and deep-seated perceptions of prefab as temporary or low-quality, are more decisive. This supports a theoretical pivot from linear technology adoption models to sociotechnical transition frameworks such as the Multilevel Perspective (MLP) and Strategic Niche Management (SNM), where institutional alignment, regulatory interoperability, and trust-building become central. This study, therefore, contributes to a more post-technical paradigm in innovation theory, emphasizing systemic coordination, not just technical feasibility, as the primary barrier in advanced settings.

3. Enhancing Multi-Criteria Decision-Making (MCDM) with Narrative Interpretation

A third contribution is methodological: the integration of BWM with in-depth qualitative justifications yields a hybrid model that combines structured prioritization with narrative sensemaking. While BWM efficiently ranks stakeholder preferences, the accompanying interview data reveal the underlying heuristics, constraints, and political logics that shape these priorities. For instance, high rankings of "standardisation" by developers reflected not only technical concerns but also procurement policy biases, subcontractor coordination challenges, and insurance constraints. This methodological integration aligns with value-sensitive design and decision behavior theory, illustrating that MCDM tools benefit from embedded contextual interpretation. The approach provides a replicable model for complex decision environments where ranking alone is insufficient and where rich explanation of stakeholder logic is necessary for effective intervention design.

4. Extending Suarez's (2004) Framework: From Uncertainty to Phase-Based Capabilities

One of the main theoretical contributions of this study is that it updates and adjusts Suarez's (2004) model of technology dominance to better reflect what happens in the built environment, especially in the case of prefabricated housing. Suarez originally described five stages that a new technology moves through on its way to becoming widely adopted: research and development, technical feasibility, creating the market, decisive battle, and post-dominance. This model was mainly developed for digital or high-tech innovations, where changes happen fast and government involvement is often limited.

However, this study shows that the model can also apply to construction and housing, where progress depends heavily on physical infrastructure, government rules, and institutional decisions. To make the model more relevant for prefabricated housing, this study introduces three types of uncertainty that affect adoption: technical, market, and institutional. Technical uncertainty refers to whether prefabricated homes can meet safety standards and building codes. In recent years, this kind of uncertainty has decreased, as engineers, architects, and digital tools have improved design and performance.

However, market and institutional uncertainties remain major obstacles. Market uncertainty includes concerns about whether people trust prefab homes, whether they hold their resale value, or whether banks are willing to finance them. Institutional uncertainty refers to unclear or inconsistent rules between municipalities, and changing interpretations of regulations. These uncertainties often create delays and confusion during the stages where the market is supposed to grow and where competition becomes intense. The study also finds that these challenges are not felt equally by everyone. Larger companies often have more resources, such as legal teams, internal designers, and lobbying power, which help them adjust to changing conditions. In contrast, small firms and local governments often lack the time, money, or political support to manage such complexity. This leads to a key insight: success in moving through Suarez's model is **not just about how good the technology is, but also about who is involved and how capable they are**. In this way, the study offers a new perspective on the dominance process, showing that actors with more flexibility, stronger networks, and better resources are more likely to help make prefabricated housing part of the mainstream.

5. Institutional Network Effects and Actor-Network Complexity

Fifth, this study adds a new layer to how we understand network effects and how innovations spread, especially in the context of the built environment. In most theories, network effects are about things like how many people are using a product or how fast a market is growing. But this study shows that in housing and construction, it is not just about users or how well-known the technology is, it is also about how well different systems and institutions are connected. For example, zoning rules, insurance approvals, and how prefab housing fits into existing logistics systems all act like network "nodes" that must be aligned for innovation to grow.

This study shows that adoption depends on many different players working together smoothly, not just people, but also laws, technologies, and institutions. If just one part of this network breaks down, such as when prefab homes are not recognized by insurance companies, the entire process can get stuck. That small misalignment can spread delays across the system and stop the innovation from scaling up.

This means we need to move beyond simple ideas like "people will copy others" or "markets grow naturally." Instead, we should see innovation in construction as something that needs strong connections between systems and institutions. Without that connection, the network falls apart. The key message here is that if we want prefab housing (or similar innovations) to succeed, the efforts must focus not just on consumer interest or technical tools, but also on getting institutions ready and aligned.

6. Cross-Thematic Contributions to VTI, Energy, Housing, and Climate Governance

Beyond the housing sector, this study also contributes to several important fields. In the area of Value, Technology, and Innovation (VTI), it shows that social factors like trust, legitimacy, and how prefab housing is presented or framed to the public often matter more for adoption than the technical features themselves. In the Energy and Industry domain, the study connects prefabricated housing with climate goals such as reducing carbon emissions, supporting circular construction, and improving long-term efficiency. But it also makes clear that having good technology is not enough, impact only happens when the right policies, institutions, and systems are in place to support it.

When it comes to Housing and Governance, the study uncovers the many local-level challenges, like inconsistent zoning rules or frequent changes in political leadership, that often slow down or block national efforts to promote modular housing. And in the area of Climate Design and Sustainability, it offers real-world evidence that prefab housing can support circular economy goals and reduce embodied carbon, but only if the industry can scale up and agree on clear standards.

Altogether, these findings suggest that prefabricated housing should not be seen as just another construction method. Instead, it can act as a powerful tool for systemic change across different sectors, linking climate policy, urban governance, and innovation in a practical, coordinated way.

8. A Generalizable Framework for Innovation Under Complex Institutional Conditions

Finally, the study contributes to a more general theory of innovation adoption in high-complexity environments. By embedding Suarez's framework within a context of multilevel governance and applying both structured and narrative methods, the study shows how technical readiness must be supplemented by institutional synchronisation, actor capability-building, and governance alignment. The insights extend to broader sustainability transitions, offering a roadmap for multi-layered adoption strategies that blend technological maturity with legitimacy-building, role-specific engagement, and adaptive governance. In doing so, the study also contributes to the literature on sociotechnical lock-ins, institutional complexity, and adaptive capacity in public policy and innovation management.

6.4 Practical Implications

The results of this study provide actionable insights for policymakers, developers, housing associations, and planning authorities aiming to mainstream prefabricated housing in the Netherlands.

- **For the government sector**, the study highlights the urgent need to reform the financial system and regulatory support. This includes simplifying permitting processes, introducing prefab-specific subsidies, and developing clearer zoning codes. Government incentives must be aligned with long-term commitments to support investment in prefab manufacturing and housing projects.
- **For the industry sector**, particularly developers and contractors, the findings underline the importance of improving consumer perception. Marketing efforts should focus not only on technical performance but also on aesthetics, personalisation, and comfort. Demonstration projects and design competitions can help reframe prefab homes as desirable and permanent living solutions.
- **For the academic and professional training sector**, the study shows a gap in workforce preparedness. New vocational programs are needed to train workers in modular construction, BIM, and digital site coordination. Cross-sector platforms should also be established to share best practices, address bottlenecks, and foster collaboration across the value chain.

- Furthermore, **public sector buyers**, such as social housing providers and municipalities, should update their procurement criteria to explicitly reward the advantages of prefabrication, including speed, reduced disruption, and carbon savings. These intangible benefits must be included in tender evaluations to reflect their actual value.

Ultimately, **communication between sectors needs to improve**. Misalignments in goals and definitions, especially around abstract terms like “trust”, ”perception”, “sustainability”, and “collaboration”, can only be resolved through co-created strategies, mutual learning, and regular cross-sector dialogue.

7) Discussion, Limitation, and Future Research

7.1 Discussion

This study aimed to investigate the factors influencing the market adoption of prefabricated housing in the Netherlands, drawing on perspectives from the Triple Helix model, such as government, industry, and academia. Through a combination of three stages of expert interviews (with 12 experts in total), extensive literature review, the Best-Worst Method (BWM), and thematic analysis and triangulation, the study has shown that although all three sectors are actively seeking ways to advance prefabrication, they view both the challenges and the pathways forward in fundamentally different ways. These differences are not only sectoral but also shaped by individual roles, responsibilities, and mental frameworks. What becomes clear is that the issue at hand is no longer primarily technical; it is systemic, social, and institutional (Aziz et al., 2024; Widanage & Kim, 2024).

One of the most striking outcomes is the consistently low ranking of technical factors, Technological Advancements & Standardisation and Supply Chain & Logistics Efficiency. These factors, often emphasised in international prefab adoption literature (Pan & Sidwell, 2011; Wuni & Shen, 2020; Arashpour et al., 2017), are here seen as relatively minor obstacles. The consensus among Dutch experts is that the technology required to scale prefabrication already exists. As Wu et al. (2024) also note, the challenge is not how to produce prefabricated homes, but how to align regulatory systems, financing structures, and societal acceptance to make them viable at scale.

This shift in perspective mirrors the broader evolution in construction innovation literature, from “technology-push” narratives to “system-pull” thinking (Chen et al., 2024). The bottleneck is no longer about feasibility but about integration: how to embed prefabrication into a wider housing system that includes local governments, public trust, housing associations, and market mechanisms. As also argued by Harty (2008) and emphasised in recent studies (Graham et al., 2024; van Oorschot et al., 2021), innovation in construction often fails not because of poor design, but because it does not fit well within existing institutional and cultural contexts. The Dutch context, with its decentralised governance and strong consumer protection culture, reinforces this need for social alignment and institutional support (Hoppe, 2012; Halman et al., 2008).

This challenge is also well explained by Suarez (2004), who developed a framework to understand why some technologies succeed in the market while others do not. He explains that a new technology typically goes through several stages, starting with research and development, then progressing to technical feasibility, market introduction, a decisive battle, and finally reaching a stage where it either becomes the dominant choice or fails to gain traction. In the decisive battle stage, what Suarez calls the “battle for dominance”, it is not the technical quality of the product that matters most. Instead, what becomes important is how well the technology aligns with its environment: for example, whether there are clear rules and regulations, whether people trust it, and whether companies promote it effectively. In the case of prefab housing in the Netherlands, the problem is not the product itself, but that it still does not fit well within the existing systems, policies, and public expectations.

The differences in what each sector considers important also reflect their distinct roles and pressures. Government-sector experts tend to prioritise financial viability and regulatory support (Navaratnam et al., 2022; van Oorschot et al., 2021), which also aligns with the study findings. Their concerns are deeply rooted in practical limitations, including budget management, fiscal accountability, and the political risk of promoting housing solutions that are not profitable, or worse, that the public may not accept. In a country where spatial planning is complex and contested, government actors are understandably focused on ensuring that prefab developments are both legally sound and financially responsible (Geraedts et al., 2021).

This focus aligns with what Suarez calls environmental factors, things outside a company's control that can either help or hinder the adoption of a new technology. Regulation, for example, plays a significant role. If prefab housing is not supported by existing building codes, planning rules, or political priorities, it will not be widely used. In this case, government support is not only helpful, but also essential for opening the door to the market.

Industry experts, by contrast, are deeply concerned with public perception, profitability, and sustainability narratives. They are aware that although prefab has clear environmental benefits, such as lower waste and faster build times, these advantages are not enough to win over consumers if the product is not seen as attractive or valuable (Razkenari et al., 2020; Jiang et al., 2021; Manley et al., 2016). This finding is consistent with studies highlighting the importance of aesthetic appeal, spatial identity, and consumer trust in prefabricated housing (Aruta et al., 2023; Graham et al., 2024; Pittau et al., 2017). Many Dutch consumers associate prefabrication with temporary or social housing, which makes it challenging to reposition prefab as a premium or desirable option.

According to Suarez, this challenge is both environmental and firm-level. Public perception is shaped by culture and media, which are things companies can not fully control, but firms still play a role in how they present prefab products. For example, companies can enhance their product design, clearly explain the benefits of prefab, and strive to establish trust with early customers. Suarez highlights that once some people adopt a technology and have a positive experience, it can influence others, creating a snowball effect known as network effects. But this only happens if firms take the lead in changing public opinion.

Meanwhile, academic experts tend to look beyond immediate challenges. They emphasise construction speed, cross-sector collaboration, training, and workforce development, as well as long-term system alignment (Olawumi et al., 2022; Chen et al., 2024). Their focus lies not in the current market friction but in building a more adaptive and resilient housing ecosystem. These insights align with the literature on socio-technical transitions and systemic innovation (Geels, 2005; Zhang et al., 2024), which emphasises that large-scale transformations, such as the shift to industrialised housing, require coordinated changes across institutions, culture, and infrastructure.

This long-term view is also reflected in Suarez's concept of the "structure of the technological field," which encompasses elements such as education systems, professional networks, and institutional support. If these structures are not in place, even a good technology may not move forward. Academic experts often consider how to prepare the entire system, not just sell the product.

What makes these sectoral differences especially important is that they are not just about sectoral roles or job titles; they are rooted in lived professional experiences. Thematic analysis revealed that prioritisation is often shaped by what people are exposed to in their daily roles, past experiences, and key performance indicators. As Schön (1983) and Avenier & Thomas (2015) suggest, professional knowledge is "situated and interpretive"; it reflects the practitioner's world. This explains why abstract yet impactful factors, such as cultural perception or aesthetic quality, were rarely top-ranked, despite their strong influence on adoption outcomes (Jiang et al., 2021; Graham et al., 2024).

It is important to note, however, that the findings are shaped not only by the sample size and composition (12 experts from three sectors), but also by the variation in participants across the three interview stages. Not all experts participated in all stages. Some were involved only in identifying factors (Stage 1), others in ranking them (Stage 2), and a smaller group in explaining those rankings (Stage 3). This introduces a key limitation: the rationale gathered in Stage 3 does not always come from the same individuals who ranked the factors in

Stage 2. As a result, the explanations are interpretive rather than directly traceable, reflecting collective themes rather than individual logic. Moreover, the perspectives that shaped the initial factor pool may differ from those that influenced the prioritisation. This variation adds richness, but it also means that the links between identification, ranking, and reasoning are indirect; therefore, the findings should be understood in this context.

Additionally, the overall sample size, while sufficient for generating meaningful insights, does not represent all possible perspectives within the Dutch housing sector. Including more interviewees, such as local builders, contractors, housing tenants, or financial institutions, could have introduced new priorities or altered the weight given to existing ones. A broader sample might also have uncovered more nuanced disagreements or consensus across stakeholder groups. Therefore, while the results offer valuable insights into how key sectors perceive and prioritise adoption factors, they should be interpreted as indicative rather than exhaustive. That is, they highlight key patterns and tensions, but do not claim to capture the full complexity of stakeholder perspectives in the Netherlands.

Another insight is that stakeholder priorities shift depending on context. Experts have noted that during crises, such as the COVID-19 pandemic, energy shocks, or housing shortages, short-term concerns like speed and affordability often take precedence. During calmer periods, however, long-term priorities such as sustainability, architectural quality, and system innovation regain importance. This dynamic supports adaptive governance approaches, such as the adaptive pathways model (Haasnoot et al., 2013), which emphasises learning under uncertainty and building flexibility into decision-making processes (Hoppe, 2012).

Finally, the study reveals a subtle but real conflict of interest between sectors, not adversarial, but strategic. Government actors seek policy accountability, industry wants profitable growth, and academia advocates for systemic transformation (Halman et al., 2008; Zhang et al., 2024). These interests do not always align, which may help explain the slow and fragmented adoption of prefabrication in decentralised systems such as the Netherlands, especially when compared to more centrally governed housing systems like those in Sweden or Singapore (Steinhardt & Manley, 2016; Geraedts et al., 2021).

This slow progress also supports Suarez's view that a technology can only dominate the market if both company actions and external conditions are working together. If different actors are not aligned, or if there is no strong organisation leading the change, then even a well-developed solution like prefabricated housing might remain underutilised.

Ultimately, while the BWM helped identify ranked preferences, it could not by itself explain why those preferences emerged. This is where the third-stage qualitative interviews and thematic analysis played a vital role, by surfacing the deeper values, trade-offs, and institutional logics that shape expert judgments. The combination of methods confirms that prefabricated housing is not just a technical innovation; it is also a social, economic, and institutional shift. To succeed, it requires alignment across all these dimensions, or in Suarez's terms, success depends not only on the product, but on how well it fits the world around it.

7.2 Limitation

There are several limitations, including time constraints, personal skills, ongoing updates, and other factors, during the research conduction. For instance, the extensive literature reviews were conducted in October–December 2024. This research does not take 2025 publications into account. New factors that determine the market adoption of prefabricated housing in the Netherlands might appear from 2025 publications. Thus, further research that takes publications from the latest year should be done.

Firstly, the **literature review was conducted between October and December 2024**, and therefore only includes publications available up to that point. As a result, this research does not incorporate findings from academic literature published in 2025 or later. New insights, frameworks, or adoption factors related to prefabricated housing in the Netherlands may have emerged since then. Future research is encouraged to **update and expand the literature review** using more recent publications to ensure continued relevance and accuracy.

Secondly, there were **limitations in technical skills and familiarity with database interfaces**. Specifically, the author was unaware of the proper method for using search strings in the Web of Science database. It was later discovered that Boolean operators (e.g., OR, AND) can be entered using separate rows in the advanced search interface. Due to this misunderstanding, the literature review relied on basic keyword searches rather than more advanced Boolean combinations. This **methodological oversight** may have limited the comprehensiveness and reproducibility of the literature review process.

Third, this research was conducted under **stable macroeconomic and geopolitical conditions**, without ongoing crises such as war, economic shocks, or major climate events. The findings should therefore be interpreted as applicable to "normal" or stable conditions. Since stakeholder priorities can shift significantly during emergencies, prioritizing factors such as speed, cost, or supply chain resilience, **future research should examine prefabrication adoption under crisis conditions**, such as during pandemics, housing emergencies, or energy disruptions.

In terms of expert interviews, the research design initially aimed for **more than 15 participants**, with at least five experts from each of the Triple Helix sectors (academia, government, and industry), and ideally the **same experts participating in all three interview stages**. However, due to time constraints and participant availability, only **twelve experts were interviewed in total**, and their participation varied across stages. Six experts joined the first-stage interview, ten experts joined the second-stage ranking using BWM (including some new additions), and only one of the original participants continued into the third-stage interview. Three additional experts participated only in the third stage. This variation means that **not all insights could be traced across all stages**, and the rationales gathered in Stage 3 may not fully align with the preferences recorded in Stage 2. As a result, findings reflect **group-level themes** rather than continuous individual reasoning.

Moreover, interviews were conducted **individually by sector** and not through **cross-sector focus groups**. While this ensured clarity and depth within each sector, it limited opportunities for **consensus-building or direct dialogue** between stakeholders. Future research should consider incorporating **multi-stakeholder focus group discussions or Delphi methods**, allowing experts from different sectors to debate, reflect, and potentially reach shared understandings on key adoption factors. Such collaborative formats may yield different results and deeper insights into shared or contested priorities.

Regarding the representation of expert views, participants were selected based on their professional expertise and sector affiliation, and were treated as **sectoral representatives**. This approach reflects the broader **institutional framing** of the Triple Helix model. However, two important limitations must be acknowledged. First, the **sample size within each sector is limited**, which constrains the ability to capture the full diversity of views that may exist within each domain. For example, not all perspectives within government or industry, such as local policymakers, contractors, or sustainability officers, were covered. Second, sectoral views are **not monolithic**; even within the same sector, experts may hold differing views based on their roles, responsibilities, or institutional cultures.

Finally, this research adopts the **Triple Helix model (Academia, Industry, and Government)** as its stakeholder framework. While this model remains widely used, more recent frameworks such as the **Quintuple Helix** or **Penta Helix** include **Mass Media and Civil Society/NGOs** as additional stakeholders. These actors can play critical roles in shaping public perception, community acceptance, and policy advocacy around prefabricated housing. **Excluding these perspectives** limits the scope of the findings. Therefore, future research should aim to incorporate **Mass Media and NGO stakeholders** to reflect the full ecosystem influencing housing innovation and adoption.

In summary, while this research provides meaningful insights into the market adoption of prefabricated housing in the Netherlands, the limitations discussed above should be taken into account when interpreting the results. The findings are best viewed as **indicative**, offering grounded signals and trends, but not as **exhaustive or definitive** across all stakeholder groups or changing external conditions.

7.3 Future Research

From the discussion and limitations, this study opens many ideas for future research, such as:

1) Focus Group Discussions and Co-Design Workshops

While this study emphasizes the differences in how government, industry, and academia prioritize adoption factors, future research could benefit from complementing this with focus groups or facilitated workshops, not to eliminate differences, but to better understand how those differences evolve when stakeholders engage in direct dialogue.

The aim of such group discussions would not necessarily be to force consensus, but rather to explore how interactions, negotiations, and collective reasoning shape stakeholder views. In individual interviews, participants often speak from the standpoint of their own sectoral roles and constraints. However, in group settings, they may re-evaluate or reframe their views when confronted with other perspectives, trade-offs, or real-world constraints voiced by others. This shift can reveal how flexible or entrenched certain positions are.

Moreover, focus groups could uncover tensions, synergies, and knowledge gaps that are not visible when sectors are interviewed in isolation. For example, a builder may prioritize speed and cost, while a government planner may highlight regulatory risk, but when they discuss these issues together, they may discover practical compromises or even shared frustrations (e.g., regarding unclear permitting rules).

So, the value of incorporating focus groups is not in seeking agreement for its own sake, but in understanding how dialogue shapes perceptions, how misunderstandings emerge or dissolve, and how collaboration could be improved. This would enrich the findings by showing not only what stakeholders think individually, but also how they think collectively, especially in a sector like housing that relies on multi-stakeholder coordination.

2) Including More Stakeholders Beyond Government, Industry, and Academia

While this study focused on the Triple Helix, comprising government, industry, and academia as the core sectors, future research should expand the sector scope to include mass media, environmental organisations, and private consumers. These groups play distinct but complementary roles in influencing the adoption of prefabricated housing. Mass media outlets such as De Volkskrant, NRC Handelsblad, Trouw, NOS, and Groene Amsterdammer shape public narratives by framing prefabrication either positively, as a sustainable and innovative solution, or negatively, as a cheap or temporary alternative. Including media professionals in future studies could uncover how coverage, language, and visual framing influence consumer trust, acceptance, and long-term demand.

Similarly, environmental NGOs and civic organisations such as Milieudefensie (Friends of the Earth Netherlands), Urgenda, and Woonbond (the Dutch Union of Tenants) can act as both enablers and critics of prefab initiatives. Their advocacy helps shape local opinion, mobilise community support or resistance, and influence policymaking. For instance, Urgenda and Milieudefensie often push for climate-neutral building practices, while Woonbond highlights housing affordability and tenant welfare, both of which intersect with the prefab agenda. Engaging these groups would help assess whether prefabrication aligns with broader sustainability and social justice values.

In addition, private consumers, as the ultimate users of housing, bring crucial insight into what drives actual adoption. Their preferences, aesthetic expectations, trust in quality, and willingness to pay directly affect market outcomes. Exploring their views through surveys, focus groups, or interviews would provide a more grounded understanding of demand-side dynamics and reveal how societal narratives translate into personal decisions.

Altogether, including these additional stakeholders would offer a more comprehensive and multi-layered picture of the factors influencing the adoption of prefabricated housing in the Netherlands, capturing not only institutional logics but also public sentiment, advocacy influence, and lived experience.

3) Studying Prefab Adoption During Crises

This research was conducted during a period of relative stability, with no major crises or disruptions. However, in real life, situations such as wars, economic problems, or natural disasters can quickly alter what people care about. For example, in a crisis, speed might become more important than design. Future research could investigate how priorities shift in response to such events, allowing us to develop more effective plans that accommodate various situations.

4) Comparing the Netherlands with Other Countries

To understand what is unique about the Netherlands and what lessons can be learned, future research could compare it with other countries that are further ahead in the development of prefab housing. For instance, Sweden has more centralised planning, and Japan treats prefab as a high-tech, high-quality option. These comparisons could help Dutch policymakers and builders improve their strategies by learning what has worked elsewhere.

5) Comparing prefabricated housing with other technologies

Prefabricated housing is known to be more sustainable than the conventional building. However, the implementation is very context dependent. For instance, it is almost impossible to use prefabricated technologies in a resident that is already congested, because the logistics could disrupt the limited space. In the meantime, there is another emerging building technology that is also considered sustainable, which is bio receptive concrete and bricks, which facilitate moss growth on vertical surfaces once the housing has been built. This kind of technology is considered as conventional building but brings sustainable value to the people. Future research should compare this two.

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“Prefab housing is like the quiet kid in class; efficient, smart, and full of potential, but always overlooked because it doesn’t show off like the others.”

- Prima Sandy Yonanda

9) Appendixes

Appendix A

Table A.1. List of questions for the first stage interview

Question Category	Questions
Background and Experience	1. Could you briefly describe your experience in the prefabricated housing industry?
	2. How has your role influenced your perspective on the adoption of prefabricated housing technologies?
General Insights on Market Adoption	1. From your experience, what are the key factors that have historically influenced the adoption of prefabricated housing?
	2. Can you discuss any significant changes or trends you've observed in the market demand for prefabricated housing over your time in the industry?
Specific Influential Factors	1. In your view, what are the most critical technical factors that affect the adoption of prefabricated housing technologies?
	2. What economic or financial aspects do you believe most strongly impact the market adoption of prefabricated housing?
	3. How do regulatory frameworks and building codes influence the adoption of prefabricated housing technologies?
Challenges and Barriers	1. What are the biggest challenges or barriers you have encountered in promoting or implementing prefabricated housing technologies?
	2. How have these challenges impacted the growth of the prefabricated housing market?
Consumer Perception and Market Dynamics	1. How do consumer perceptions of prefabricated housing affect its adoption?
	2. What role do sustainability concerns play in the adoption of prefabricated housing technologies?
Innovations and Future Trends	1. Are there any recent innovations in prefabricated housing that you think could significantly influence its adoption?
	2. How do you foresee the future of the prefabricated housing market in the next 5-10 years?
Comparative Insights	How does the adoption of prefabricated housing in the Netherlands compare with other countries where you have experience or knowledge?
Advice and Recommendations	1. Based on your experience, what advice would you give to new entrants in the prefabricated housing industry?
	2. What strategies would you recommend to increase the market adoption of prefabricated housing technologies?

Appendix B

Table B.1. List of questions for the second stage interview

Step	Questions
Introduction to Ranking Process	We have identified a set of factors influencing the adoption of prefabricated housing technologies through both literature review and first-stage interviews. We will now list these factors. Please let me know if you need clarification on any of them before we proceed. Below are the factors.

Table 2.1. Shortlisted Factors

No.	Main Factor	Definition
1.	……	……
2.	……	……
3.	……	……
4.	……	……
5.	……	……
6.	……	……
7.	……	……
8.	……	……
9.	……	……

Ranking Instructions

Please identify the factor you consider **most crucial** for the adoption of prefabricated housing technologies. This will be recorded as your **'best' factor**.

Next, please identify the factor you consider **least crucial**. This will be recorded as your **'worst' factor**.

Note:
The factor you select as **best** will be labeled as **'a'**, while the remaining factors, ranked from **second to ninth**, will be labeled as **'b' through 'i'**, in descending order of importance.

1) Best factor (a) : ....
2) Worst factor (i) : ....

Detailed Ranking

For each remaining factor, I would like to rank them between Best and Worst Factor.

2) b) ….
3) c) ….
4) d) ….
5) e) ….
6) f) ….
7) g) ….
8) h) ….

Review and Adjustment

Now that we've gone through all the factors, let's quantify the comparison of Best Factors to others from 1 to 9. 1 supposed to be the factor with the closest similarity and connection with the best factor. For this case, 1 is only for the best factor. 9 is for the factor with the least similarity with the best factor. So, it supposed to be worst factor.

Table 2.2. Ranking Factor Based on Best Factor

Best to others	a
a	1
b	
c	
d	
e	
f	
g	
h	
i	

Note:
a represents the **best (top-ranked) factor**, while **b through i** represent the **second to ninth-ranked factors**, in descending order of importance.

Now let's quantify the comparison of Worst Factors to others from 1 to 9. 1 supposed to be the factor with the closest similarity and connection with the worst factor. For this case, 1 is only for the worst factor. 9 is for the factor with the least similarity with the worst factor. So, it supposed to be worst factor.

Table 2.3. Ranking Factor Based on Worst Factor

Others to the Worst	i
a	
b	
c	
d	
e	
f	
g	
h	
i	1

Note:
a represents the **best (top-ranked) factor**, while **b through i** represent the **second to ninth-ranked factors**, in descending order of importance.

Reflection and Additional Insights	Based on the ranking you've provided, what are the reasons behind your choice of the most and least important factors? Are there any emerging trends or future developments that might change the importance of any of these factors?"

Appendix C

Table C.1. List of questions for the third stage interview

Section	**Question**
Introduction to the result of Best-Worst Method	**Using the Best-Worst Method (BWM), the relative importance of each factor was identified across all sectors. The overall weights were then determined by calculating the average of these weights from the government, industry, and academia perspectives, as shown below:**

Table 1. Final Rank of Factors

No	**Categories & Factors**	**Government**		**Academia**					**Industry**			**Global Average Weight**	**Rank**
		Expert 1	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 9**	**Expert 10**	**Expert 11**		
1	Policy & Regulatory Support	0,1915	0,1915	0,0766	0,0479	0,1915	0,0766	0,0638	0,1442	0,1915	0,1277	0,1303	3
2	Financial & Economic Viability	0,3146	0,3146	0,0274	0,0547	0,3146	0,0958	0,0958	0,0721	0,3146	0,3146	0,1919	1
3	Technological Advancements & Standardization	0,0547	0,0547	0,0958	0,0274	0,0547	0,0638	0,1915	0,0206	0,0766	0,0274	0,0667	8
4	Supply Chain & Logistics Efficiency	0,0274	0,0274	0,0479	0,0958	0,0638	0,0547	0,0274	0,0412	0,1277	0,0958	0,0609	9
5	Sustainability & Environmental Impact	0,0766	0,0766	0,1915	0,0766	0,0766	0,1277	0,0547	0,2368	0,0274	0,0547	0,0999	5
6	Speed & Construction Efficiency	0,0479	0,0479	0,3146	0,0638	0,0958	0,1915	0,1277	0,0721	0,0958	0,0766	0,1134	4
7	Consumer Perception & Market Demand	0,1277	0,1277	0,1277	0,1915	0,1277	0,3146	0,3146	0,2368	0,0479	0,1915	0,1808	2
8	Industry Collaboration & Workforce Development	0,0958	0,0958	0,0547	0,3146	0,0274	0,0274	0,0766	0,0320	0,0547	0,0479	0,0827	6
9	Structural Quality & Durability	0,0638	0,0638	0,0638	0,1277	0,0479	0,0479	0,0479	0,1442	0,0638	0,0638	0,0735	7

Purple: Best Factor
Yellow: Worst Factor
Black: Factors ranked 2nd – 8th

Section	**Question**
Reflections on Differences in Prioritization	When looking at the BWM results, what stands out to you about the differences in how experts prioritized the factors?
	Why do you think certain experts might value some factors (for example, consumer perception or financial viability) more highly than others?
	What kinds of professional background, worldview, or experiences do you think could shape how someone prioritizes these factors?
Framing and Cognitive Orientation	In your view, what mental frameworks (for example, short-term gains, long-term sustainability, feasibility) tend to influence how experts assess importance?
	Do you think people generally favor factors that align with their area of expertise or daily responsibilities? Why might that happen?
	In your opinion, are people more likely to prioritize what they can control or what they believe has the biggest impact?
Influence of Experience and Bias	How might experts' past project experience influence the way they judge what matters most in adopting prefabricated housing?

	Do you think experts might unintentionally undervalue factors they are less familiar with or perceive as abstract (for example, policy or collaboration)?
	Can personal or organizational bias explain some of the divergences you see in the rankings?
Reflections on the Method and Process	What do you think about using methods like BWM to compare expert judgments? Do you think it captures people's thinking accurately?
	Were there any factors in the list that you think tend to be *over-simplified* or *under-discussed* in ranking exercises like this?
	If participants had discussed their rankings in a group before submitting them, do you think the results would have been different?
Prioritization Under Changing Conditions	If external conditions changed (for example, a sudden housing demand, new climate policy), how might the importance of some factors shift?
	Which factors do you think are more *situational* (i.e., changing with time) versus *structural* (i.e., always important)?
	Looking ahead, are there any factors you expect to gain importance in the next decade? Why?

Appendix D

Table D.1. List of answers of the third stage interview

Aspect	Responses				Similarities	Differences
	Expert 2	**Experts 9**	**Experts 10**	**Experts 11**		
Why some factors are valued more?	*Experts tend to value the things that matter most in their field. For examplecompanies care a lot about market demand and sustainability because those affect their business image and profits. Me as someone from government sector is more focused on things like financial viability and policy, because we must make sure public money is used wisely. Academics might focus on collaboration or workforce training, especially if they work closely with research or social issues. Everyone brings their own work experience into how they see what's important.*	*Experts tend to prioritize factors that resonate most with the core goals, risks, and key performance indicator of their sector. For instance, individuals from the private sector often prioritize consumer perception and market demand because these directly influence profitability and competitive positioning. Similarly, government officials emphasize financial and economic viability due to the need to justify spending and policies through measurable public outcomes. These preferences come from practical concerns, which is each expert is likely evaluating the factors through the lens of what enables or constrains their day-to-day decision-making processes.*	*It is quite natural that different experts place more importance on certain factors and a lot of it comes down to what they are most familiar with. People tend to focus on what they know best.* *For examplesomeone with a financial or economic background might naturally view financial viability as the key to success, because they've spent their careers thinking in terms of costs, investments, and returns. Similarly, someone working closely with customers or in the marketing field is more likely to emphasize consumer perception and market demand, because That is where their day-to-day challenges lie.* *An expert's professional background, work experience, and personal interests all shape how they see the world. These experiences form mental shortcuts that help them quickly decide what matters most. So, it is not just about what's important in theory, but what feels relevant and actionable to them based on what they've done and seen before.* *In other words, prioritization often reflects familiarity and expertise not necessarily an objective ranking of what's most important overall.*	*People tend to value the things that affect them the most in their work. For examplein construction, we're constantly dealing with budgets, timelines, labor, and client satisfaction. So naturally, we focus on things like cost, speed, sustainability, and market demandbecause those directly impact the success of our projects.*	*All experts agreed that people tend to value factors they directly deal with in their work. This is human nature. We notice, care about, and understand things that are part of our responsibilities. For examplea financial manager will emphasize cost control, while a site manager will care more about construction speed or labor. In other words, our job shapes what feels important.*	*Expert 7 talked about how people use "mental shortcuts" familiar things feel more important simply because they are easier to judge. Expert 8 said that in stressful environments like construction, people will prioritize things that help them get the job done fast and well. Expert 6 highlighted that key performance indicators (KPIs) and measurable goals at work drive how people rank priorities. Expert 4 reflected that as someone in government, her focus is naturally drawn to financial and regulatory concerns.*
Shaping influence: background, worldview, and experience	*People's jobs and fields of study shape how they rank things. If someone works in social sciences or HR, they may care more about workforce issues. A marketing person may focus on consumer demand. Me as someone from government sector tends to look at the systemic level. For instance, I see on the whole housing systemwhere the bottlenecks are and what slows things down. So their ranking is based on how well the system works overall, not just one part of it. These backgrounds affect what each expert pays attention to.*	*Yes, absolutely. Professional backgrounds significantly shape how someone evaluates priorities. For examplesomeone with experience in market analysis or business development is likely to focus on consumer-related factors, while a civil servant might concentrate on regulatory feasibility and cost efficiency. Even within academia, a researcher's focus whether on environmental science, engineering, or public policy can shift their attention to innovation, collaboration, or impact. Worldview also plays a role; someone oriented toward systems thinking may view cross-sector collaboration or workforce development as very important, whereas a results-driven practitioner may gravitate toward immediate implementation concerns.*	*Yes, a person's professional background, worldview, and life experiences play a big role in shaping how they decide what's important. For instance, someone from an engineering or construction background might focus more on technological advancements, structural quality, or efficiency in construction because That is what they deal with daily. Meanwhile, a person working in policy or public administration may prioritize regulatory support or long-term sustainability, as they are often focused on creating stable frameworks and public value.* *Worldview matters too. Someone who thinks in terms of social equity or environmental responsibility might give more weight to sustainability or consumer needs, even if those factors do not offer immediate financial returns. On the other hand, someone with a business-driven mindset may view market demand, profitability, and logistics as more critical to getting things done.* *Past experiences also leave a mark. If an expert has seen projects fail due to poor coordination or lack of workforce skills, they are likely to view industry collaboration or workforce development as essential.* *In short, people's professional roles, values, and personal journeys all influence how they see the puzzle and which pieces they believe are most crucial to completing it.*	*In construction, for instance, we see firsthand how important it is to have reliable suppliers, clear project timelines, and a well-trained crew. So we tend to rank logistics, cost, and labour related factors higher. And if they've had projects delayed by unclear regulations, they will probably rank policy support higher. The more hands-on experience you have in a certain area, the more you realize how critical that piece is to the whole puzzle.*	*Everyone agreed that a person's professional background, education, and work history heavily shape their thinking. It is like wearing glasses that color what you see as important. For examplesomeone who's worked on failed projects because of poor collaboration will see that factor as critical in the future. In the same way, someone from a design or research background may rank innovation or policy differently than someone from operations.*	*Expert 7 discussed how worldview and personal values (like social justice or systems thinking) can shape what people prioritize, not just their job. Expert 8 emphasized practical, hands-on lessons from previous projects for example, when a supply delay ruins a timeline, supply chain becomes top of mind. Expert 6 mentioned that even within academia, different research fields (like engineering vs. environmental science) cause differences in how factors are perceived. Expert 4 said her government experience makes her view housing as a system where bottlenecks and regulatory flow matter most.*

Do people favor factors tied to their responsibilities?	Yes, they often do. This is very intuitive of human. This happens because people are more comfortable thinking about what they know best. If someone works on workforce training every day, they are likely to think it is very important. If someone works in finance, they will think about money first. It is natural to focus on the part of the system you deal with most, and this shows up in how people rank the factors.	Yes, people tend to prioritize factors aligned with their domain expertise or scope of control. This tendency is natural because it allows them to make informed, confident decisions based on firsthand experience. These are the areas where they can more easily measure outcomes, predict challenges, and foresee opportunities. Moreover, focusing on familiar domains reduces uncertainty. For instance, someone working in logistics may downplay regulatory concerns because they perceive those as outside their scope, while a policymaker may not focus on construction speed due to its technical specificity.	Yes, absolutely. People tend to favor factors that align closely with their own area of expertise or daily responsibilities and there are several reasons for this. First, familiarity brings confidence. When someone understands a topic well, they are more comfortable assessing its importance, risks, and potential outcomes. As a result, they are more likely to see it as a priority because they can evaluate it with clarity and certainty. Second, experts often view the world through the lens of their role. If someone spends every day managing logistics, for examplethen supply chain efficiency will naturally feel more urgent and relevant than, say, consumer perception or policy. It is not that other factors are not important it is just that people are more attuned to the issues they deal with regularly. Lastly, people may unconsciously promote factors they can directly influence. It feels more productive to focus on areas where they have control or expertise, rather than trying to assess unfamiliar or abstract topics that seem out of reach. So overall, favoring familiar factors is a natural human tendency it helps people stay grounded in what they know and where they can make a difference.	Yes, definitely. People feel more confident talking about things they understand. In construction, we know how delays or material shortages can ruin a timeline, so we pay close attention to supply chain efficiency and scheduling. We may not think as much about policy or academic collaboration unless we've had issues in those areas. This happens because we're trained to solve problems in our field. Also, we're accountable for those results. So if you're a site manager, for examplestructural quality and workforce reliability are top of mind, not government regulations unless they are causing a delay.	All four experts agreed people give more weight to factors that are part of their job or where they are held accountable. This is intuitive: you understand it better, can act on it, and are measured by it. If someone manages suppliers, supply chain matters more. If someone designs policy, regulations are key. This is not bias it is practical focus.	Expert 7 explained that this is driven by confidence people prefer areas they feel skilled in. Expert 8 used on-site construction as an example: site managers care deeply about materials and labor but may not even think about policy unless it causes delays. Expert 4 agreed but said it also reflects where people feel they have the most impact.
How experience shapes judgments	Past experience makes a big difference. For exampleif a local government has worked with prefab housing before, they may be more open to using it again. If they've never used it, it might seem risky or unfamiliar. The same goes for companies or researchersif they've seen something work well (or not work), that experience will likely shape how they judge new ideas or priorities.	Indeed. Past experiences play a crucial role in shaping expert judgment. If a prior project failed due to poor market perception, an industry stakeholder may place greater weight on consumer perception. Likewise, if a government initiative faced criticism for being too complex or costly, decision-makers may become more risk-averse, and prioritize economic viability over innovation. Similarly, an academic might shift focus toward collaborative impact if their prior research lacked real-world application. These past lessons help experts recalibrate their judgment based on what worked or did not in similar contexts.	Yes, an expert's past project experience has a strong influence on how they judge what matters most when it comes to adopting prefabricated housing. These experiences serve as a practical reference point helping them understand what tends to work well and what often leads to problems. For exampleif someone was involved in a project where logistics caused major delays, they may place more weight on supply chain efficiency in future projects. On the other hand, if a project succeeded because of strong government support or clear regulations, that expert might now see policy and regulatory frameworks as essential to success. Every project leaves behind a trail of lessons learned both positive and negative. Over time, these lessons shape how experts prioritize risks and opportunities. They do not just rely on theory or general assumptions; they draw from real-world outcomes that they've seen firsthand. So in many cases, what an expert believes to be "most important" is actually shaped by their direct exposure to past failures and successes, rather than abstract criteria.	Past experience has a huge influence. If you've worked on a project where delays happened because the components did not arrive on time, supply chain efficiency will probably stick out as a key issue for you. Or if you've seen a project where the client was unhappy due to poor finishes, you might prioritize quality and consumer perception more. We tend to remember what went wrong and what went well. These experiences shape what we think matters most, even if we do not realize it at the time.	Everyone agreed that past project experiences deeply influence current priorities. If someone saw a project fail because of workforce shortages, they will likely rate workforce development higher next time. Real-life lessons leave a stronger impression than abstract theory.	Expert 7 said these experiences create new mental patterns once you've "felt" a failure, you never see that issue the same way again. Expert 8 gave vivid examples like remembering how poor finishes angered a client, making quality a top concern ever since. Expert 4 explained that policy-makers draw from case histories of what went wrong in public programs.

Organizational bias?	*To some degree, yes. I believe that personal and professional bias explains smaller differences in rankings. But some of the big differenceslike how sectors view financial viability or sustainabilityare probably not just due to bias. They likely come from deeper differences in how each sector sees its role and responsibilities in the housing system.*	*Absolutely. Personal values, organizational mandates, and institutional culture all influence how factors are interpreted and ranked. An academic affiliated with a housing association may value collaboration more than a traditional researcher would. Government officials often operate within fiscal and political constraints that shape their priorities toward cost-effectiveness. These biases are not necessarily negative they provide context-specific reality but they do explain why different sectors view the same problem through different lenses.*	*Yes, definitely. In many cases, experts are not just speaking for themselves they are also reflecting the priorities and values of their organization. So their rankings may be influenced, consciously or unconsciously, by the position or goals of the group they represent.* *For examplesomeone from a private company might rank market demand and profitability higher because those are critical to their organization's success. Meanwhile, someone from a public agency or non-profit might focus more on regulations, sustainability, or social impact, because those align more closely with their mission.* *Even personal biases can play a role. People might downplay factors they see as less relevant or harder to influence not necessarily because they are unimportant, but because they do not fit their usual way of thinking or working.* *In the end, expert rankings are not just technical assessments they are shaped by context, interests, and institutional identity. That is why it is common to see clear differences across sectors like government, industry, and academia.*	*Yes, for sure. Organizations often have their own priorities, and people tend to reflect that. In construction companies, for examplethere isoften a focus on timelines, budgets, and deliverables. That shapes how we see what's important. A company (industry) focused on innovation might highlight technology. And someone who works on cost control would view every decision through a financial perspective first.*	*Yes all experts agreed that people are shaped by their workplace environment, mission, and culture. Even when answering personally, they often reflect what their organization values. For examplean industry expert might rate market demand higher because That is what the company talks about all day.*	*Expert 4 said small biases come from individual perspective, but big differences stem from sector-wide missions. Expert 7 went further suggesting that people almost "speak for" their institutions, even unconsciously. Expert 8 highlighted how in construction firms, timelines and deliverables dominate thinking, while in NGOs, collaboration and impact might be more central.*
Thoughts about BWM Methods	*BWM is helpful to show where experts disagree, but it does not explain why they think that way. It gives a simple way to compare rankings, but it does not show what's going on underneath. According to that, I suggested using other methods toolike interviews or workshopsso we can understand more about why people think the way they do.*	*Well, BWM is a useful method for capturing structured perceptions, especially when dealing with qualitative judgment. It helps compare the relative importance of multiple factors across stakeholders. That said, while BWM captures general lines of thinking, it may not always reflect the full depth of reasoning or internal trade-offs. For instance, I am surprised that academia ranked collaboration higher than innovation a nuance that required further qualitative explanation. Hence, BWM is best used if added with interviews or contextual data.*	*Not entirely. While methods like the Best-Worst Method (BWM) are useful for organizing and comparing expert input, they can often oversimplify complex thinking.* *In reality, people's judgments are shaped by multiple layers of reasoning, context, and trade-offs. BWM requires experts to rank and assign weights to factors, but this process can't always reflect the nuanced way people actually make decisions. For examplesomeone might consider two factors equally important but still be forced to rank one above the other. Or, they might think a factor's importance changes depending on the situation but BWM assumes a fixed value.* *Additionally, experts might give answers that are more reflective of what's easier to measure or justify, rather than what they deeply believe, especially under time constraints or when faced with a rigid framework.* *So while BWM can provide a structured snapshot of expert preferences, it may miss the richness and variability of real-world thinking particularly when experts are balancing uncertainty, conflicting goals, or organizational pressures.*	*I think BWM is a useful tool, especially when you have lots of factors to consider and need to see what matters most to different groups. It forces people to think more carefully about trade-offs, which is something we deal with all the time in construction, whether it is budget versus quality, or speed versus sustainability. However, it still has its limits. People might rank a factor low not because it is unimportant, but because it is hard to measure or control. Also, the method does not always capture the reasons behind the choices. Two people might rank the same factor highly but for very different reasons. Grouping together so many different respondents also means that there will be general variability/spread in the priorities. So a single number for the factors (which I assume is the average from the different respondents in each sector) might not accurate.*	*All four experts said BWM is useful for comparison, but it does not explain why people think the way they do. It simplifies deep thinking into rankings and can miss nuance. Many recommended combining BWM with interviews, workshops, or open questions.*	*Expert 7 was the most critical saying BWM oversimplifies real reasoning and forces unfair tradeoffs (for example, ranking two equally important things). Expert 8 noted that BWM does not reflect why someone made a choice for instance, two people may rate a factor highly for very different reasons. Expert 6 said it is best used when paired with deeper data collection.*

Over-simplified or under-discussed factors?	*Yes. Some factors, like "consumer perception & market demand," are very broad and can mean different things to different people. Someone working in marketing will see it one way, while someone in policy might see it another. This can cause confusion and mismatched rankings. The expert recommended being more specific about what each factor means, so that everyone is ranking the same thing.*	*Yes. In my view, the factor "industry collaboration and workforce development" was unclear and possibly oversimplified. Without a clear definition, such factors may confuse respondents or be interpreted inconsistently. This highlights the importance of precise terminology in ranking exercises. Other more technical or abstract factors such as supply chain logistics or standardization may also be overlooked if respondents do not feel directly responsible for them.*	*Yes, definitely. Some factors in ranking exercises like BWM often end up being over-simplified or under-discussed, even though they play a critical role in real-world outcomes. One example is "industry collaboration and workforce development." This factor is usually interpreted narrowly for instance, as just training or partnerships but in reality, it involves complex dynamics like cross-sector trust, long-term relationship building, and aligning incentives across companies, government, and academia. These deeper challenges often get overlooked.* *Another is "consumer perception and market demand." This factor might sound straightforward, but understanding what drives consumer trust and willingness to adopt new housing technologies is incredibly nuanced. It involves cultural values, past experiences with housing, and communication strategies things that are not easily captured by a single score.* *Similarly, "policy and regulatory support" can seem like a box to check, but it includes layers of legal frameworks, bureaucratic capacity, political will, and enforcement all of which can make or break adoption.* *These kinds of factors are often condensed into a short label, which risks ignoring the messy, human, and evolving nature of the real issues they represent.*	*Yes, collaboration across the industry and workforce development are often simplified or under-discussed. From my experience, having a skilled and reliable workforce is one of the biggest challenges in construction, especially with new technologies like prefabrication. But this factor is sometimes treated as a background issue, rather than a top priority. Another example is supply chain logistics. On paper, it might seem like a basic planning issue, but anyone who's had to manage delays in component delivery knows how disruptive it can be. These types of issues are complex in practice, but rankings do not always show that complexity.*	*Yes terms like "consumer perception" or "collaboration" are often too general. People interpret them differently, and that creates inconsistent rankings. Important issues might be oversimplified into a word or phrase that does not do them justice.*	*Expert 7 unpacked the layers within these broad terms for example, consumer trust includes values, past experience, and marketing. Expert 8 explained how logistics is treated like a technical issue, when in reality, it is a complex web of suppliers, timing, and risk. Expert 6 noted that some people may even ignore a factor because they do not feel it applies to their job.*
Would group discussion change results?	*Yes, probably. We have done lots of meeting across sectors such us with those from industry & academia. In real-life meetings between them, people often agree on many things after talking them through. So while individual rankings in BWM show big differences, discussions often show that people actually share common goals and concerns. This suggests that BWM results might look less divided if experts had a chance to talk together first.*	*It is likely that group discussion would have led to some agreements, especially for factors like sustainability or financial viability that are recognized across sectors. However, deep-seated sectoral values would probably still result in some divergence. For instance, industry may still emphasize consumer responsiveness, while government officials may still rank regulatory feasibility higher. Nevertheless, discussion could enhance mutual understanding and perhaps produce a more balanced or negotiated ranking.*	*Probably not significantly. While group discussion can help clarify misunderstandings or bring new perspectives to light, most experts already have strong, well-formed opinions based on their own roles, experiences, and organizational goals. These views are often deeply rooted and unlikely to shift drastically through conversation.* *In fact, group discussions can sometimes reinforce individual positions rather than change them. People may become more confident in their choices after hearing others with similar viewpoints, or they may avoid challenging ideas to maintain group harmony especially in cross-sector settings where power dynamics or professional reputations are at play.* *So, while discussion might lead to better understanding of why others think differently, it is unlikely to dramatically change how each participant ranks the factors. Their final priorities would probably still reflect their core values, responsibilities, and expertise with only minor adjustments.*	*Yes, definitely. In group discussions, people learn from each other's experiences and start to see things they hadn't considered before. For examplesomeone working in design might not realize how much workforce shortages affect construction timelines until they hear it from a project manager.* *In my own projects, I've seen how different perspectivessite crews, engineers, clientsbring unique insights that can shift priorities. A group discussion might not lead to total agreement, but it would lead to more balanced decisions and a shared understanding of what's really at stake.* *Although it could lead to other issues like certain individuals pushing for certain factors that they deem the most important and try to lobby the others in that group. Thus skewing the results in favour of that individual.*	*All agreed group discussions could increase understanding between sectors and reveal hidden agreements. When people talk through their choices, they often find common ground, even if their initial rankings differ.*	*Expert 4 and 6 believed cross-sector dialogue would lead to more balanced rankings. Expert 7 was skeptical saying group talks might reinforce existing beliefs rather than change them. Expert 8 warned that dominant voices could steer the discussion, especially if some participants are less confident or more deferential.*

What happens if conditions change?	*External conditions change what people think is important. For exampleif new climate rules are introduced, then sustainability would become more urgent. If interest rates go up, financial feasibility becomes even more critical. In the meantime, policies should be strong enough to encourage better practices, but not so strict that only a few companies can meet them. So governments try to balance ambition and fairness when setting rules.*	*External conditions can drastically change prioritization. A sudden spike in housing demand could make construction speed and financial efficiency more urgent. On the other hand, strong climate policy or environmental pressure might push sustainability and material innovation to the prioritization. Market dynamics, policy incentives, or crisis events can all shift what stakeholders view as "critical." These shifts are a reminder that priorities are not fixed, but responsive to both internal and external environments.*	*Yes, absolutely when external conditions change, the way experts prioritize factors can shift dramatically.* *Take the example of war or geopolitical instability. In that kind of scenario, the focus may quickly move toward speed and construction efficiency, supply chain resilience, and basic structural durability. There would be an urgent need for fast, reliable housing solutions, especially in areas affected by displacement or damage. In such cases, long-term considerations like environmental sustainability or consumer preferences might temporarily take a backseat to immediate needs.* *Similarly, a sudden spike in housing demand due to population growth, migration, or economic shifts could also elevate the importance of logistics, cost-effectiveness, and labor availability. The system would need to scale quickly, and the focus would shift toward solutions that can be delivered fast and at scale.* *On the other hand, a new climate policy or environmental regulation might push sustainability and green technology to the top of the priority list. Factors that previously seemed secondary could suddenly become non-negotiable as compliance becomes essential.* *In short, priorities are not fixed they are shaped by the context. Factors like war, policy change, economic crises, or environmental disasters all have the potential to reshape what's seen as "most important," depending on the urgency and type of challenge being faced.*	*In construction, we have to adapt fast when conditions change. If there were a housing shortage, speed and supply chain efficiency would jump to the top of the list. Clients and governments would want homes built quickly, and we'd need reliable delivery of prefab parts to stay on schedule.* *On the other hand, if stricter climate policies were introduced, sustainability would become a bigger priority. Things like energy efficiency, materials sourcing, and waste reduction would be under the spotlight. Our team would have to adjust not just our construction methods but also how we communicate the value of these changes to clients.* *So yes, the importance of some factors can shift quickly based on external pressure.*	*Everyone agreed that priorities are not fixed they respond to crises, policy shifts, public demand, and more. For exampleduring a housing crisis, construction speed becomes top priority; under climate pressure, sustainability rises.*	*Expert 7 gave examples like war or migration where quick housing becomes essential. Expert 8 explained that teams also have to shift how they* ***work and communicate*** *when things change for instance, aligning with new regulations or client expectations. Expert 6 noted that new laws can elevate a previously minor factor into a legal must-have.*
Future priorities	*I expect that workforce development and sustainability will become more important in the future. There are growing labor shortages, and more pressure to reduce environmental impact in construction. Both of these issues are long-term challenges, so I believe that they will be key focus areas in the next decade. Other things, like supply chain issues, may also become important, but they will not affect housing as much as other industries like energy.*	*Sustainability is expected to gain even more importance in the next decade, particularly under pressure from climate goals, material scarcity, and public scrutiny. There is growing urgency to reduce environmental impact in construction, especially in Europe. As consumers become more environmentally conscious and policies become stricter, the demand for green building practices will rise. This, in turn, will influence market perception and push industry stakeholders to innovate sustainably.*	*Yes one factor that is likely to gain significant importance in the coming decade is geopolitical-related policy and regulation.* *As the global landscape becomes more uncertain, with rising tensions, trade restrictions, and shifting alliances, housing policy will increasingly be shaped by international relations and geopolitical risks. For exampleaccess to critical building materials, labor, or technologies may be influenced by trade sanctions, cross-border disputes, or global supply chain disruptions. Governments may also implement stricter policies to reduce dependency on foreign suppliers or enforce national security through more localized construction practices.* *This shift will elevate the role of policy and regulatory support, especially policies that ensure resilience, supply security, and strategic autonomy in the construction sector. Prefabricated housing which often relies on globally sourced materials and technologies could be directly affected by these changes.* *In short, as the world faces greater political instability and economic uncertainty, regulations tied to geopolitical concerns will likely become a more dominant factor influencing how and where prefabricated housing can scale.*	*Yes, I expect sustainability, workforce development, and consumer perception/market demand to become even more important. As regulations around carbon emissions are tightened, we will need to build in greener ways, using better materials and reducing waste. Clients/consumers are also starting to expect this.* *Workforce development is also critical. We're already seeing shortages in skilled trades, and with prefabrication requiring a different set of skills, we will need to invest more in training and attracting new talent.* *How people view prefabricated housing (whether they trust it and want to buy it) will shape how fast the market grows. So building public confidence will be just as important as building homes.*	*All agreed:* ***sustainability*** *and* ***workforce development*** *are rising priorities. As regulations get stricter and labor shortages grow, these issues will become central to housing and construction sectors.*	*Expert 7 emphasized the influence of* ***geopolitics*** *global instability may affect access to materials and lead to new construction regulations. Expert 8 added that* ***public trust*** *in prefabricated housing will determine how fast it grows people must feel confident in buying and living in prefab homes. Expert 6 stressed that climate goals will push industry toward greener innovation.*

Appendix E

Table E.1. List of literatures review to be compared with the answers from the third stage interview

Aspect	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5
Paper	Wu, Z. et al. (2024). *Analysis of factors affecting the prefabricated housing promotion from the perspective of stakeholders. Energy & Buildings, Vol. 320*.	Gan, X., Chang, R., Langston, C., Wen, T. (2019). *Exploring the interactions among factors impeding the diffusion of prefabricated building technologies: Fuzzy Cognitive Maps*. ECAM 26(3): 535–553.	Wang, Ying (2023). *A Multi-Perspective Analysis and Strategies Development of Mitigating the Housing Problem in Hong Kong Through Adopting Modular Integrated Construction to Build Transitional Houses*. PhD Thesis, Hong Kong Polytechnic University.	Khan, A., et al. (2022). *Drivers towards Adopting Modular Integrated Construction for Affordable Sustainable Housing: A Total Interpretive Structural Modelling (TISM) Method*. Buildings, 12(5), 637.	Chen, Y., Okudan, G. E., & Riley, D. R. (2010). *Decision support for construction method selection in concrete buildings: Prefabrication adoption and optimization.* Automation in Construction, 19(5), 665–675.
Why some factors are valued more?	Factors are valued based on **how directly they affect stakeholders' operations, risks, and rewards**. For exampledevelopers are economically motivated, so ROI-driven factors dominate. Government factors are rooted in policy levers meant to nudge behavior. Academic actors focus on long-term structural change and knowledge diffusion.	Each group focuses on barriers **closest to their operational pain points**. Developers worry about costs and ROI, while governments look at system-level levers like policy. Researchers zoom in on structural deficiencies and knowledge gaps.	Policymakers prioritize **timely delivery and public visibility**, aligning with political goals. Developers focus on **efficiency, cost, and deliverability** due to commercial pressures. Academics emphasize **interoperability, evaluation methods, and system learning**seeing MiC as a platform for innovation rather than just construction.	**Social factors** such as user trust, stakeholder mindset, and cultural perceptions drive MiC success and indirectly shape all other drivers. Time and cost are prioritized due to market pressure and government urgency. **Productivity and policy** gain attention as they directly affect scalability and institutional backing.	Early project characteristics (for example, repeatability, site space, equipment availability) drive feasibility. In the tactical level, attributes such as **long-term cost**, **quality**, and **environmental impact** become more valued as the **risk profile** becomes more apparent and strategic outcomes are targeted.

Aspect	Paper 6	Paper 7	Paper 8	Paper 9	Paper 10
Paper	Martin, H. et al. (2025). *Validating the Relative Importance of Technology Diffusion Barriers – Exploring Modular Construction Design-Build Practices in the UK*. International Journal of Construction Education and Research, 21(1), 3–23.	Sepasgozar, S.M.E., & Davis, S. (2018). *Construction Technology Adoption Cube: An Investigation on Process, Factors, Barriers, Drivers and Decision Makers Using NVivo and AHP Analysis*. *Buildings*, 8(6), 74.	Martin, H., Garner, M., Manewa, A., & Chadee, A. (2025). *Validating the Relative Importance of Technology Diffusion Barriers– Exploring Modular Construction Design-Build Practices in the UK*. IJCER, 21(1), 3–23.	Manceur, A., et al. (2023). *Mass Timber: A Review of Typologies and Environmental Benefits*. Buildings, 13, 872.	Bademosi, F., & Issa, R. (2021). *Factors Influencing Adoption and Integration of Construction Robotics and Automation Technology in the US*. J. Constr. Eng. Manage., 147(8), 04021075.
Why some factors are valued more?	High-weighted factors are **deeply behavioral and perceptual** rather than technical. Practitioners resist MC not due to system immaturity but due to *habits*, *mindsets*, and *lack of tested trust systems*. Compatibility dominates because people value **continuity of practice**, comfort, and project familiarity.	Across the CTAP process, factor valuation shifts: – *Early stage*: Need identification, perceived value, and vendor familiarity. – *Middle stage*: Cost-benefit analysis, equipment adaptability, stakeholder influence. – *Later stage*: Performance reliability, user confidence, after-sales support. Each stakeholder group emphasizes what most affects their role or risk.	Because they reflect **deep-rooted mental models and risk aversion**, not objective constraints. "Conventional mindset" and "resistance to change" are rated higher than cost or logistics. This shows that **psychological and cultural barriers dominate over technical ones**.	Because mass timber systems address **multiple layers of the construction challenge simultaneously**: - Environmental goals – Industrial standardization – Aesthetic and occupant well-being As such, they are seen as an ideal bridge between policy ambition, developer needs, and user preferences.	Because of the **immediate financial implications**. Industry actors are primarily cost-driven; RAT's long-term efficiency is not compelling if the **initial capital cost and reliability concerns** are too high. Meanwhile, academics look at system-level productivity and long-term ROI.

Aspect	Paper 11	Paper 12	Paper 13	Paper 14	Paper 15
Paper	Nagarjuna, G. G., et al. (2022). *Prefabricated Houses – A Model to Sustainable Housing Market*. ECS Transactions, 107(1), 3781–3792.	Blismas, N., Wakefield, R., & Hauser, B. (2010). *Concrete Prefabricated Housing via Advances in Systems Technologies (Concrete PHAST): Development of a Technology Roadmap*. ECAM, 17(1), 99–110.	Krajewska, M., Siemińska, E., Rącka, I., Szopińska, K., & Kostov, I. (2025). Prefabricated Construction in the Residential Real Estate Market. Real Estate Management and Valuation, 33(1), 35–46.	Wu, Z., Yang, K., Xue, H., Li, S., & Antwi-Afari, M.F. (2024). *Investigating the mechanism of developers' willingness to adopt prefabricated housing using an integrated DEMATEL-SD framework*. *ECAM*, 31(6), 2392–2414.	Adeyemi, A.B., Ohakawa, T.C., Okwandu, A.C., Iwuanyanwu, O., & Ifechukwu, G. (2024). *Integrating modular and prefabricated construction techniques in affordable housing: Architectural design considerations and benefits*. *CRRST*, 2(1), 10–19.
Why some factors are valued more?	**Durability and sustainability** have a statistically significant and positive influence on the **preference to own**. **Affordability** and **quality** surprisingly have *negative effects*, showing that **price alone is not enough** if people perceive prefabs as low-quality or inferior. Barriers (for example, awareness gaps) have a strong positive path coefficient, meaning they influence decisions even when consumers are interested.	Because the **Australian housing crisis**, cyclical demand, and construction labor shortages converge to make **cost, time, and supply-chain reliability** central. Flexibility (for example, future adaptability of homes), integrated digital design (BIM), and lean production methods are prioritized as leverage points.	Rapid assembly and carbon reduction appeal to industry and policy actors due to housing crises and climate mandates. Buyers, however, emphasize **urban design quality** and **perceived safety**, not just affordability. This misalignment shows that **perception and performance** are equally critical.	Developers react most strongly to **economic incentive and mandatory implementation policies**, which directly influence their *perceived usefulness* (i.e. whether prefab housing makes business sense). **Standardization** and **economic strength** impact *perceived ease of use*whether they can easily implement prefab in their workflow.	Because they directly address **the triad of housing issues**: cost, time, and environmental impact. For developers, **cost efficiency and time savings** matter most. For governments, **scalability and climate alignment** are emphasized. For architects, **design modularity and flexibility** are essential.

Aspect	Paper 16	Paper 17	Paper 18	Paper 19	Paper 20
Paper	Johnson, W. (2007). *Lessons from Japan: A comparative study of the market drivers for prefabrication in Japanese and UK private housing development*. University College London MSc Report.	Hong, J., Shen, G.Q., Li, Z., Zhang, B., & Zhang, W. (2018). *Barriers to promoting prefabricated construction in China: A cost–benefit analysis*. *J. Cleaner Production*, 172, 649–660.	Amtered El-Abidi, K.M., & Ghazalia, F.E. (2015). *Motivations and Limitations of Prefabricated Building: An Overview*. *Applied Mechanics and Materials*, 802, 668–675.	Li, L., Li, Z., Wu, G., & Li, X. (2018). *Critical Success Factors for Project Planning and Control in Prefabrication Housing Production: A China Study*. Sustainability, 10(3), 836.	Shah, R., O'Mahony, L., Matipa, W., & Cotgrave, A. (2020). *The Public Perception of Prefabricated Housing in the UK*. EPiC Series in Built Environment, 1, 266–273.
Why some factors are valued more?	In Japan, PHMs value **brand trust, consumer choice, and lifecycle durability** to compete with traditional builders. In the UK, **cost, planning constraints, and risk aversion** dominate private developer behavior. UK perception of prefab remains linked to **post-war low-quality housing**.	Manufacturing accounts for **32.3%–63.3%** of incremental cost (Fig. 8, p. 658). High cost drivers include: – steel-heavy components (facades, forms) – professional design requirements – specialized logistics and lifting – lack of standardized processes. Cost escalates with higher *precast rate* (i.e. more prefab = higher cost).	Practical drivers like *labor shortage*, *on-site safety*, *project speed*, and *waste reduction* dominate, particularly in high-cost labor regions. Governments value prefab when it supports **sustainability and resilience goals**, while academia values **replicability** and **scalability** of prefab models.	The **top 5 CSFs**designers' experience, manufacturers' experience, PM's problem-solving ability, technique maturity, and stable policiesdirectly shape **buildability, cost predictability, and schedule control**. Experience-related variables scored the highest (mean >4.5).	**Cost and finance** emerged as the strongest drivers of public interest. ~87% of "Yes" responses in the survey cited affordability, speed, or efficiency. On the flip side, **lack of information** and **perceived quality concerns** were the top reasons for "No" or "Maybe" (see Table 1, p.5). This reflects the **emotional and informational framing** of housing decisions.

Aspect	Paper 21	Paper 22	Paper 23	Paper 24	Paper 25
Paper	Morake, O., Meng, Q., Sampene, A.K., & Kyere, F. (2024). *Influencing Factors and Promotion Strategies for the Adoption or Resistance of Prefabricated Buildings by Construction Companies in Botswana*. *Buildings, 14(11), 3556*.	Phillips, D., Guaralda, M., & Sawang, S. (2016). *Innovative Housing Adoption: Modular Housing for the Australian Growing Family*. *Journal of Green Building*, 11(2), 147–170.	Ziaesaeidi, P., & Noroozinejad Farsangi, E. (2024). *Fostering Social Sustainability: Inclusive Communities through Prefabricated Housing*. *Buildings*, 14(6), 1750.	Grills, C. (2013). *Industrialization of the Construction Industry through Prefabrication and Adoption of Current Technologies*. BSc Thesis, UBC.	Salama, T., Moselhi, O., & Al-Hussein, M. (2021). *Overview of the Characteristics of the Modular Industry and Barriers to its Increased Market Share in Canada*. *IJIC*, 2(1), 30–53.
Why some factors are valued more?	Firms prioritize **time savings**, **environmental goals**, and **government incentives** when clear and economically aligned. Conversely, they resist PFB due to **lack of guidelines**, **design limitations**, **logistical complexity**, and **consumer mistrust**especially when short-term feasibility seems compromised.	Flexibility needs were driven by interviews with Brisbane families. Factors most valued: • *Layout adaptability* • *Recreation space* • *Safety and surveillance*. Families prefer spaces that evolve as children grow, without having to relocate.	**Affordability, housing security, sense of belonging, and community integration** were the most frequent themes mentioned by survey respondents (*see word cloud on page 4*). They represent both tangible (cost) and intangible (identity, cohesion) needs central to social sustainability.	Prefab is praised for reducing waste, shortening timelines, and enabling automation, but uptake remains limited due to high capital costs, inflexible design processes, and fragmented regulation. Industry values reproducibility and factory protection; policymakers look to prefabrication for affordability solutions.	Stakeholders emphasized **schedule reliability**, **transport costs**, and **coordination tools (like BIM)** as most impactful. Project delivery systems like IPD had better schedule sync and productivity capture rates, reflecting higher perceived control.

Shaping influence: background, worldview, and experience	Developers operate from a **commercial/entrepreneurial mindset**, focusing on returns and feasibility. Government views housing through a **policy efficacy lens**, favoring levers like subsidies. Academia, informed by **systems thinking and quality research**, emphasizes norms, standards, and skill development.	Developers' business logic drives attention to **economic and market constraints**. Government officials act as **policy architects**, seeking interventions that shift the system. Researchers are shaped by their emphasis on **systemic complexity** and **inter-factor dependencies**. Designers focus on *aesthetic barriers*, reflecting their domain orientation.	Government actors adopt a **public planning and regulation** lens. Developers are shaped by **risk sensitivity and investment timelines**. Academics, from an innovation systems view, emphasize **capability building and modular knowledge dissemination**.	Policymakers focus on MiC as a **regulatory and investment enabler**, often shaped by their goal to meet SDGs. Developers and industry focus on time/cost, reflecting their **ROI-centered worldview**. Researchers adopt a **systemic, innovation-driven view**, pushing for tech integration and ecosystem maturity.	Contractors bring experience with construction constraints and project delay risk, hence **risk-averse attitudes** for cost and quality. Engineers are balanced, reflecting **technical feasibility and systemic performance**. Academia (authors) introduces **rational decision modeling** under uncertainty (for example, utility independence, exponential utility functions).	Practitioners shaped by traditional UK contracting norms favor **lowest bid**, *standardized procurement*, and *project-by-project design logic*. Designers exhibit *aesthetic skepticism*; contractors push *repeatability and modularity*. Academics and progressive designers adopt a **technology integration worldview**, using innovation theory to explain adoption inertia.	Contractors prioritize past experience and delivery certainty. Executives focus on financial return and strategic fit. Operators look at ease-of-use and maintainability. Researchers embed organizational learning and behavior theories to explain adoption outcomes.	**Contractors** see MC through a lens of logistics, aesthetic monotony, and on-site adaptability. **Designers** are more open but worry about architectural limitations. **Academics** analyze behavior and perception, viewing modular as an idea needing narrative, not just evidence. **Less experienced professionals** are more skeptical. Experience softens resistance.	Engineers and architects view mass timber through a lens of *material innovation and modular flexibility*. Sustainability researchers view it as a *carbon strategy*. Construction practitioners see it as a *streamlined, low-waste prefab option*. Policy actors are driven by *building code updates and decarbonization targets*.	Contractors bring a **practical execution mindset**, emphasizing performance and installation challenges. Researchers use **systems modeling and diffusion theory**, interpreting technology adoption through ROI potential, innovation maturity, and firm readiness. Experience with early-stage tech lowers perceived risk.	Indian consumers prioritize **durability and environmental performance**, likely due to climate vulnerabilities and building longevity concerns. Industry players focus on **cost-performance tradeoffs**, while researchers bring a **behavioral and systems lens** using decision models. Government discourse reflects **housing supply urgency**, but less focus on **consumer-level adoption behavior**.	Contractors emphasize current **cost, labor, and site delivery issues**. Researchers aim to **industrialize and synchronize** prefab housing systems using lessons from manufacturing. The roadmap reflects a strong **supply-chain transformation worldview**, drawing from aerospace and automotive analogies.	In post-socialist contexts (Poland, Bulgaria, Ukraine), past mass prefab systems influence current skepticism. **Academia** sees prefab as part of *urban ecological modernization*. **Industry** wants efficiency. **Buyers**, shaped by past negative associations (esp. in Bulgaria), evaluate value through community space and design quality.	Developers in Shenzhen are seen as **business-rational agents** with limited risk appetite. They respond to proven ROI, market stability, and low transaction friction. Academics model this behavior with **quantitative feedback loops**, emphasizing both technical and cognitive thresholds.	Developers emphasize *constructability and speed*, influenced by urban housing delivery pressure. Academics frame their approach through *sustainable systems thinking*, highlighting carbon savings and long-term resilience. Government regulators are challenged by outdated codes and resistance to perceived “temporary” aesthetics.	Japanese firms evolved from **industrial conglomerates** (for example, Sekisui, Toyota, Daiwa), bringing a manufacturing mindset. UK developers evolved through **real estate speculation**, not product innovation. UK regulators focus on *design and affordability*, while Japanese regulators push *performance and seismic safety*.	Developers are risk-averse, shaped by budget constraints. Offsite contractors struggle with **low-tech, manual-intensive production**. Researchers use life-cycle and systems thinking to show prefab's **long-term payback**, though upfront cost is emphasized.	• Industry stakeholders in advanced countries operate under **just-in-time construction logics** and are familiar with **mechanized systems**. • Researchers apply global comparisons to argue for prefab contextualization. • Governments with constrained land (for example, Singapore, HK) use prefab to **accelerate public housing** and **reduce site disruption**.	Chinese developers and contractors are shaped by **recent exposure to PHP**, and seek **low-risk, replicable delivery**. Researchers highlight **systems integration**. Governments drive adoption with incentives, but the **implementation capacity** (technical and managerial) is still developing.	• **Younger respondents** and those *desperate to get on the property ladder* were more open to prefab (p.5). • **Older participants** still carried post-war biases against quality and longevity. • Policy scholars and planners are concerned with *housing supply targets*, while industry remains focused on *demonstrating performance*.	• Firms used to traditional workflows fear disruption. • Internal environmental considerations and prior experience with prefab drive openness. • Government efforts are shaped by policy mandates but challenged by implementation gaps.	Young families in **early lifecycle stages (Duvall Stage II & III)** experience spatial stress but value **adaptable, medium-sized dwellings**, not more bedrooms. Researchers use **qualitative insights** and design theory to model family needs across time.	Participants with previous exposure to modular homes were more open to the **idea of permanence and flexibility**. Others expressed concern about **temporary aesthetics, prefab "lightness"**, and perceived lack of robustness reflecting generational and cultural biases.	Industry shaped by **past cycles of prefab booms and busts** (for example Levittown, mobile homes). Policy is shaped by housing crises and the need for sustainable alternatives. Academia draws from **manufacturing theory, energy systems**, and post-industrial design frameworks.	Modular manufacturers are driven by **design-manufacture integration**. Government actors are shaped by public procurement constraints. Researchers focus on **diffusion theory, systems fragmentation**, and innovation modeling. Experience with modular significantly shaped positive perception.
Mental frameworks at play	Developers: *cost-benefit, competitiveness, feasibility*. Government: *indirect influence, incentivization, regulation*. Academia: *knowledge transfer, quality assurance, innovation frameworks*.	Developers and manufacturers operate with a **cost-performance-risk lens**. Government frames its thinking through **instrumental rationality** (policy effectiveness). Academia uses **systems thinking** (interconnected barriers, emergent complexity).	**Industry** uses a *cost–logistics–execution* mindset. **Government** operates under a *social delivery and legitimacy* framework. **Academia** applies *design science* and *lifelong learning frameworks*, treating MiC as an evolving solution space.	**Industry** frames MiC using a *performance-risk-cost* model. **Government** views it through a *public impact and housing delivery lens*. **Academia** leverages *systems thinking*, *modular design logic*, and *policy-innovation coupling*.	• **Industry**: *Risk-cost-logistics-performance framework* • **Academia**: *MAUT/SMART-based rational evaluation* • **Project Teams**: adopt a *satisficing vs. optimizing tradeoff mindset* depending on early or late project phases.	**Industry**: *Behavior-risk-tradition inertia* dominates. **Academia**: Applies *Diffusion of Innovation theory*, framing adoption as a staged behavioral and contextual process. **All sectors** see modularization through a lens of *cultural dissonance*, not just technical unfamiliarity.	• Industry: *Execution feasibility*, *cost-benefit-risk tradeoffs* • Academia: *Decision theory*, *organizational sociology*, *technology adoption modeling* • Government (implicitly): *Policy enforcement*, *public welfare*	• Industry: *Cost–risk–image–habit heuristic* • Academia: *Diffusion of Innovation theory*, *behavioral attitude modeling* • Government (perceived): *Regulation–reputation–public accountability*	• **Academia**: Life-cycle thinking, material circularity, and climate systems modeling. • **Industry**: Cost-speed-performance tradeoffs; aesthetic + acoustic value for occupants. • **Government (implied)**: Risk regulation and carbon accounting.	• **Industry**: cost–risk–value tradeoff heuristic • **Academia**: innovation maturity models, AHP-based strategic decision-making • **Policy (inferred)**: innovation stimulus, competitive productivity framework	• **Academia**: Behavioral modeling, SDG alignment, SEM theory. • **Industry**: ROI-first logic, delivery timelines, logistics control. • **Government**: Top-down transformation via housing schemes (PMAY, Smart Cities), but with limited financial innovation.	• **Industry**: Shift from artisanal contracting to production logic (JIT, CAD-CAM, modular kits). • **Academia**: Innovation roadmapping, systems integration, and technology performance benchmarking. • **Policy** (implied): Cost efficiency, upskilling, and housing delivery responsiveness.	• Industry: *cost-speed-efficiency* • Academia: *decarbonization-LCA-policy integration* • Consumers: *legacy bias vs. need for affordability and function* • Government (implied): *climate compliance and housing delivery pressure*	• **Industry**: Profit-risk equilibrium model, operational feasibility. • **Academia**: Behavioral modeling (TAM), systems theory (SD), multi-criteria decision analysis (DEMATEL). • **Government**: Incentivization logic, carbon peak and neutrality targets.	• **Industry**: Performance-driven, productivity-focused logic. • **Academia**: Modular theory, SDG alignment, LCA-based logic. • **Policy (implied)**: Urban housing urgency + decarbonization goals.	• **Japan**: Industrial efficiency + consumer satisfaction + lifecycle performance. • **UK**: Risk minimization, land speculation, tradition. • **Academia**: Systemic modeling and cross-national lessons.	• **Industry**: short-term ROI, logistics realism, labor scheduling • **Academia**: system optimization, process segmentation, carbon lifecycle impact • **Policy**: subsidy-based modernization and housing delivery urgency	• **Industry**: Operational efficiency and safety. • **Academia**: Adoption stage theory, classification frameworks, regional studies. • **Policy (inferred)**: Infrastructure modernization and housing output acceleration.	• **Industry**: practical execution logic, standardization, and cost-focus • **Academia**: statistical modeling, multivariate analysis, project control theory • **Government**: incentive design, regulatory scaffolding	• **Public**: Affordability + Trust. • **Government**: Homeownership enablement. • **Industry**: Productivity through modularity. • **Academia**: Communication and behavioral science (reputation modeling).	• **Industry**: ROI-first, project-based feasibility. • **Government**: Sustainability and housing access mandates. • **Academia**: Cognitive modeling (BRT), inductive thematic logic.	• **Industry**: Factory optimization vs. on-site variability. • **Academia**: Lifecycle-driven flexibility, layered systems, adaptability through component decoupling. • **Policy**: Urban sustainability, spatial justice, affordable housing continuity.	• **Public**: Equates affordability with identity, trust, and emotional security. • **Academia**: Applies social sustainability frameworks, user-centered design, participatory planning. • **Government (implied)**: Must frame prefab housing as *viable and desirable*, not just *fast and cheap*.	• **Industry**: Emphasis on standardization, modularization, and productivity. • **Academia**: Applies innovation diffusion theory and lean production parallels. • **Government**: Seeks affordable housing scalability with reduced environmental impact.	• **Industry**: ROI-focus, operational feasibility, and tech readiness. • **Academia**: Diffusion of innovation, system integration, lean production. • **Government**: Regulatory oversight, risk minimization, and housing policy timelines.

Do people favor factors tied to their responsibilities?	Strong alignment observed: developers emphasize what affects cost and project control; academia values factors relevant to technical robustness and education; policy instruments dominate the government's concern set.	Yes. Designers uniquely emphasize *aesthetics*; developers care about *business model* and *cost*. Government focuses on *policy*, while researchers prioritize *expertise* and *standardization*. Stakeholders are **strongly siloed**, each **amplifying their own constraints**.	Yes. Government prioritizes *land use, incentives, and regulation*. Developers care about *standardization, procurement, delivery logistics*. Academia focuses on *technical R&D, digital design, and skills transfer*. Each sector defends and promotes its domain-specific contributions.	Yes. Government favors **policy** and **public perception**. Developers lean heavily on **cost and time**. Academics emphasize **productivity**, **quality**, and **environmental performance**. Each sector elevates factors within their influence domain.	Strongly yes. In the case study: – **Clients** care about long-term cost and aesthetics. – **Contractors** emphasize constructability and health/safety. – **Engineers** prioritize quality and integration. – **Precasters** focus on logistical feasibility and prefabrication scope.	Strongly yes. Contractors emphasize *modularity benefits*, *logistics*, and *bid competitiveness*. Designers resist *perceived monotony* and *aesthetic sacrifice*. Non-adopters cite *lack of policy clarity* and *uncertain supply chains*. Roles mediate what is seen as feasible or risky.	Yes. Procurement favors pricing. Engineers favor technical compatibility. Site managers focus on operability. Vendors highlight product strengths aligned with buyer concerns. The AHP model quantifies these variations in decision weights.	Yes. Contractors rate *aesthetic risk* and *design inflexibility* highly. Project managers focus on *procurement and lead time*. Non-adopters fear *policy gaps* and *supply chain immaturity*. Each prioritizes barriers within their **sphere of control or fear**.	Yes. – Industry favors *cost, scheduling, logistics, and on-site efficiency*. – Academia emphasizes *GHG mitigation, reuse, and material flows*. – Government (implied) focuses on *policy alignment and permitting pathways*. Each stakeholder lens frames timber adoption differently.	Yes. – Contractors and project managers emphasize *on-site integration*, *technical support*, and *training costs*. – Researchers focus on *long-term benefits* and *system effectiveness*. – Owners care about *cost and strategic returns*.	Yes. – **Consumers** (surveyed): favor sustainability, durability, and customization (reflected in negative scores for affordability and quality, possibly due to distrust). – **Industry**: aims to meet rapid demand with minimal disruption. – **Academia**: focuses on bridging supply-demand misalignment and mass customization.	Yes. – Builders emphasize *assembly logistics*, *interface design*, *cost mitigation*. – Researchers highlight *open system frameworks*, *life-cycle adaptability*, and *digital control systems*. – Government's role is financial and regulatory, focused on market enablement.	Yes. – Industry seeks **cost-efficient**, **quick-assembly**, **modular integration**. – Academia focuses on **sustainability impact** and **policy cohesion**. – Residents associate prefabs with past regimes but **Polish and Ukrainian respondents** are more open than Bulgarian ones. – Government, while not surveyed, is implicated in enabling tech and regulation.	Yes. – Developers emphasize *economic strength, logistics, vendor capabilities*. – Academics prioritize *system interactions, modeling accuracy*. – Policymakers (represented in the model) use *macro-levers* like subsidies, mandates, and regulations.	Yes. – Developers push **efficiency and scalability**. – Architects explore **design integrity and modular coordination**. – Academia emphasizes **durability, emissions, and replicability**. – Government is urged to **update planning codes and funding mechanisms**.	Yes. – **PHMs** value marketing reach, design adaptability, and structural quality. – **UK Developers** prioritize land value control and minimize construction innovation. – **Government** promotes affordability and MMC for *volume, not quality*. – **Academia** focuses on *diffusion lessons and policy leverage*.	Yes. – **Developers**: care about *initial cost and supply chain reliability*. – **Consultants**: worry about *drawings, collision checks, and timelines*. – **Academics**: address systemic fragmentation and process optimization.	Yes. – Developers in Sweden, Japan, and the UK emphasized *cost control* and *modular standardization*. – Researchers concentrated on *technology maturity, adoption barriers*, and *strategic incentives*. – Policy instruments in Singapore and Hong Kong targeted *affordability* and *timeline guarantees*.	Yes. – Designers emphasize *design maturity and input coordination*. – Manufacturers highlight *assembly feasibility and logistics planning*. – PMs stress *problem-solving and task planning*. – Each role rated factors most closely tied to their scope as more critical.	Yes. – Homebuyers focus on *cost, mortgage availability, and housing appearance*. – Government focuses on *stimulating supply and ownership*. – Industry wants *faster build and reduced snagging*. – Researchers emphasize *understanding perceptions and translating technical facts into public trust*.	Yes. – Executives emphasize *business risk and workflow control*. – Engineers focus on *technical and assembly risks*. – Regulators emphasize *policy instruments*. – Suppliers highlight *logistics and design conformity*.	Yes. – Families emphasize **day-to-day adaptability**, **visual access to outdoor play**, and **modular zones**. – Designers focus on **layout-neutrality**, **partition adjustability**, and **structural clarity**. – Researchers develop **criteria matrices** for structural, layered, and perceptual flexibility.	Yes. – Respondents emphasized **housing access and tenure security**. – Government is urged to lead with **evidence-based policy**, updated planning codes, and visible pilot projects. – Designers are pushed to provide **customizable, community-sensitive layouts**.	Yes. – Manufacturers focus on *mass production feasibility*, *design repetition*. – Government emphasizes *zoning, subsidy, market development*. – Engineers consider *CNC, mechanization, CAD integration* crucial.	Yes. – Modular firms value *design freeze, early coordination*, and *automated delivery*. – Governments are cited as needing to improve *zoning and permitting*. – Researchers call for more *case documentation* and *standard development*.
How experience shapes judgments	Past exposure to **cost overruns, coordination gaps, or failed incentives** shapes perception: developers fear cost and risk; academics appreciate structural flaws; government leans on historical policy success or failures to re-calibrate strategy.	Contractors and manufacturersoften burned by **coordination failures and cost overruns**focus on *logistics*, *manufacturing limits*, and *lack of expertise*. Their experience underlines the technical-operational focus. Government emphasizes *policy influence*, reflecting past involvement in steering programs.	Government decisions are informed by **prior transitional housing projects**, where public backlash and time delays mattered. Developers are shaped by **site access difficulties** and **logistics failures**. Academics base judgments on **MiC pilot evaluations and international case comparisons**.	Prior MiC implementation failures or successes (for example, site delays, module damage, stakeholder resistance) shape current priorities. For instance, developers distrust logistics without robust local supply chains, and governments are wary of public rejection.	Participants' responses (especially contractors and clients) showed **risk aversion**favoring less uncertain prefabrication combinations. Their **certainty equivalents** reflect conservative scoring of tradeoffs (for example, preferring guaranteed moderate quality over potentially excellent outcomes with risk).	Modular experience correlates with **less fear** of supply chain instability and more favorable views on *repeatability, design, and aesthetics*. Those unfamiliar rate **policy weakness** and **government support gaps** highersuggesting uncertainty fuels barrier perception.	Firms with prior failures in tech adoption are more cautious. Vendors with established service records are better received. Interview data reveals that organizations often consult peer firms to validate adoption decisions.	More experienced professionals rate **government barriers and skepticism lower**, suggesting **confidence grows with exposure**. Those without MC experience overrate obstacles like "lack of policy," reflecting *fear of the unknown*.	Prior exposure to prefab timber systems influences comfort with design tolerances, transport limits, and build speed. Academic studies of embodied carbon and modular reuse drive long-term advocacy. Codes evolve slowly, shaped by *risk perception from regulators and insurers*.	Those with RAT experience rank *barriers* lower and *benefits* higher. They cite successful case-based trust in *productivity*, *safety*, and *cost savings*. Non-users emphasize *risk, cost, and tech immaturity*.	Consumers unfamiliar with prefabrication equate "affordable" with "cheap" or "low-quality", explaining the negative path coefficients. Those aware of prefab benefits rate *durability and sustainability* higher, aligning with project delivery outcomes in urban areas.	Experienced precasters, contractors, and developers **reject isolated material swaps** (for example, substituting concrete blocks without process change). Instead, they advocate for **system redesign**for example, integrated services, open system architecture, mass customizationto achieve value.	Countries with **negative prefab legacies (Bulgaria)** show higher skepticism. **Polish buyers** accept prefabs more, appreciating their **urban open-space planning** from the 1980s. Ukrainians, facing housing deprivation, are **less selective**, willing to accept prefabs as long as the price, design, and service quality match expectations.	Developers with high economic strength and prior prefab experience have **higher ease-of-use perception**, lowering resistance. Conversely, less experienced developers view *standardization* and *policy clarity* as barriers.	Prior successful modular projects influence the positive framing of prefab. The paper references **factory precision**, **lower error margins**, and **durable finishes** as perceived gains. Also notes that early stakeholder involvement (Section 4.2) increases coordination and outcome success.	• Japanese consumers value brands with **track record**, warranties, and innovation. They prefer new homes and engage in design co-creation. • UK stakeholders (especially older professionals) recall prefab as **austerity-era** and resist rebranding efforts. • UK builders assume **traditional methods = safest business model**.	Firms in Shenzhen, a mature prefab market, show lower incremental cost due to **supply maturity**. Developers in less developed provinces face **up to 72.1% higher total cost** than conventional builds.	Countries with established prefab industries (for example, Japan, Scandinavia) show higher trust and willingness. In contrast, countries new to prefab associate it with *aesthetic loss*, *rigidity*, and *low flexibility*. Experience correlates with reduced perception of barriers.	Respondents with more PHP experience ranked *design and manufacturing* significantly higher. Cities with mature PHP supply chains (for example, Shanghai, Beijing) exhibited greater **confidence in planning control**, while newer regions showed **higher concern for transport and coordination risks**.	Those who had **previously lived in prefab homes** or seen them in other countries were more open (see two quotes on p.5). **Post-war memory**, even if faint, was cited by ~3% of respondents as a deterrent, while **modern prefab images** had a 54% average recognition rate (p.6).	Firms with prior prefab trials report more optimism. Those unfamiliar overrate risks and focus on design inflexibility or poor logistics. High cost perceptions persist among non-adopters. Experienced firms cite better **competitiveness** and **speed**.	Families who had moved post-children reported unmet flexibility needs. Interviews revealed that **relocation was often due to inflexibility**, not room count. Preferences shift toward **multifunctional, semi-private zones**, rather than fixed-use rooms.	Respondents who had seen successful prefab models (for example, post-WWII units, global case studies) were more optimistic. Those without exposure viewed prefab as *temporary*, *generic*, and *less dignified*. The paper notes that **visual education and narrative change** are essential.	Prefab leaders in Canada (and globally) are learning from past failures. Early exposure to prefab tech increases confidence, while older builders associate it with mobile-home stigma. Prior familiarity with **JIT, CNC, or lean** increases uptake interest.	More experienced professionals strongly supported **early design freeze**, **BIM-based scheduling**, and **integrated delivery**. Less experienced firms cited **design-change fatigue**, **logistics complexity**, and **public distrust** as barriers.
Organizational bias?	Evident across the board. Developers focus narrowly on economic metrics; academics lean on structural enablers; government does not receive feedback on its policy tools due to their peripheral position in the network model.	Strong. Each stakeholder sees the barriers **through their institutional lens**, ignoring others' bottlenecks. For exampledevelopers downplay design concerns, while designers rarely discuss cost structure. This fragmented bias **prevents**	Evident across all sectors. Developers underappreciate *public communication needs*; government may overlook *on-site modular handling difficulties*; academics might underweight *short-term commercial*	Evident. Government sees MiC as a delivery tool, ignoring on-site technical friction. Developers underestimate social cohesion needs. Academics sometimes overlook short-term viability concerns like	Yes. Table 6 (p. 672) shows different utility curves per rolefor example, the contractor is risk-prone to environmental aspects, risk-averse to cost; client is highly risk-averse across most	Evident. Construction professionals rate *aesthetic factors* higher than designers (surprisingly), showing a focus on **configuration simplicity** and **practical deliverables**. Designers might	Evident. Upper managers may rush adoption based on ROI, ignoring user-level barriers. Site operators might resist change due to lack of training or past negative experience. Vendors assume rationality, but	Yes. **Designers underestimate contractor aesthetic concerns**. Contractors downplay regulatory complexity. Government is assumed to be supportive, but many practitioners see a **policy-practice gap**.	Yes. Industry often underplays **end-of-life circularity**, while academia may overlook **short-term cost or site limitations**. Governments remain conservative due to **fire safety fears**,	Yes. Industry participants emphasize cost factors (initial, operating, maintenance), while academia weights innovation and capacity-building more heavily. Government support is	Yes. Government assumes **top-down schemes will boost demand**, but fails to bridge the **financing and awareness** gap. Industry assumes **price cuts = demand**, but SEM shows That is not enough. Academia	Yes. Industry tends to prefer **incremental changes within familiar project delivery**. Academia pushes more aggressive **disruptive innovation**, favoring the full system shift.	Yes. Industry and government assume **speed = success**, while buyers demand **aesthetics, privacy, and flexibility**. Academia tends to lean toward **long-term climate and cost**	Yes. Developers focus on short-term *capital investment and market risk*. Governments prioritize *policy enforcement* and *carbon goals*. Academics often assume	Yes. Developers see prefab as a **cost-control tool**, while academia warns against reducing modular housing to cheap "boxes." Governments treat modular systems as	• **UK developers** downplay quality and consumer control, preferring standardization and traditional methods. • **Government** equates prefab with social housing	Yes. Developers focus narrowly on **procurement and delivery risk**. Academia over-indexes on **technical potential**. Government leans on high-level policy goals but does not resolve **execution**	Yes. Industry actors often reduce prefab to *cost vs. benefit*, overlooking *design integrity* and *cultural fit*. Academia sometimes treats prefab as *universally scalable*, ignoring regional supply chain maturity.	Yes. Designers overlooked *logistics and ICT barriers*. Contractors prioritized *site-level feasibility* over *data integration*. Policymakers may overestimate **policy impact**	Yes. Industry overestimates **technical superiority**, underestimates **trust barriers**. Government underutilizes its **financing and media reach** to create "Skoda-style" image campaigns.	Yes. – Builders cling to *proven methods*. – Government overemphasizes *macro-policy* without smoothing ground-level operations. – Researchers may assume rational cognitive adoption	Yes. – Industry underestimates **service transparency** and **user-directed alterations**. – Policymakers assume **room quantity = adequacy**. – Academia often overlooks	Yes. – **Government** tends to frame prefab via macro metrics (supply, timeline), not lived experience. – **Industry** underplays aesthetic and social integration	Yes. – Builders prioritize processes that match traditional workflows. – Governments often see prefab as an emergency solution, not long-term strategy. – Scholars advocate for	Yes. – Builders emphasized *logistics and hoisting*. – Engineers fixated on *design rigidity*. – Regulators remained cautious due to *code mismatch*. – Academic voices emphasized *systems theory*,

		collective strategy.	*pressures*. These biases shape strategy focus.	logistics and initial capital.	dimensions. This skews **utility weights** and leads to diverging prefabrication preferences.	abstract aesthetics, while contractors react to client demands.	clients often act based on politics or urgency.	Each role views modular through **distinct risk-reward filters**.	despite strong environmental potential. Each sector privileges its evidence base.	assumed necessary but not proactively modeled.	recognizes these misalignments and calls for **consumer-centered design frameworks**.	Government (though not directly involved) is assumed to favor **cost-per-unit** metrics and *supply volume*, not quality or adaptability.	**indicators**, while neglecting **local emotional legacies**. These biases need reconciliation in practice.	rational behavior and system equilibrium, which may not reflect developer hesitation or distrust.	emergency solutions, not as **permanent housing strategies**. These competing expectations risk fragmenting collaboration.	affordability. • **PHMs in Japan** treat prefab as **premium housing**, with marketing, warranties, and value-add features.	**bottlenecks** like labor training and part supply.	Governments overfocus on delivery speed, neglecting *post-occupancy feedback*.	without investing in **talent, training, or manufacturing automation**.	Academia sometimes over-prioritizes technological features without integrating public-facing narratives.	models, underestimating emotional attachment to traditional practices.	**transport, regulation, and price sensitivity** in modular roll-out.	concerns. – **Academia** calls for a shift toward *people-centered design* and *longitudinal community feedback*.	**transformational design-logistics integration** but lack traction in commercial settings.	sometimes too abstractly.
Would group discussion change results?	Likely yes. A **multi-stakeholder dialogue** could reveal **hidden interdependencies** and address siloed perceptions. For instance, academics might help developers recognize long-term value of standards; developers could highlight feasibility constraints to policy designers.	Yes. A **collaborative mapping** exercise might break the siloed bias, revealing interdependencies (for example, how *policies* shape *logistics* and *knowledge gaps*). The lack of shared vision was a major themegroup interaction would likely recalibrate perceptions.	Yes. Group discussion would likely bridge knowledge gaps. For instance, **developers could inform government on logistics needs**, and **academics could help translate complex standardization into actionable toolkits**.	Yes. TISM shows strong interdependencies. For instance, social drivers affect policy success and demand dynamics. Collaborative mapping could break siloshelping policymakers understand technical friction and industry actors appreciate systemic challenges.	Yes. The aggregation of rankings (p. 673) suggests **diverse and sometimes conflicting utility perceptions**. A live group deliberation would have likely enabled *mutual adjustments and value negotiation*.	Likely yes. Fragmented roles and assumptions (for example, that designers care more about aesthetics) would be clarified. Discussions could resolve **observability gaps**, highlight shared constraints, and develop **cross-role empathy**.	Yes. Structured discussions (as modeled via AHP) would allow more balanced consideration of front-line concerns. Without them, tech adoption is often based on narrow performance metrics and executive push.	Likely yes. Cross-role forums could bridge perceptions. For example**non-adopters fearing regulation might realize others operate safely under existing frameworks**. Group dialogue would reveal shared priorities and break siloed misunderstandings.	Yes. Multistakeholder discussion would expose blind spots: for example, how **industry's cost focus might be balanced by academia's reuse modeling**, or how **government fire concerns** could be addressed by technical proofs from research labs.	Likely yes. Cross-sector dialogues could correct over-weighting of capital barriers and surface *shared support for pilot-based trialability* and *risk-sharing*. Common understanding would elevate abstract drivers like *tech trust* and *training*.	Yes. Dialogues among consumers, producers, and regulators could surface **hidden drivers like customization need**, clarify **affordability-quality tradeoffs**, and identify **shared goals** (for example, reducing time-to-market while improving trust).	Yes. Multi-stakeholder workshops **enabled cross-industry understanding** during roadmap creation. Builders, designers, suppliers, and researchers aligned on issues like **standardized grids**, **interface design**, and **kit-of-parts advantages**, proving group dialogue essential for roadmap legitimacy.	Absolutely. **Public-private-academic dialogues** could align buyer priorities (livability, perception) with policy (decarbonization) and industry (cost-efficiency). Without dialogue, each acts on outdated assumptions or siloed knowledge.	Yes. The use of **multi-professional interviews (10 experts from academia and industry)** helped simulate diverse responses. Broader forums could help **reconcile divergent policy, business, and design interests**, and align priorities in real implementation.	Yes. The **case studies** (Section 4) illustrate how coordination among designers, contractors, and city planners **helped align specs, streamline delivery, and avoid rework**. The "Y Project" in London exemplifies success from early collaborative planning.	Yes. UK policy discussions rarely include PHM executives or marketers. A broader coalitionincluding consumersw ould shift narrative from cost to **quality and lifestyle**. Japan shows this integration yields higher trust and market share.	Yes. Experts interviewed (designers, contractors, suppliers) acknowledged that **multi-party coordination** reduces design errors and improves cost efficiency. **Collective understanding** of transport, protection, and schedule constraints could shift adoption thresholds.	Yes. Integrated workshops involving architects, contractors, and public sector representatives would improve **perception management** and identify shared implementation roadmaps. The paper indirectly advocates for multi-actor collaboration to resolve aesthetic, regulatory, and cultural misalignment.	Yes. The study shows stakeholders operate in **functional silos**. Enhanced cross-role discussionse specially among *designers, fabricators, and contractors*could improve early-stage alignment and reduce changes.	Yes. The study advocates for **multi-sector engagement** homebuyers, government, and builders sharing concerns and success stories. For exampleimage-based discussions (Figure 5) could help clarify what prefab actually looks like.	Yes. Respondents echoed that **cross-role dialogue**especially between clients, regulators, and engineerscould alleviate mistrust, improve design coordination, and align economic expectations.	Absolutely. User-informed design would shift focus from **fixed bedrooms** to **configurable rooms**, from **load-bearing permanence** to **removable layers**. Including developers, users, and regulators early would resolve constraint tensions.	Yes. The study recommends **participatory planning**, including early resident input, town planner engagement, and collaborative zoning approvals. Citizens emphasized that prefab success depends on **early design trust** and *shared visioning*.	Yes. The paper promotes **early-stage multi-actor engagement**. Real-time integration of builders, architects, policy reps, and system engineers during design and planning would mitigate prefab's early-stage bottlenecks.	Yes. Survey results revealed that fragmentation and misunderstandingespecially across government, manufacturers, and designersdeepened delays and cost perception. Regular *design charrettes* and policy roundtables were proposed.
What happens if conditions change?	In a scenario like **housing shortage or climate-driven policy reform**, factors such as *speed of delivery*, *supply chain integration*, and *standardization* may rise. Consumer intent could shift based on external forces like inflation or ESG regulation.	If market demand surges (for example, due to climate policies or subsidies), it could **flip the vicious cycle** into a virtuous one. High demand → better margins → lower cost → wider adoption → policy validation. Similarly, **knowledge improvement** could yield systemic easing of technical and quality barriers.	A **housing demand spike** would amplify the importance of MiC's **rapid delivery advantage**. If **regulatory support weakens**, interest in MiC may decline unless offset by **market or NGO-driven models**. Global climate policies could also raise interest in MiC's **low-waste, low-emission potential**.	In events like natural disasters, economic crises, or policy shifts, **time, cost, and demand** factors rise sharply. If public trust increases or digital tech matures, **social and environmental drivers** gain traction. Climate regulation could also elevate environmental priorities.	A change in site access, regulation, or labor availability would significantly shift **prescreening feasibility score**. For exampleif **transportation is restricted**, cast-in-place would gain favor. Climate policies could increase the **weight of environmental factors** (X7).	Greater visibility of successful projects (observability) could raise perceived relative advantage. New government incentives or standardization tools could change perceptions of complexity. Supply-demand shocks (for example, post-pandemic logistics) would further stress modular adaptability.	• If urgency increases: speed and vendor response dominate. • If regulations tighten: compliance and data traceability become vital. • If budgets are cut: upfront cost and payback period take precedence. Flexibility in CTAP allows realignment of criteria.	• Stronger **policy incentives** (for example, planning bonuses, subsidies) would lower government-related barrier perceptions. • Aesthetic diversity tools or **design competitions** could reduce designer skepticism. • Successful public modular showcases would increase *observability* and improve *relative advantage perception*.	• A **carbon tax or decarbonization requirement** would boost mass timber's appeal. • **Supply chain shocks** (for example, due to logging restrictions or import bans) could stall adoption. • **Insurance reform or fire code modernization** could unlock high-rise prefab timber markets.	A cost crisis (for example skilled labor shortage) or policy push (for example green tech incentives) would raise RAT's adoption rate. Maturity of off-the-shelf systems and vendor reliability could drastically improve confidence.	A rising climate mandate or land shortage may boost **sustainability and prefab modular solutions**. On the other hand, **subsidized housing finance or mass trust-building** (for example, demos, government-backed loans) could shift the *negative affordability/quality perception*.	If **demand spikes** (for example, post-COVID or due to immigration), faster prefab systems will be prioritized. If carbon targets strengthen, concrete's **carbon intensity** becomes a liability unless offset by **optimized supply chains and performance enhancements**. Changes in funding (public-private) could enable advanced modular uptake.	• Natural disasters, war (for example, Ukraine), or floods (for example, 2024 in Poland) increase urgency. • Policy shifts toward **EU Fit for 55** and **post-war rebuilding** may dramatically accelerate prefab use. • High-profile successes (like Comfort Town in Kyiv) can rebrand prefab positively.	• Strengthened **mandatory policies** and **economic incentives** lead to substantial uptick in **perceived usefulness** (see *Figures 4 and 5*, p. 2404). • **Standardization** mainly boosts **perceived ease of use** (*Figure 7*, p. 2406). • **Developer economic strength** is pivotal when policy and component ecosystems remain underdeveloped (*Figure 8*, p. 2406).	A **climate crisis or housing emergency** increases prefab appeal. If subsidies and zoning updates follow, prefab may become mainstream. Conversely, if **public trust erodes** due to poor modular execution, demand may fall even with favorable costs.	• Housing shortage + land reform + consumer advocacy could make UK market more like Japan's. • If climate policy tightens or labor shortages grow, prefab adoption could rise. But without rebranding and cross-sector learning, UK prefab risks staying niche.	• If China scales up prefab demand, **bulk production and automation** will reduce unit costs. • If more cities adopt zoning/support plans (for example tax relief), cost hurdles shrink. • Poor project delivery (for example untrained installers) will reinforce reluctance.	• Climate adaptation and pandemic response (for example, reducing labor density on-site) increase prefab appeal. • If governments introduce **net-zero mandates** or **urban densification policies**, prefab demand will likely spike. • Poor execution (for example, poor design quality or cracking) could stall its growth.	• If China scales up PHP investment, *automated production* and *training ecosystems* will be needed. • If local governments reduce policy support, *developer appetite and manufacturing investment* may decline. • Environmental disasters or pandemics could prioritize **quick-assembly prefab models**.	A financial stimulus (like **subsidized mortgages**) or **broader public exposure** to high-quality prefab housing would likely trigger uptake. If economic pressure (for example, post-Brexit affordability issues) continues, prefab may become a **necessity-driven norm** rather than an optional alternative.	• Incentive reform and infrastructure upgrades (especially transport) could **drastically increase adoption**. • Housing backlog or climate legislation could boost prefab. • Without regulatory simplification and workforce upskilling, adoption will remain **fragmented**.	• Climate shifts → preference for better indoor-outdoor integration. • Urban densification → modular homes could scale horizontally or vertically. • Policy on family tax benefits → may reward flexible housing types for growing families.	• Housing crises, disaster recovery, and affordability pressures will accelerate prefab interest. • Without a **rebranding effort**, public resistance due to *low-trust aesthetics* will persist. • Increased *government pilot support* could normalize prefab as a durable, integrated housing type.	• Rising climate pressures and material costs → increased prefab interest. • If governments fund innovation and establish **modular-friendly zoning**, adoption will increase. • Global recession or land shortages may delay prefab unless strategic subsidies are maintained.	With clearer codes, incentives, and more **government housing support (for example, RHI)**, modular adoption will accelerate. If regulations stay outdated, adoption will remain limited to innovators. Stakeholders agreed *crisis situations (housing or climate)* would be key inflection points.

Future priorities	*Stakeholder competence*, *integration of supply chains*, and *developer-strategy alignment* will become more important as **prefabrication transitions from niche to mainstream**. Demand for systemic resilience and cross-sector collaboration will rise.	**1. Strengthen mandatory policies and incentives** to shift systemic resistance. **2. Expand training and curricula** to build stakeholder knowledge. **3. Stimulate demand** (for example, subsidies for buyers or tax breaks for developers) to unlock economies of scale. Long-term, this will allow **cost to drop and quality to rise**, resolving the core adoption paradox.	1. **Establish a MiC governance body** for cross-sector coordination. 2. **Create standardized MiC design libraries and approval pathways**. 3. **Invest in upskilling labor and MiC-specific certification schemes**. 4. **Develop participatory engagement tools and post-occupancy studies** to track public perception and performance.	1. **Institutionalize social impact KPIs** to mainstream trust and inclusion. 2. **Embed circular economy principles** into MiC supply chains. 3. **Invest in public-private pilot projects** showcasing cost, speed, and sustainability wins. 4. **Develop policy toolkits** that align MiC with national housing goals.	1. **Digitalize CMSM** as a software or web-based tool for real-time decision-making. 2. Expand attributes to cover **modular MEP systems and smart integration**. 3. Link project performance to **post-occupancy sustainability metrics** for continuous feedback.	1. **Develop modular-friendly policy packages** (for example, subsidies, pre-approvals, warranties). 2. **Create design libraries** and *configurable modules* to overcome design inflexibility. 3. **Build trust through trialability pilots** and **shared public-private metrics**. 4. Empower intermediaries (PMs, quantity surveyors) to evaluate MC via transparent frameworks.	1. **Create digital tools based on CTAP** for SMEs and contractors. 2. **Incorporate real-time feedback loops** into the model (for example, from sensors, after-sales data). 3. **Adapt CTAP for public sector procurement** by integrating policy levers. 4. Broaden studies across regions to test cultural variations in tech adoption logic.	1. **Create regulatory frameworks and modular approval pathways**. 2. **Build national design libraries** that allow for *aesthetic flexibility*. 3. **Launch modular pilot zones and observability campaigns**. 4. **Develop KPIs for compatibility and perception management**, not just cost-time metrics.	1. **Establish standard modular typologies** for timber panels. 2. **Develop post-occupancy monitoring systems** for environmental and user comfort. 3. **Push regulatory and insurance reform** to support tall timber. 4. **Integrate timber within circular economy policies** and material passports.	1. **Government tax incentives and grants** for RAT adoption 2. **Return-on-investment (ROI) modeling frameworks** 3. **Risk mitigation via pilot adoption and staged integration** 4. **Workforce development and retraining programs** 5. **Cross-sector collaboration between academia, vendors, and contractors**	1. **Build awareness campaigns** to shift perceptions on quality and cost. 2. **Establish financing structures** for middle-income prefab buyers. 3. **Support public-private R&D** to improve aesthetics and modular options. 4. **Embed consumer feedback** into prefab design cycles.	1. **Roll out grid-based kit-of-parts with interface standardization**. 2. **Align digital systems (for example, CAD-CAM-BIM) across supply chain tiers**. 3. **Establish training hubs for prefab concrete assembly**. 4. **Pilot open building systems** with adaptable partitions, pods, and service modules.	1. **Rebrand prefab through design excellence and urban planning quality**. 2. **Provide green financing pathways** for modern prefab builds. 3. **Strengthen EU-linked climate-driven policies** that reward prefabrication. 4. **Include community participation and cultural narrative repair** in prefab advocacy efforts.	1. **Scale mandatory policies**, especially in lagging regions (for example, NW China). 2. **Strengthen standardization authorities** to reduce customization inefficiencies. 3. **Support PPP collaborations** to offset developer capital burden. 4. **Deploy SD models** as practical tools to test policy impact before implementation.	1. **Codify flexible design standards** for modular building blocks. 2. **Update zoning and permit pathways** for prefab implementation. 3. **Develop workforce training for factory assembly and site coordination**. 4. **Incentivize green modular prototypes** with lifecycle performance metrics.	1. **Create UK equivalent of JPA** to certify quality and support marketing. 2. **Encourage "land with conditions" sales** to align design customization with prefab. 3. **Reframe prefab as premium product** with lifecycle benefits, not just cheap social housing. 4. **Open prefab development to industrial entrants** (like IKEA or Toyota models). 5. **Streamline planning and accreditation** for MMC systems.	1. **Financial subsidies and incentive design** based on precast ratio. 2. **Establish automatic production standards** to reduce labor cost and error. 3. **Government-backed prefab infrastructure investment** in immature regions. 4. **Promote full life-cycle cost frameworks**, not just construction phase.	1. **Develop adaptive design typologies** to counter the "boxy" stereotype. 2. **Invest in off-site skill training** to boost workforce flexibility. 3. **Create cross-sectoral task forces** to align incentives and clarify standards. 4. **Measure and communicate long-term prefab value** beyond just first cost or timeline.	1. **Expand training for design–manufacture interface roles**. 2. **Invest in BIM–CAD–CAM pipeline standardization**. 3. **Encourage lean "pull-based" logistics planning**. 4. **Sustain policy incentives long enough** to let industrial capability catch up.	1. **Launch national awareness campaigns** to reposition prefab as premium, not provisional. 2. **Develop prefab-specific mortgage and equity products**. 3. **Incentivize builders to provide visible demo projects**. 4. **Study and replicate visual preference behavior** to shape design strategy.	1. **Codify PFB standards and guidelines**. 2. **Launch education & skill-up campaigns** for contractors and workers. 3. **Improve logistical infrastructure**, esp. for cross-regional transport. 4. **Build government–industry–academic partnerships** for real-world PFB trials. 5. **Create national public campaigns** to shift public and industry perception of prefab as "low quality".	1. **Maximize module width and joint tolerance** for internal flexibility. 2. **Design removable partition systems with clear visual legibility**. 3. **Standardize service core locations with accessible rerouting options**. 4. **Support family lifecycle modeling** in spatial programming and housing regulation.	1. **Design for cultural and household diversity** using modular layouts. 2. **Embed participatory planning** early in the prefab development process. 3. **Launch government-backed marketing and awareness efforts** to shift public perception. 4. **Amend zoning and building codes** to promote modular integration across contexts. 5. **Track post-occupancy social impact** of prefab communities with long-term metrics.	1. **Apply learnings from automotive and electronics industries** (JIT, modularity, CAD/CAM). 2. **Establish adaptable prefab zoning codes and standardization on benchmarks**. 3. **Invest in digital design education and inter-industry innovation programs**. 4. **Build public trust and interest** in factory-built homes with superior performance and lower lifecycle cost.	1. **Separate modular codes and permitting logic**. 2. **Streamlined procurement for integrated delivery (DB, IPD)**. 3. **Modular-specific insurance and lending models**. 4. **Large-scale public awareness campaigns** to reduce stigma. 5. **Standardize productivity tracking** for offsite processes.