Ministerie van Volkshuisvesting en Ruimtelijke Ordening

TU Delft

Innovating Policy Analysis Through Explainable AI

Exploring Drivers for Homeownership

CLIENT:

Ministry of Housing and Spatial Planning

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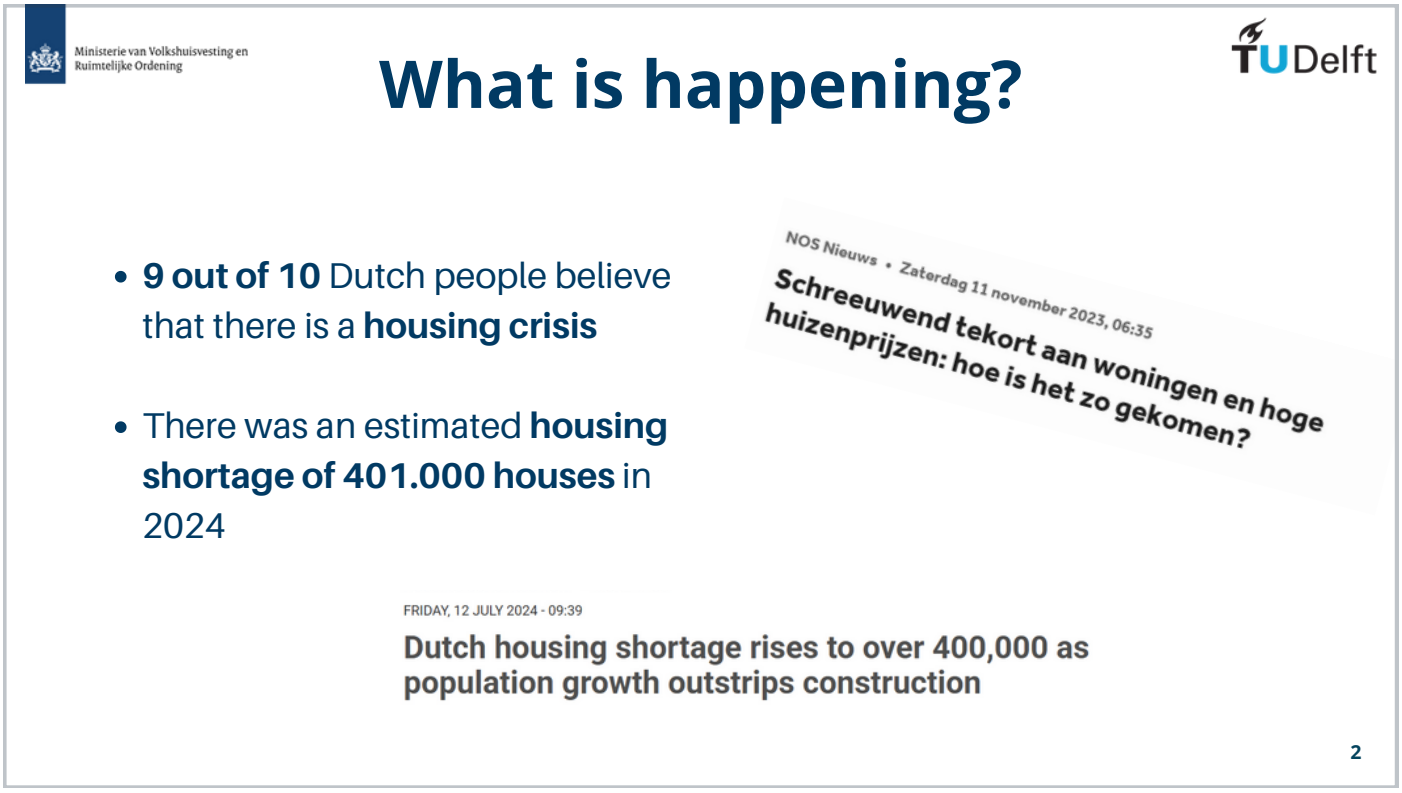

A recent survey indicates that almost nine out of ten Dutch people believe there is a housing crisis (Kellij & Hilhorst, 2023). This perception is understandable given the estimated shortage of 401,000 houses in 2024 (Ministerie van Volksverhuizing en Ruimtelijke Ordening, n.d.).

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What is happening?

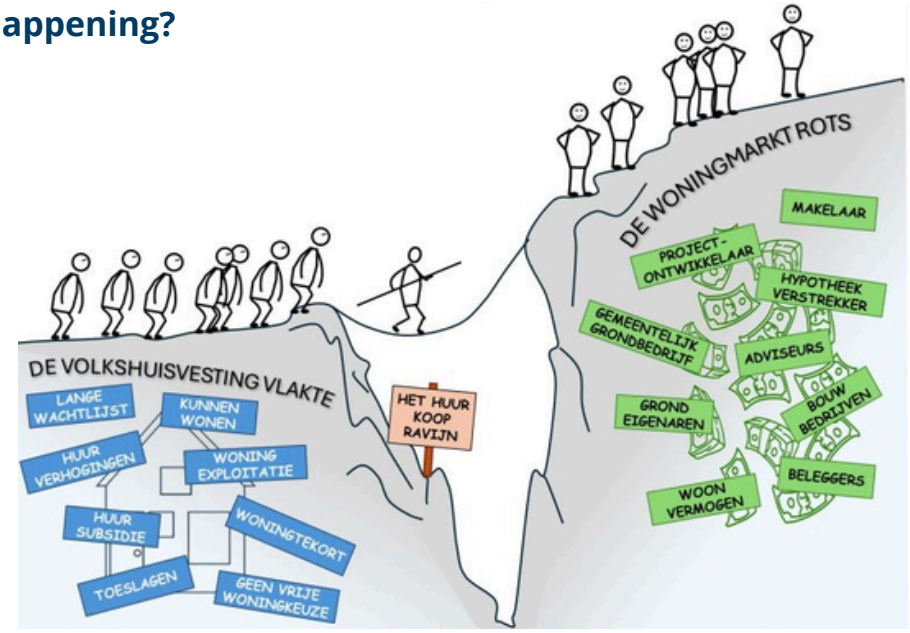

Figure 1: Tenant-Homeowner Gap (Hol, E., 2024).

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However, this crisis is not just about numbers—it highlights deep societal inequalities. Researchers from TU Delft, Utrecht University, and the University of Amsterdam emphasize that the housing crisis is, at its core, a crisis of inequality. Many people are forced to rent, leaving them with limited opportunities to save for purchasing a home. As a result, the gap between homeowners and renters continues to widen (van Mil, 2024).

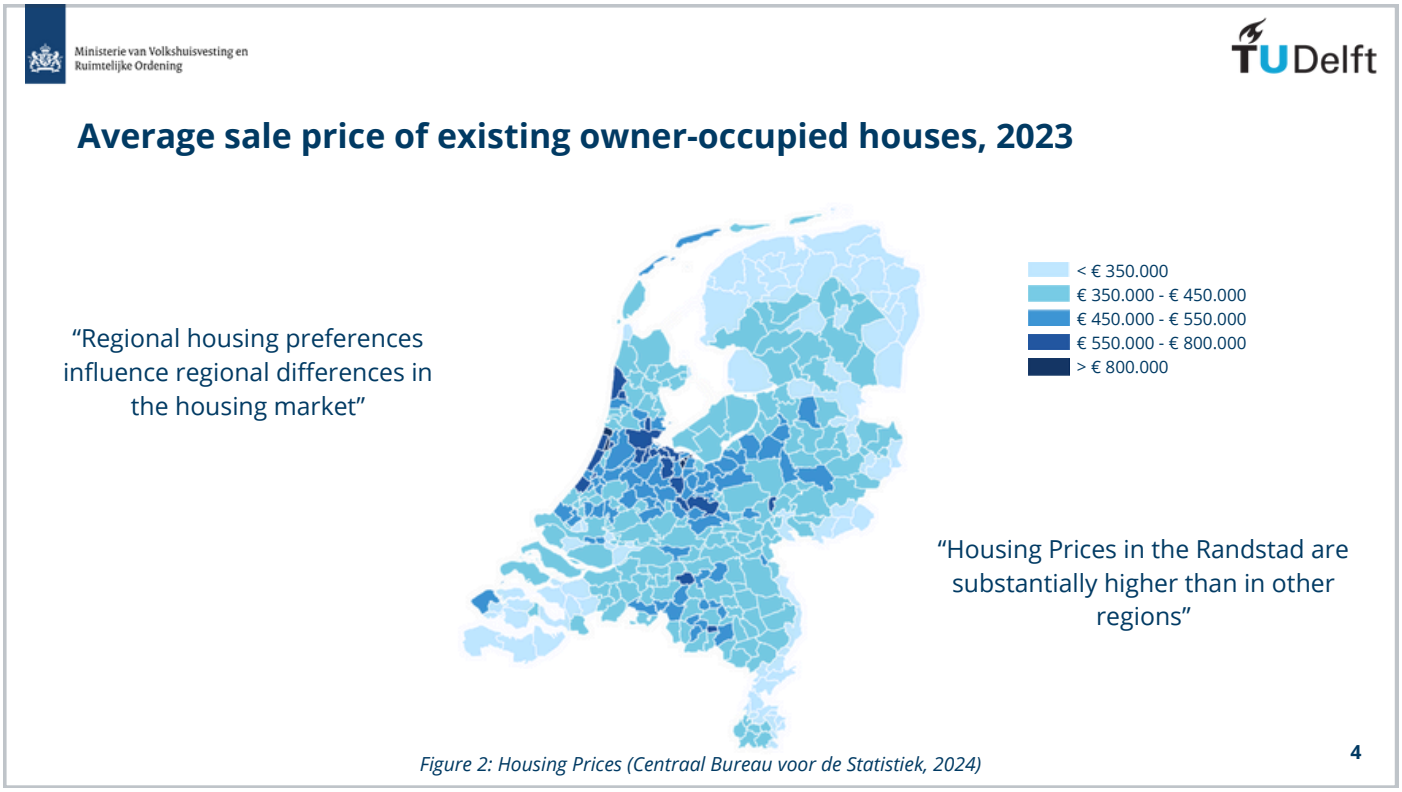


Figure 2: Housing Prices (Centraal Bureau voor de Statistiek, 2024)

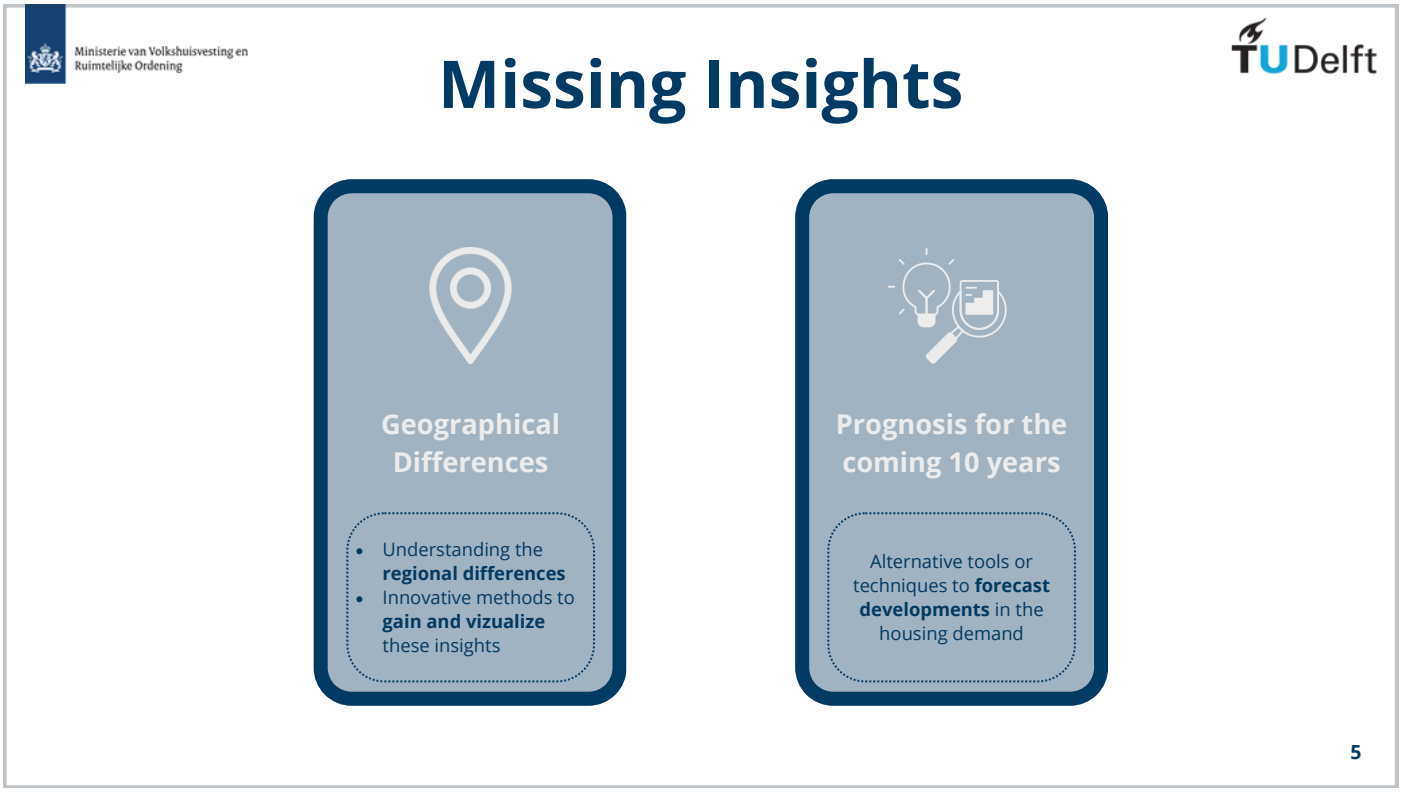
Furthermore, the housing market varies significantly depending on location. This makes it challenging to develop effective national policies. For instance, as one interviewee noted, housing prices in the Randstad are substantially higher than in other regions (Interview with Respondent A, January 14, 2025).

As demonstrated in the figure, darker colors represent regions with higher housing prices. The Randstad is colored darker, indicating higher housing prices in that area.

Regional differences in housing preferences are influenced by a number of factors. The price and availability of housing are certainly among them, but other factors such as housing preferences also play a role. For example, a family in the Randstad may be satisfied with an apartment, while in other regions single-family houses (eensgezinswoning) may be preferred (interview with respondent B, 20 January 2025). This makes regional differences very complex.

It is important to understand these regional differences and what influences them in order to develop effective housing policies that are customized to specific areas.

This brings us to the key questions from the Ministry of the Interior and Kingdom Relations.



The Ministry of housing and spatial planning has highlighted two key areas where they currently miss insights:

1. Geographical Differences: They want to understand the regional variations in the housing market. Specifically, they've asked us to explore innovative methods to gain and vizualize these insights.

2. Future Prognoses: They are looking for alternative tools or techniques to forecast developments in the housing demand for the next 10 years.

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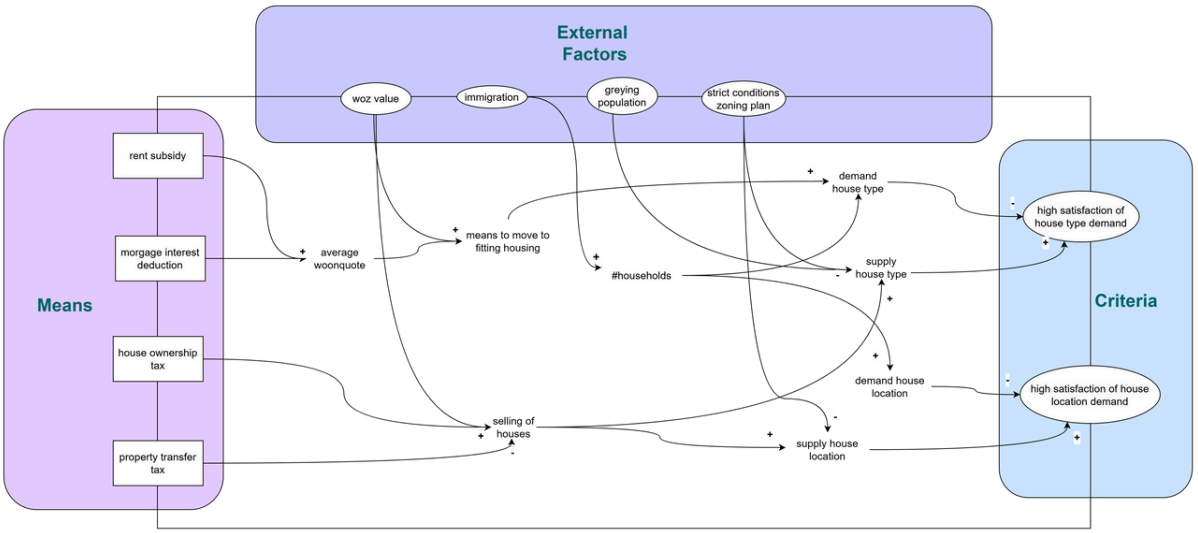
Systems diagram



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This diagram shows goals of the ministry: they would like to reach a better fit of housing type and demand. This can mean that people would like to buy a house instead of rent, but are unable to so far, and the ministry can support them in this journey. Or differently, people could want to live somewhere where supply is low and the ministry can influence housing supply and sales.

The diagram also shows the external factors that influence these criteria: On the one hand there are the two strongest factors influencing housing type demand nationally (Staatscommissie Demografische Ontwikkelingen 2050, 2024).

Other factors included like the 'woz value' and 'strict conditions zoning plan' were sourced from World Café 1 (Appendix D).

Lastly, the means of the ministry are included and shown to influence the internal factors. Their power lies into coping with the external factors to influence the criteria.

What is important to recognise is that the factors noted by 'Staatscommissie Demografische Ontwikkelingen' (2024) only covers two factors, whereas the previously noted factors from the World Café do show to be influential on the criteria of the ministry. This is corroborated by our interviews (Appendix A-C): Other factors outside of migration and ageing impact the housing type and location demand.

From this diagram, we can see that the nationally most important factors have a clear influence on the criteria of the ministry. However, from other sources, different factors can have an influence

should one rescope to a local or even personal level for supply and demand.

We can see it is important for the ministry's choice of means to know which external factors are the most important and on which level. For example, should they scope to a personal level and want to influence the 'woonquote' they would employ different means than if they would want to motivate the sale of housing.

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Power-Interest Grid for Housing Market Stakeholders

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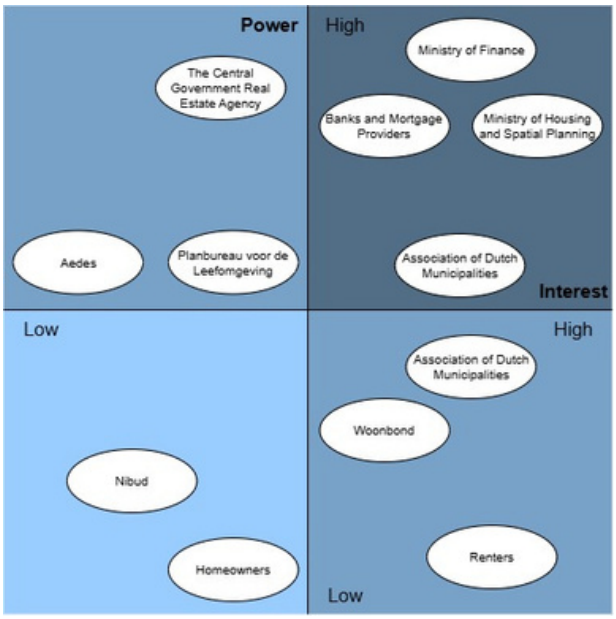

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The system analysis demonstrates that the Ministry's primary goal is to achieve a better alignment between housing supply and demand. However, the system diagram reveals that numerous external factors significantly influence the effectiveness and outcomes of the Ministry's measures.

It is not only external factors that play a role; actors also have a significant influence within this system. Therefore, it is essential to identify the involved actors, their complex relationships, dependencies, and nuances. This understanding should consider not only the Ministry's perspective but also the unique interests, roles, and challenges of other actors. These actors and their positions within the system are visualized in the PI-grid.

1. High Power, High Interest (Key Players):

Ministry of Finance:

• Role: Sets financial regulations, such as mortgage conditions, which directly impact affordability and housing demand.
• Dependency: Banks and mortgage providers depend on stable financial policies set by this Minis try.

Ministry of Housing and Spatial Planning (VRO):

• Role: Central in designing housing policy and aligning housing supply with demand.
• Dependency: Relies on municipalities for local implementation and on advice from the

Planbureau voor de Leefomgeving.

Banks and Mortgage Providers:

• Role: Facilitate homeownership through loans and mortgages, influencing the 'woonquote' (housing cost-to-income ratio) and overall affordability.
• Dependency: Strongly influenced by financial regulations and market stability.

Association of Dutch Municipalities:

• Role: Facilitates collaboration between municipalities to strengthen their execution capacity (Rijksoverheid, 2024).
• Dependency: Depends on national funding and guidance but provides feedback on local housing dynamics.

2. High Power, Low Interest (Keep Satisfied):

Government Real Estate Agency:

• Role: Manages state-owned housing projects and land, indirectly influencing supply (Rijksvastgoedbedrijf, n.d.).
• Dependency: Works under national policies set by the Ministry of Housing. It is a part of the Ministry of VRO.

3. Low Power, High Interest (Keep Informed):

Woonbond (Dutch Tenants Association):
• Role: Advocates for tenants' rights, influencing policies through lobbying (Woonbond, n.d.).
• Dependency: Relies on municipalities and ministries for tenant-focused solutions.

Renters:
• Role: Impacted by affordability and availability issues.
• Dependency: Depend on the ministries and local municipalities for accessible housing.

4. Low Power, Low Interest (Monitor):

Nibud (National Institute for Family Finance Information):
• Role: Provides financial education and tools, such as advising on the 'woonquote'.
• Dependency: Indirectly influenced by policies affecting household finances.

Homeowners:

• Role: Influenced by housing policies when seeking new homes.
• Dependency: Depend on stable housing prices and favorable mortgage conditions.

Complex Relationships and Dependencies:

1. Ministry of VRO & Ministry of Finance:
• These Ministries collaborate on policies like the mortgage interest deduction, impacting housing affordability (Rijksoverheid, n.d. b). They may conflict on their spending priorities. It is the role of the ministry of Finance to balance the entire budget and thus take into account more than only the budget of VRO.

2. Ministry of Housing & Municipalities (via VNG):
• The Ministry not only relies on municipalities for local implementation but also strengthens their capacity by facilitating knowledge-sharing, standardization, and collaboration with the private sector. The additional insight from municipalities can expand the perspective of the ministry, but may also not align with their national goals.

3. Ministry of Finance & Banks:
• Financial regulations set by the ministry directly impact the conditions under which banks can offer mortgages. Their perspectives offer an important collaboration to balance the interests of Min. VRO with the financial feasibility.

4. Ministry & Woonbond:
• The Tenants' Association advocates for affordability, influencing policy through lobbying. They offer an important perspective for the ministry of VRO and their collaboration can support both their interests.

5. Ministry of Housing & Government Real Estate Agency:
• The Central Government Real Estate Agency (RVB) is tasked by the Ministry of Housing and Spatial Planning (VRO) to prioritize societal objectives, including the development of (affordable) housing, when selling government-owned properties (land and buildings) (Rijksoverheid, n.d. a). Their collaboration is formally established.

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From Problem to Product

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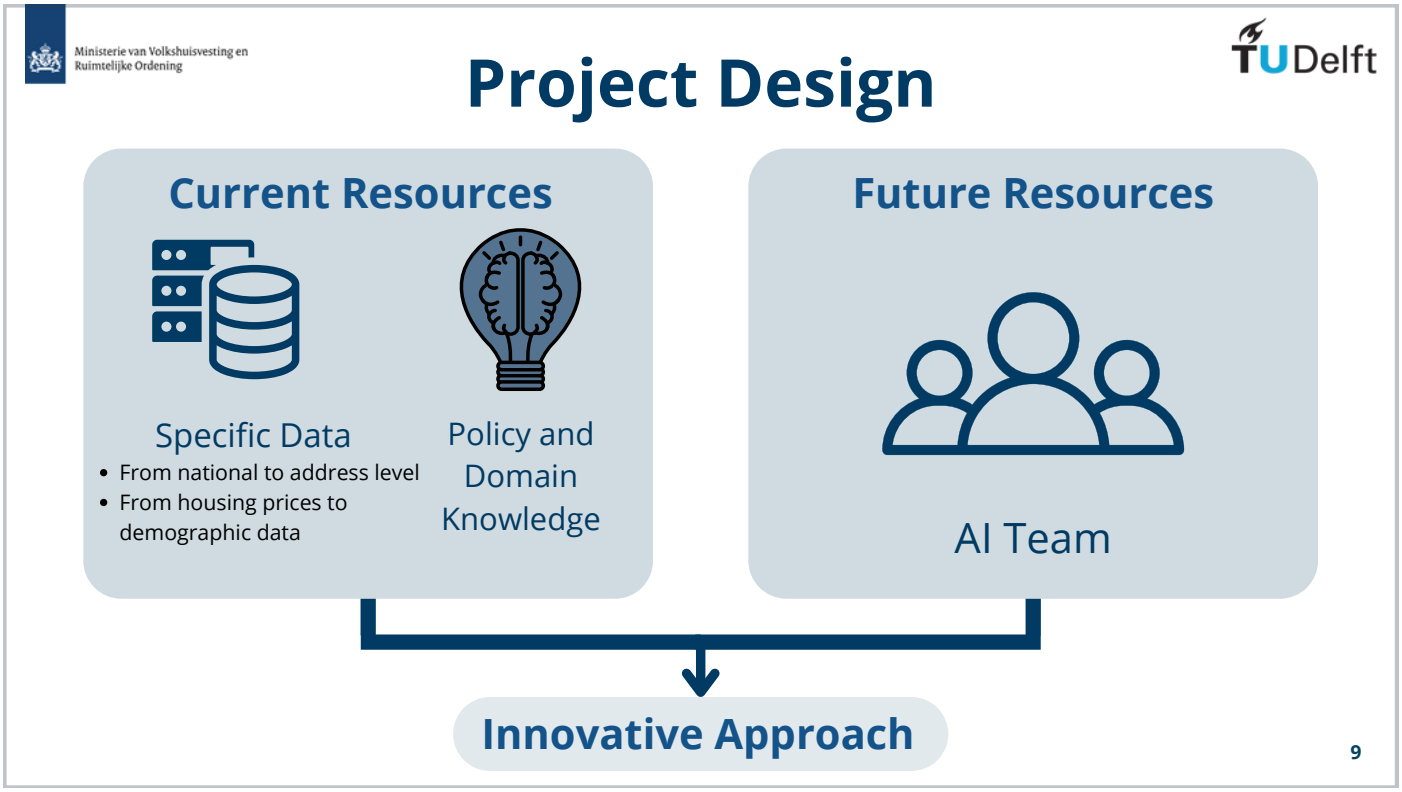

The project began by examining the resources available within the ministry, ensuring these were utilized effectively in the product design.

During meetings, the client explained that the ministry has highly specific data, ranging from national to address level, including housing prices and demographic information. Additionally, valuable policy and domain knowledge is available.

The client also mentioned plans to establish an AI team.

These resources and future developments were central to shaping the product design to align with the ministry's capabilities and vision.

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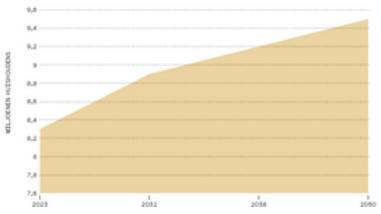
Related products

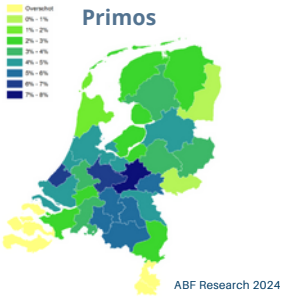
Staatscommissie Demografie



Staatscommissie Demografische Ontwikkelingen 2050, (2024)

National level
Demographic change impact on housing

Primos



ABF Research 2024

Translate demographic developments and housing shortage to local level

Identified Gap

Methods depend on knowing the most important causal relations.

→ Expand with **different method**

Methods depend on limited view of driving factors on national level

→ Allow for inclusion of **local drivers of demographic change** or other variables of interest

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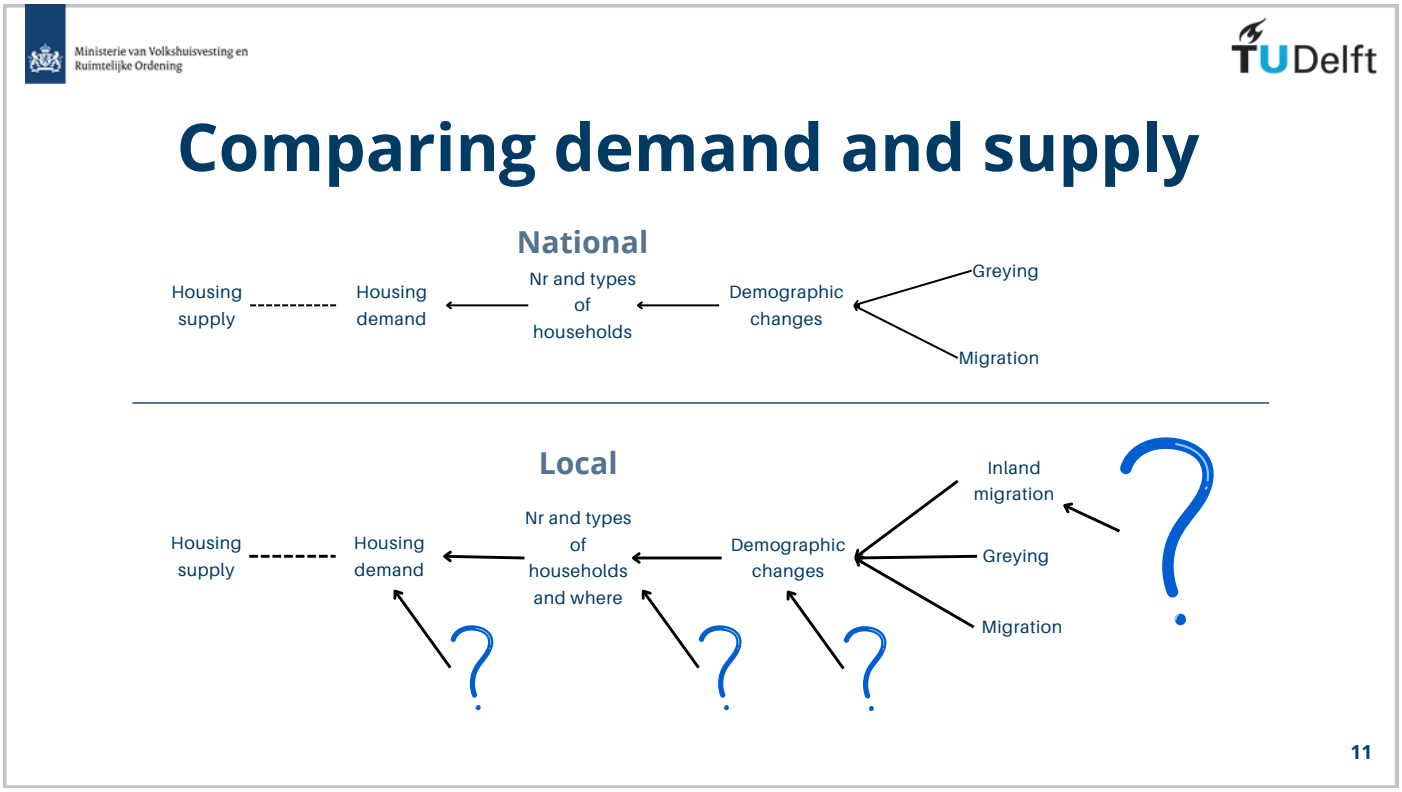
First we will examine resources and tools the ministry already has at their disposal as the closest other products.

On the slide you can see the products of State Commission Demographic Developments 2050 en the Primos prognosis. (Staatscommissie Demografische Ontwikkelingen 2050, 2024; Gopal et al., 2024).

State Commission Demographic Developments uses calculated prognoses to determine most important drivers for demographic change on national level and their impact on housing demand for different types and number of housing using simple scenarios.

Primos translates these calculated prognoses for national demographic changes to local level and compares to building plans to determine housing shortages on semi-provincial level.

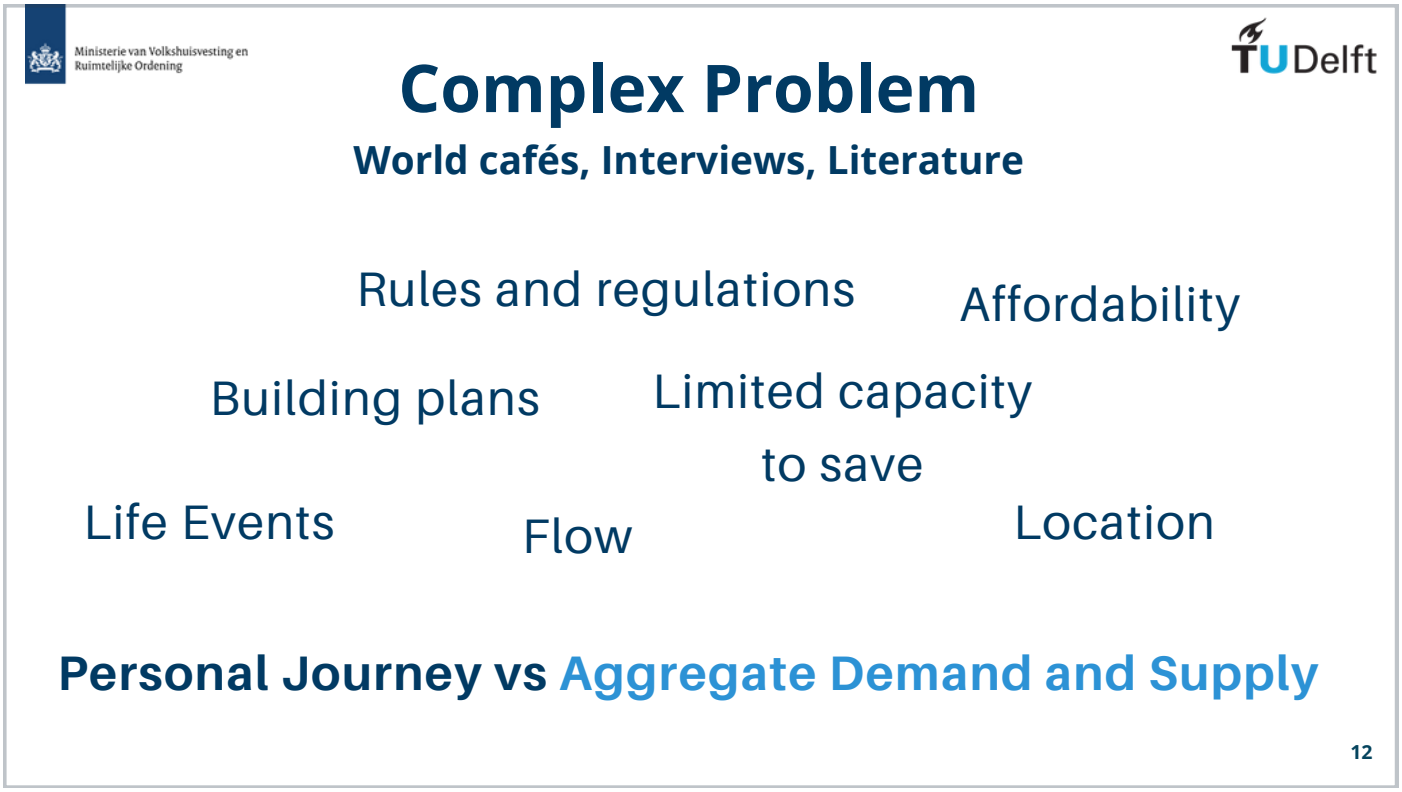
Our main conclusions are that the current products depend on knowing the most important drivers and causal relations. A new product would add value by expanding with a method that acknowledges that we may be ignorant of what the most important drivers are. From our studies at EPA, we have learned methods that can address this gap. Our product design is based on these insights.



On this slide we illustrate the approach of the related pruducts.

On the left we see that the ministry is interested in the level of match between housing supply and demand. Both related products intend to prognose the development of housing demand by translating the number and types of households into housing type demand. Thus it becomes a challenge of prognosing demographic changes. On a national level they are concluded to be driven by migration and a greying population.

However, to illustrate our gap, if we translate this approach to a local level, we see an indication of blindspots. The Primos report already notes that to translate to a local level, one must take inland migrations into account. One may intuit that other factors are also important on a more local scale of the problem. This can be seen on the next slide.



Accumulating information from the world café (Appendix D), interviews (Appendix A-C) and literature (Staatscommissie Demografische Ontwikkelingen 2050, 2024; Gopal et al., 2024), we create an overview of all the factors our interviewees, cliënt and other interested parties figure are important to take into account for the housing market.

On the left, we see the request from the BZK for insights into the transition from renting to buying and new methodology to map that.

During the world café, the participants indicated the most important factors for them relating to this problem: affordability, but also restrictive regulations and how they can disadvantage different groups. These are factors that can be researched both from an individual but also a spatial perspe ctive.

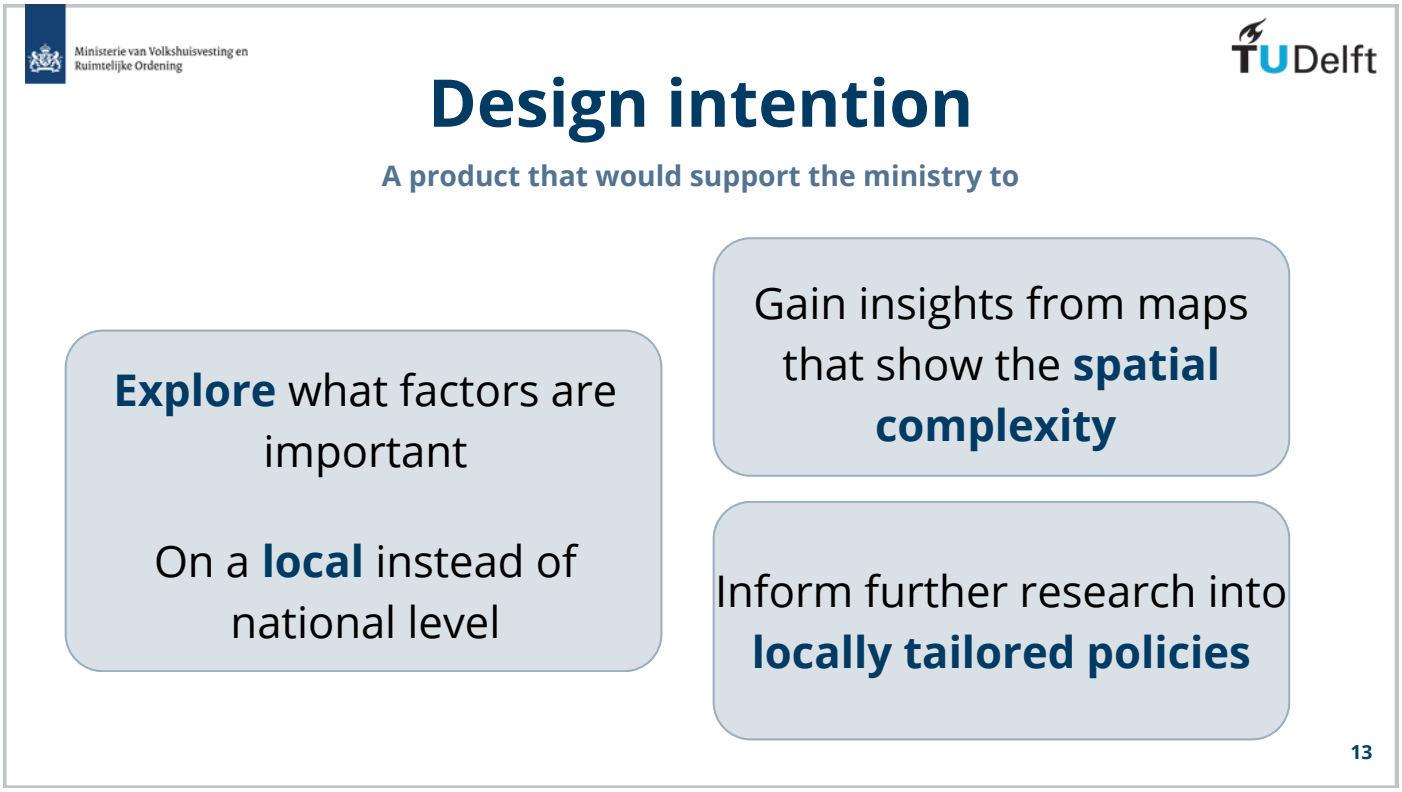
It is clear from both interviews and literature that the problem on a local and national scale is about throughput. The reports by state commission of demography (State Commission on Demographic Developments 2050, 2024). and Primos (Gopal et al., 2024) show that there is housing shortage and that it spreads to more than just starter homes.

This shows this problem is complex and can be addressed on several levels from personal obstacles to aggregated match between demand and supply.

From interviews (Appendix A-B) we learn that people looking to buy a house know themselves very well, what their obstacles are. The current available interventions of the ministry also lean on

large scale interventions, not personal support. The ministry also indicated that they have a wealth of spatial data available.

Having shown the local and personal problems are more complex than the national aggregate housing demand and supply, we conclude that in order for the ministry to adapt their policies to the local nuances, they should use their resources to look into what local factors should be researched for policy development.



In the previous slides, we identified the need of the client by exploring their current products and the complexity of the problem.

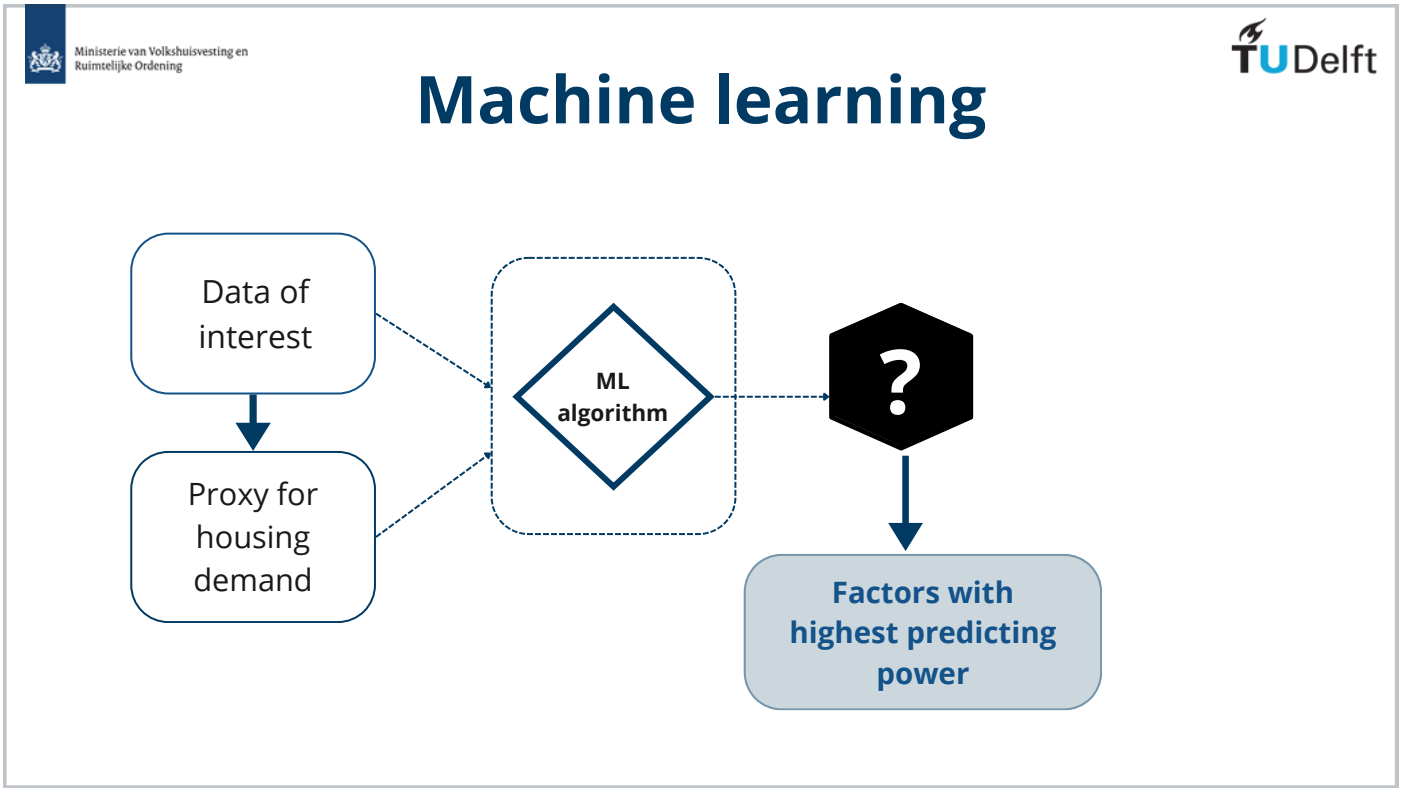
We decided that our product will address the identified gaps to complement the complexity of the problem and their other resources. This lead to the three design intentions on the slide.

We will address the identified gap by designing a product with a novel method that allows exploring local instead of national factors.

Next, we intend to address the missing insights of the ministry by presenting product results in spatial maps that support gaining insights from viewing the spatial complexity.

Lastly, we intend to show how the ministry can use our approach to inform new policies with insights from local driving factors, thereby tailoring policies to the spatial complexity of the problem.

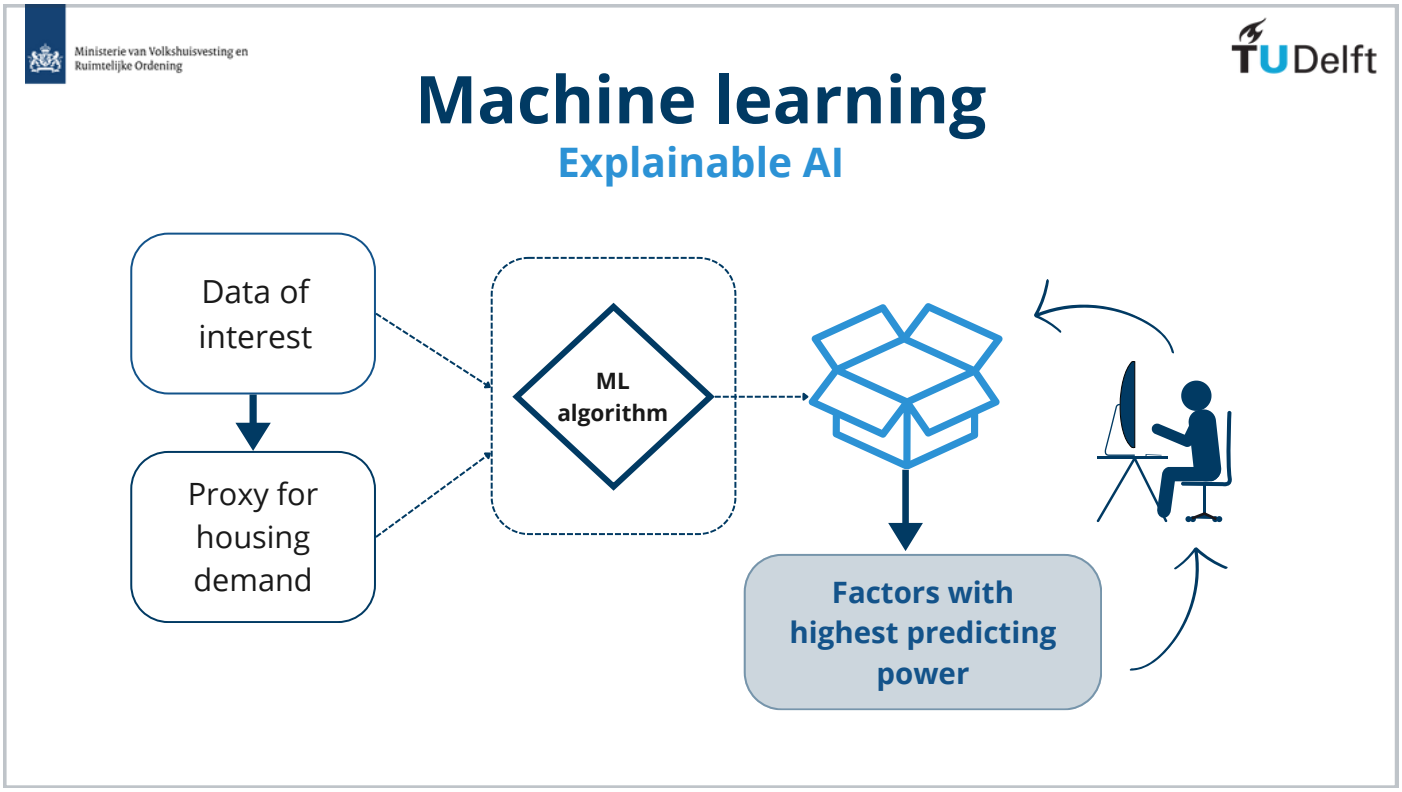
Product Design



Machine learning makes it possible to process data of interest without having to assuming certain causal relationships. They learn patterns and relationships from the data based on correlations. This makes them particularly powerful in analyzing large data sets and discovering hidden relationships. Moreover, these types of models can process big data and indicate the factors with the highest predictive power.

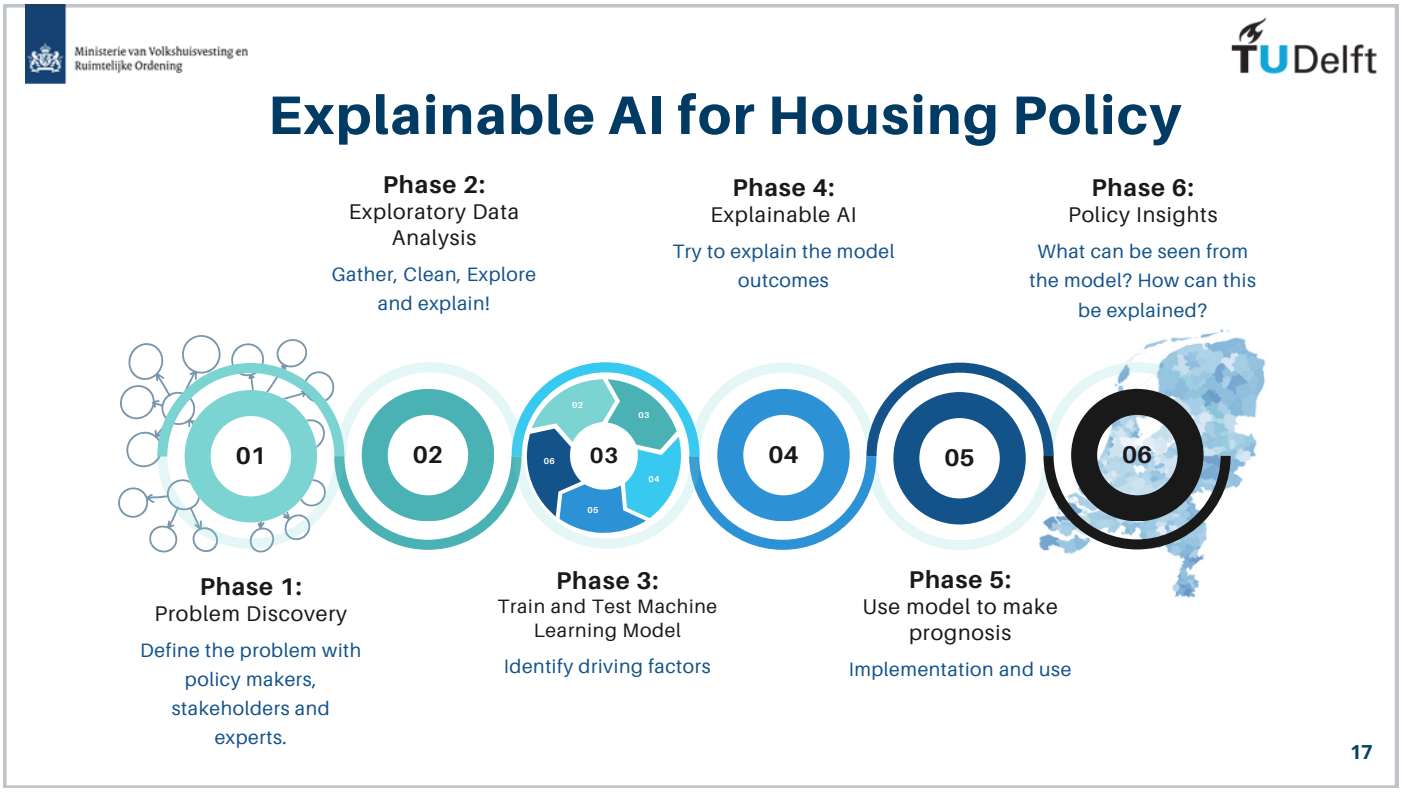
We developed a simplified machine learning model. The purpose of the model is to demonstrate how raised within the ministry can be addressed differently. To illustrate this, we used a straightforward example.
A key advantage of machine learning is that you do not need to predefine causal relationships yourself. This approach can lead to new and unexpected insights.

However, machine learning is often a "black box," which poses challenges. The lack of transparency can lead to bias and discrimination. Moreover, it is difficult to explain or justify decisions if the internal workings of the model are not understandable. This is problematic in sectors where accountability and transparency are crucial, such as government agencies (Gryz & Rojszczak, 2021).



To address this concern, we introduce the concept of Explainable AI, enabling the ministry to better understand and trust the outcomes generated by the model.

Explainable AI aims to develop machine learning techniques that create understandable models without losing performance, enabling humans to interact with, trust, and manage AI systems.



To provide a clear framework for the Ministry on how to approach subjects using explainable AI, a roadmap has been created. This roadmap outlines the six stages required to develop such a model. All stages are iterative, meaning that it may be necessary to revisit previous stages during the process. For instance, after completing stage 4, it might be necessary to return to stage 3, or even back to stage 1 or 2. This iterative nature is visually represented by the figure-eight-shaped "road" that encircles the stages, emphasizing the non-linear progression of the process.

The roadmap will be explained in the following slides using an use case as an example. This approach provides a practical illustration of each stage, demonstrating how the methodology can be applied in a real-world context for the Ministry.

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Use Case: Percentage Price Increase in Dutch Regions

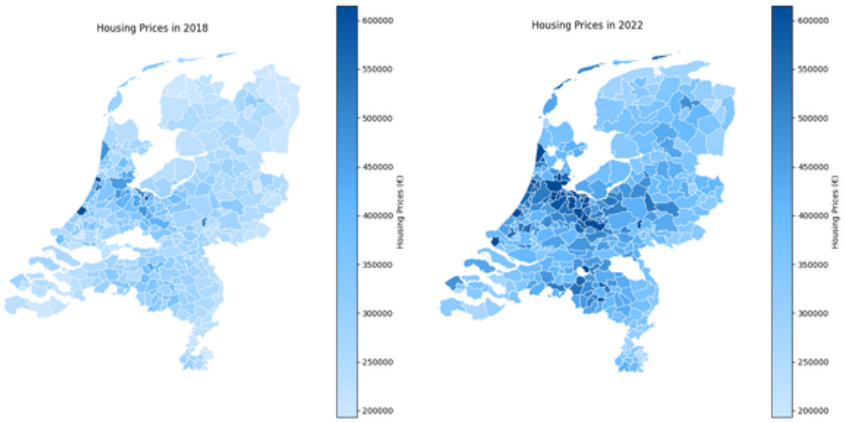

Figure 3: Housing Prices in 2018 and 2022 (Centraal Bureau voor de Statistiek, 2024)

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As a use case to demonstrate how Explainable AI can be applied within the ministry, we chose to predict the percentage increase in house prices per region in the Netherlands. For this purpose, we used data from 2018 and 2022, as these were the most complete datasets available to us. However, has can be seen in the figures, even this data lacked information for certain municipalities. To simplify the model, these gaps were addressed by filling them with the median houseprices of the respective year.

The figures clearly show that house prices have risen significantly over the course of four years, as evidenced by the regions being clearly darker in colour. The exact reasons for this rise are not immediately clear. While there are some hypotheses about possible causes, these can be better substantiated using Explainable AI to provide deeper insights and support data-driven explanations.

Note: there shouldn't be taken any conclusion from these figures, since we used less than optimal data.

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STAGE 1: PROBLEM DISCOVERY

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1 Literature Research

2 Involve stakeholders, experts, policy makers and laypeople

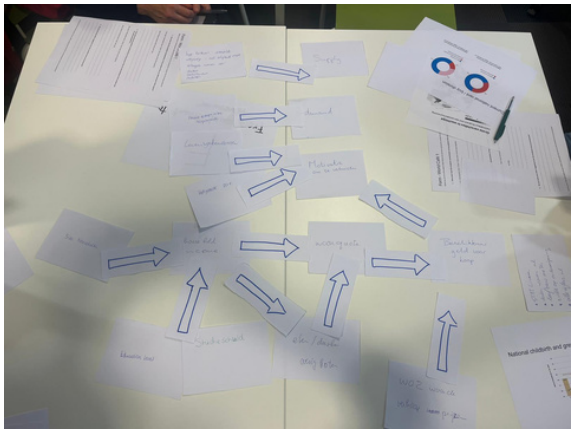

Figure 4: World Cafe 1

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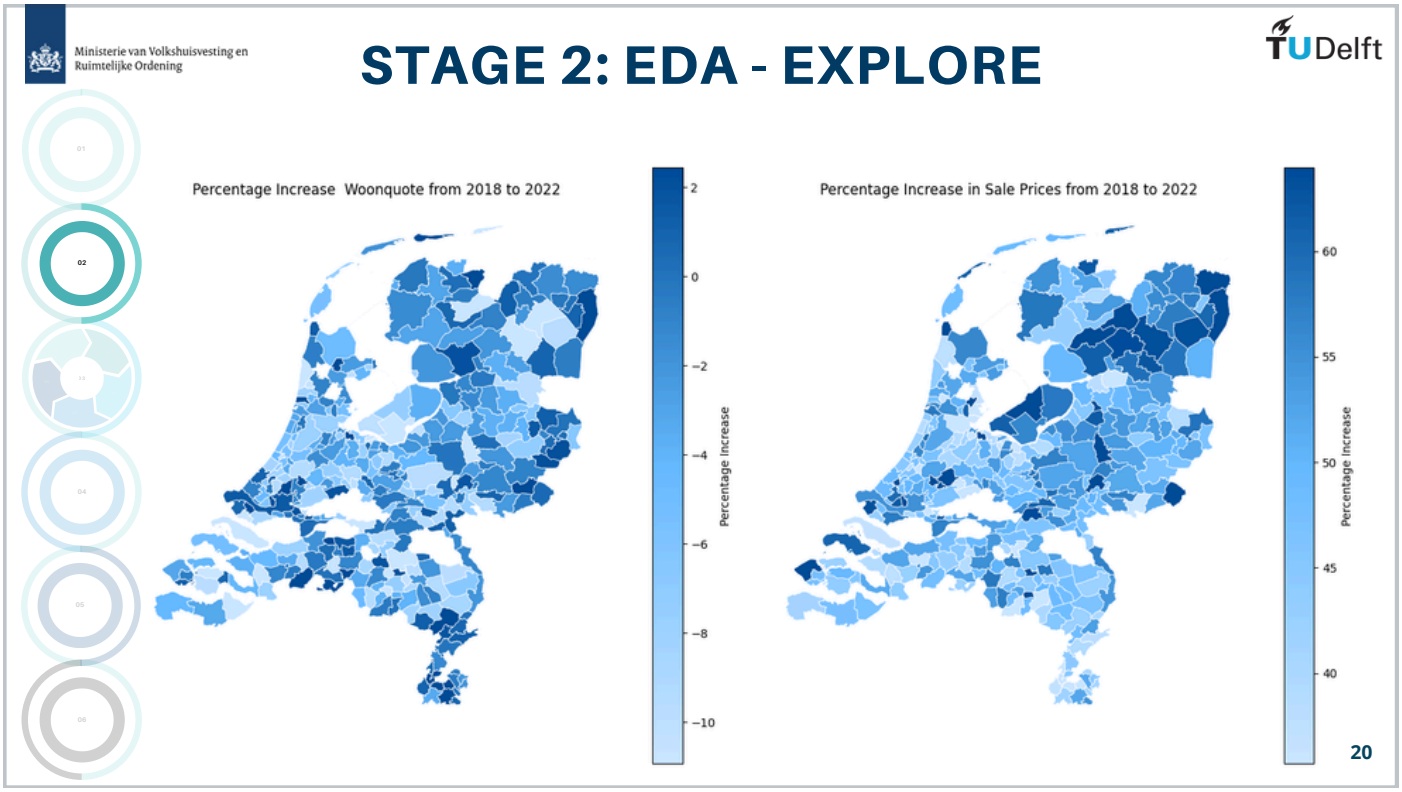
This is the first and arguably most critical phase. To make your model explainable, it is essential to have a thorough understanding of the problem and the scope of your investigation. Achieving this requires gathering diverse insights about the issue. This can be done through literature reviews, as well as engaging with stakeholders, experts, policymakers, and even laypersons. Each perspective contributes valuable information to define the problem effectively.

For the case study, these discussions were facilitated using a visual method during the World Cafe, which is presented in the figure. The cards on the table illustrate the factors and the connections between them that participants identified as most important for the topic of transitioning from renter to homeowner.

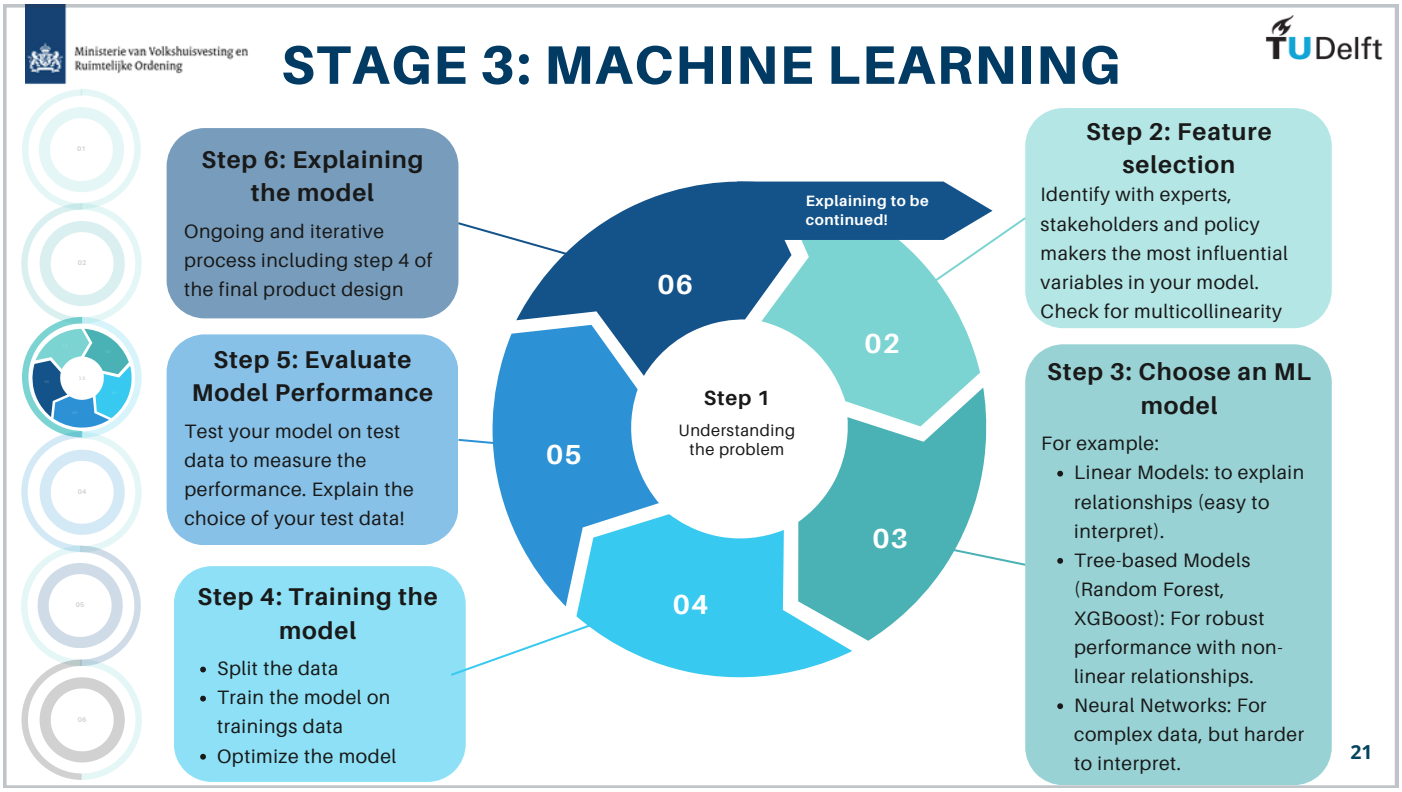
From this exercise, we learned that participants identified many factors they considered essential to explore. Insights like these can inform decisions about which data might be valuable for the next phase of the process.



Phase two involves collecting, cleaning, and exploring the data, which can be done through Exploratory Data Analysis (EDA).

To ensure the data is suitable for explainable AI, it must meet several criteria. Incorporating domain expertise into data selection and preprocessing is essential, as this helps align the data with real-world relevance and enhances interpretability. High-quality, representative, and unbiased datasets are critical to improving the interpretability and fairness of machine learning models. Any data anomalies, such as missing or mislabeled entries, must be addressed to avoid skewed or misleading insights. Proper preprocessing techniques—such as handling outliers, normalizing features, and imputing missing values—are crucial for preparing the data effectively. Advanced methods, such as perturbation-based techniques and intermediate representation extraction, can further enhance data preparation for interpretability (Xiong et al., 2024).

This slide demonstrates how to explore data effectively. On the left, you see a value obtained from CBS that we processed to display the percentage increase over the period 2018-2022. On the right, you see the same data, but represented as the variable we aim to predict. Thus, the left represents the independent variable, while the right represents the dependent variable. Creating visualizations like these provides valuable insights into the data, helping to better understand patterns, relationships, and trends within the dataset.

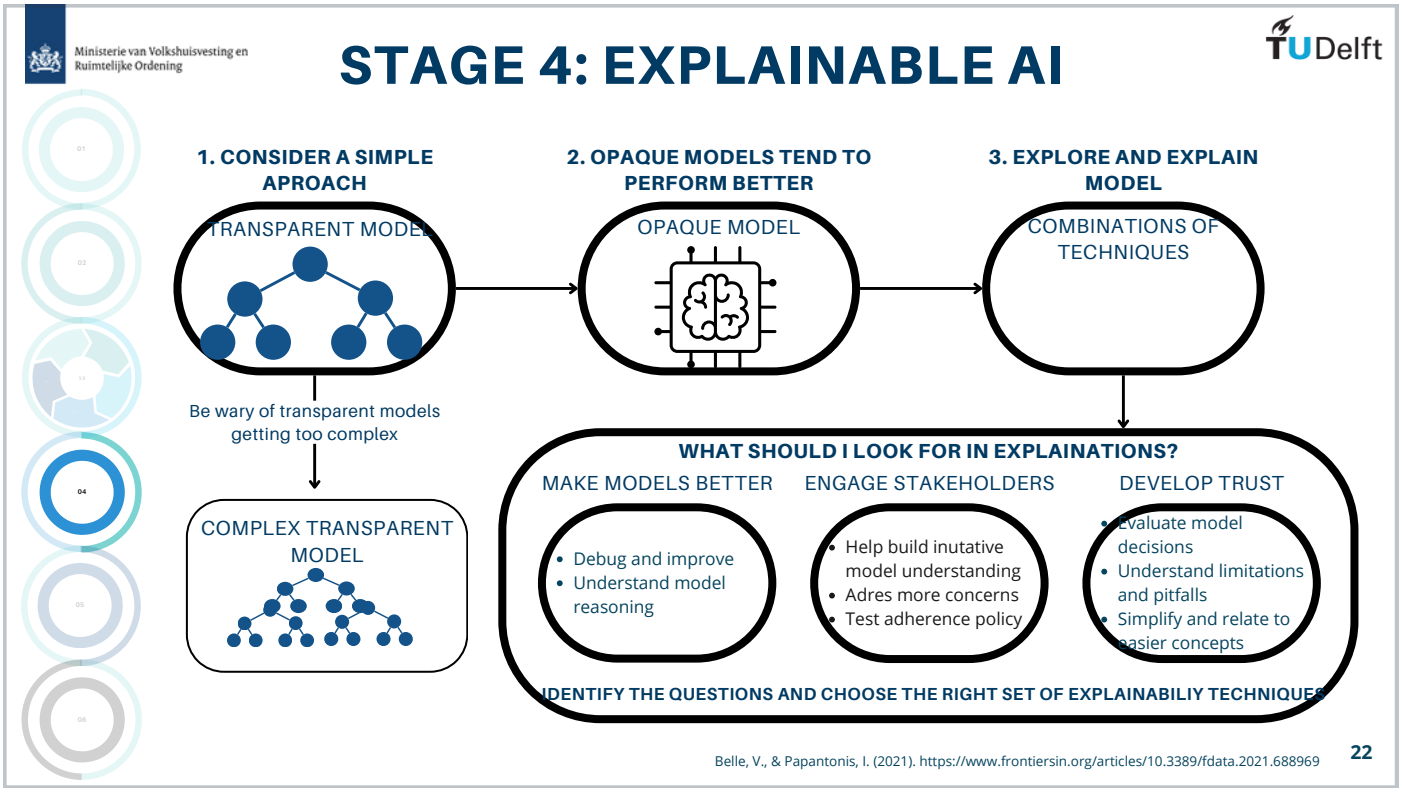


Phase three involves applying machine learning, a process that consists of six key steps.

One of these steps - understanding the problem - is continuous and iterative and aligns with phase one of the roadmap. This step remains critical throughout the process because the definition and scope of the problem may change as new insights are gained.

Explainability is central to this phase. Transparency in data usage requires clear documentation of training data, including sources and constraints, to build trust. Integration of domain knowledge aligns data and preprocessing with actual relevance, improving interpretability.

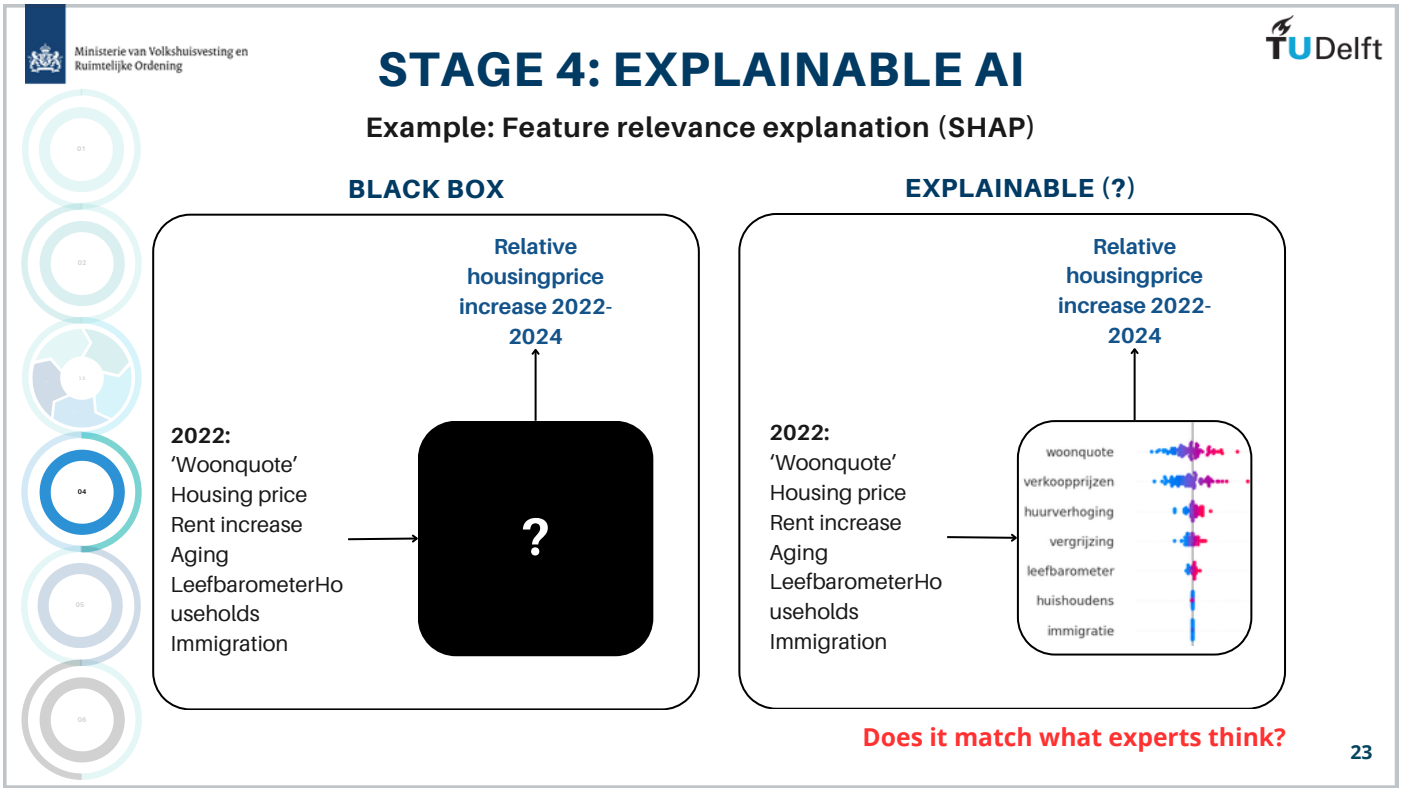
Finally, Evaluation and Validation use iterative methods, such as Shapley values and Leave-One-Out, to assess model reliability and output. Following these principles better aligns the machine learning model with the requirements of Explainable AI, improving both the clarity and reliability of the insights it generates (Xiong et al., 2024).



The article by Belle and Papatonis discusses the challenges and opportunities of using machine learning (ML) and big data in the public sector. They highlight the powerful potential of ML for policymaking and public service delivery, such as predicting trends, evaluating policy effectiveness, and optimizing services.

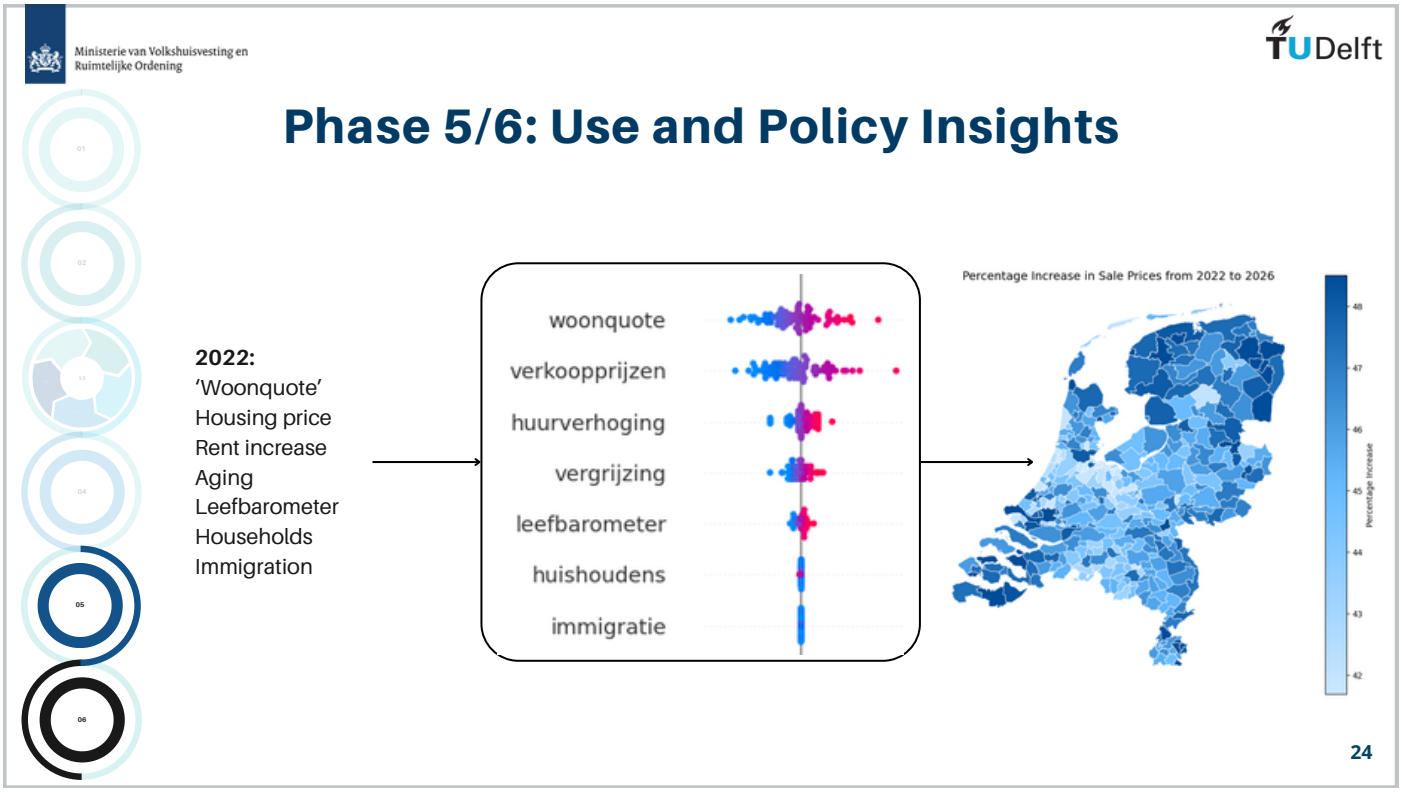
They emphasize ML's ability to identify complex patterns and relationships in large datasets without relying on predefined assumptions. However, standard ML models learn correlations and are not designed to identify causal relationships. This poses a problem when making policy decisions where causality is essential. Additionally, ML models can amplify biases present in the training data, which is a significant risk in the public sector, where fairness and transparency are critical.

The article states that by employing causal inference techniques in ML models and focusing on ethical considerations, these challenges can be addressed, and ML can be applied responsibly. The slide outlines a 'cheat sheet' of sorts for approaching explainability.



There are a lot of tools for (Post-hoc) explainability. Feature relevance explanation aims to describe the functioning of an opaque model by ranking or measuring the influence, relevance or importance each feature has in the prediction output by the model to be explained.

SHAP (SHapley Additive exPlanations) by Lundberg and Lee (2017) is a method to explain individual predictions.
The goal of SHAP is to explain the prediction of an instance x by computing the contribution of each feature to the prediction.



For this example case, we chose to look at the relative price increase and its most predicting facto rs.

With phase 5 you could now make a prognosis of the percentage price increase over the next 4 years. The colour scale is centred between the first and third quartile. Despite the lacking performance of the model, this prognosis could be logically consistent. For example, looking at a region like Bloemendaal, this region already has high prices and would therefore increase relatively less than other regions. The map shows the spatial complexity, indicating some regions increase more than others.

Phase 6 combines all previous steps to gain insights that inform future policies and strategies. We show this with the conclusion of our case example.

We have identified the most predicting factors and have developed a prognosis for the relative sale price increase that shows spatial complexity. Should we look at our important local factors, we can identify the most predicting factors are woonquote and sale prices. Should the ministry look at the prognosis and want to develop policy, they can see which local driving factors are important to take into account for that policy. This should not be done naively, but should encompass more research and feedback from existing theory.

Concluding from our 6 phases, we would like to reflect on the differences with the existing policy process. Currently, the ministry intuitively knows there are local and even personal nuances to the housing problem. Yet, the current operations only allow discussing prognoses based on national

driving factors. This new approach would allow further nuance in the discussion and development of regional impacting policies. This new approach would also require more knowledge and resources, which we reflect on in the limitations and recommendations.

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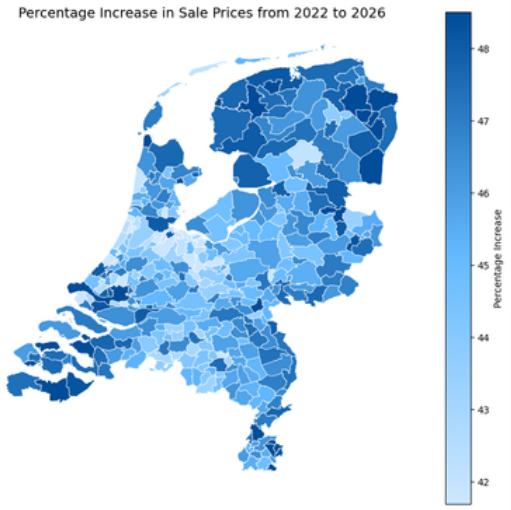
Product Value Client

Our approach

helps	Inform **locally tailored housing policy**
by	• **Utilising the database** the ministry has • infer what **local factors** are most important for housing demand • visualise the **spatial complexity** of these factors
Based on	Explainable AI
While	Trying to complement the existing and future resources of the Ministry



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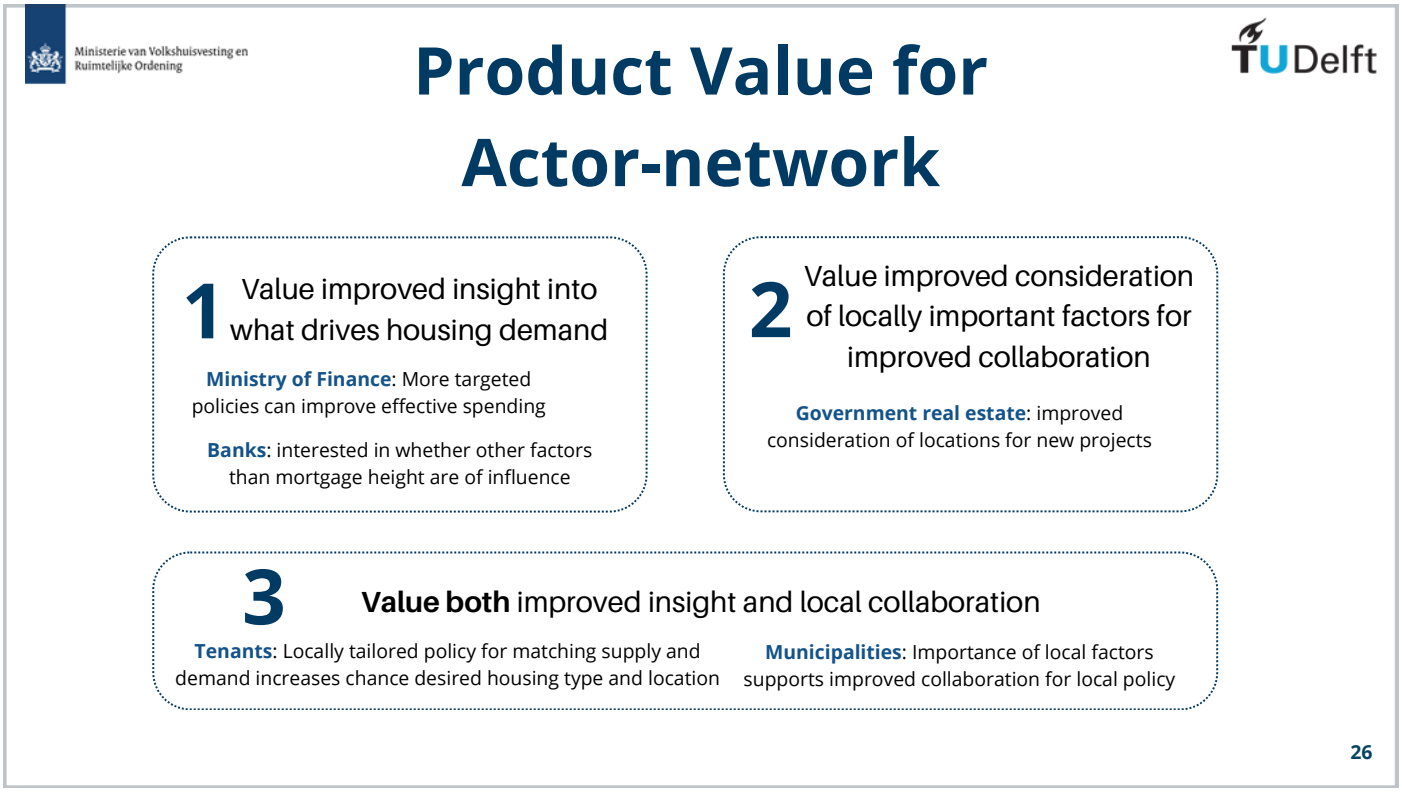
On this slide we have summarised the value of our approach for our client.

To summarise, our approach provides the client with an explainable tool that supports tailoring housing policies to local levels by exploring what factors could be influential on the future scenarios and should be researched futher.

Concretely, this approach serves as a recommendation to the AI team of the ministry and underlines the importance of exploring local nuances in housing policy and recommends an explainable approach to support their collaboration with less technically educated policy analysts.



As the previous slide shows, the product helps inform more locally tailored housing policy. The value this brings the actor-network is two-fold:

1. It improves insight into what drives housing demand
2. It allows and improves inclusion of factors considered locally important by other parties

1. Actors who value the first point are parties who have an interest in whether they will be influential and whether they will be targets of changing policies resulting from a different view of the driving factors.

The Ministry of Finance would be interested in knowing if the VRO spending could become more effective through this new approach.

Banks are interested in whether mortgage policies will change because of this new approach should this show to be the most important factor.

2. Actors that value the second point are actors that are interested whether the spatial complexity and locally varying factors show to be of importance. They would benefit of local interests being taken into account or would utilise knowing which locations are important for policies to focus on.

The government real estate branch can improve their operations knowing which locations are influenced most by improved supply, instead of other factors.

3. Actors that value both are not only dependent on any new policies that target other factors (that hopefully improve demand and supply), but also enjoy the consideration of factors that they would indicate are important to their location.

This would include local tenants associations that are the target group of improved local policy and can provide insight into which factors should be explored that improve housing opportunities in their location.

At the same time, municipalities are also affected by local policies as they improve flow out of social housing, making room for allocating tenants that need it most. This releases pressure on other amenities they provide.

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Limitations & Recommendations

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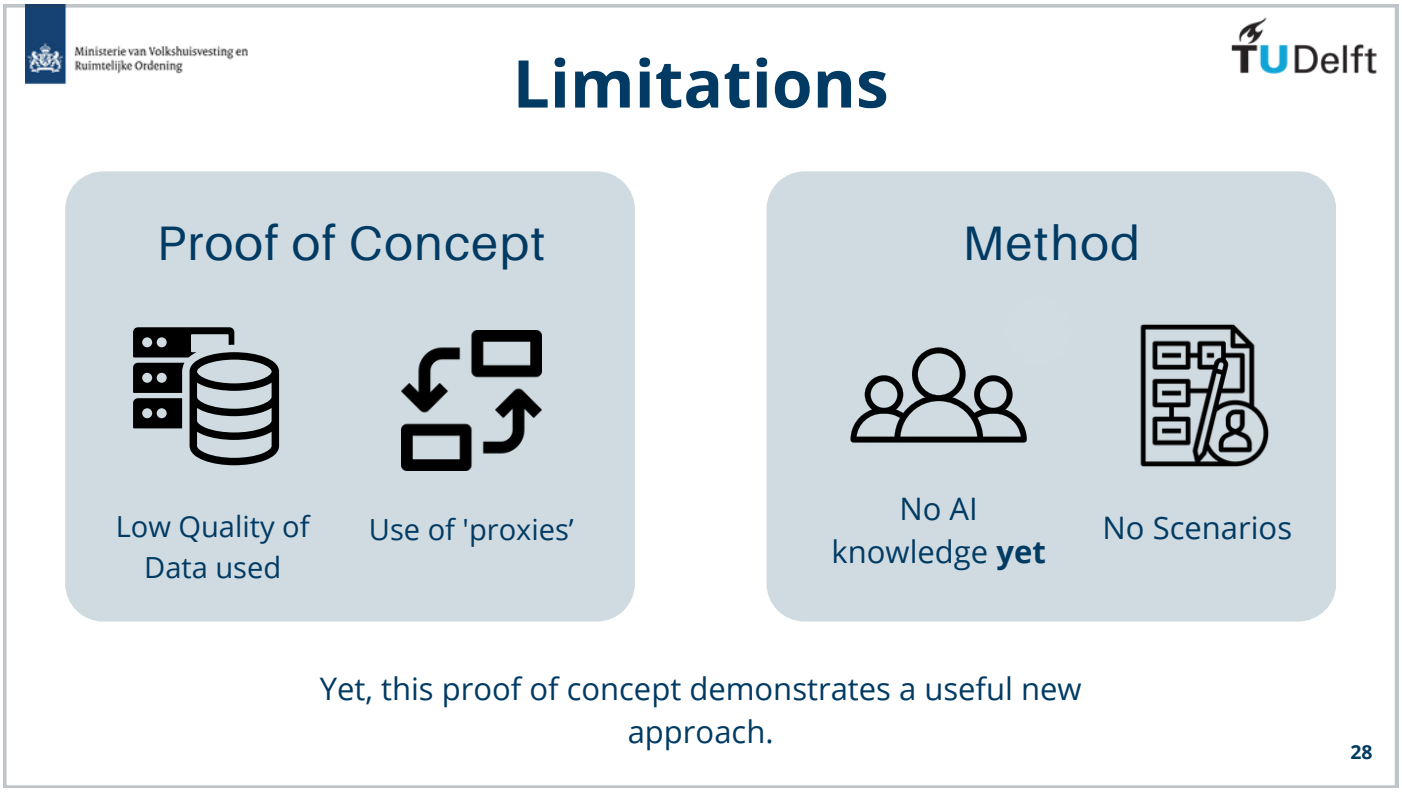

This project has several limitations that should be considered.

The proof of concept created in this project is limited as:

- The data used is of less quality than available to the ministry.
- The proof of concept presented in this project uses proxies for the variables of interest to the ministry. Future iterations should expand on this.

The method developed in this project is limited as:
- The ministry does not yet have the in-house knowledge to further develop this product, but it is planned with a new AI-team.
- This method does not incorparate scenarios, whereas the comparable products allow for simple scenarios.

Yet, this proof of concept shows a useful new approach.

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Recommendations

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In addition to national, also consider the local perspectives.
Until now, *local driving factors* of housing demand are overlooked.

Important local phenomena to take into account were indicated by our interviewees (Appendix A-D):

- Ripple effect
- Urbanisation
- Cultural differences
- Facilities

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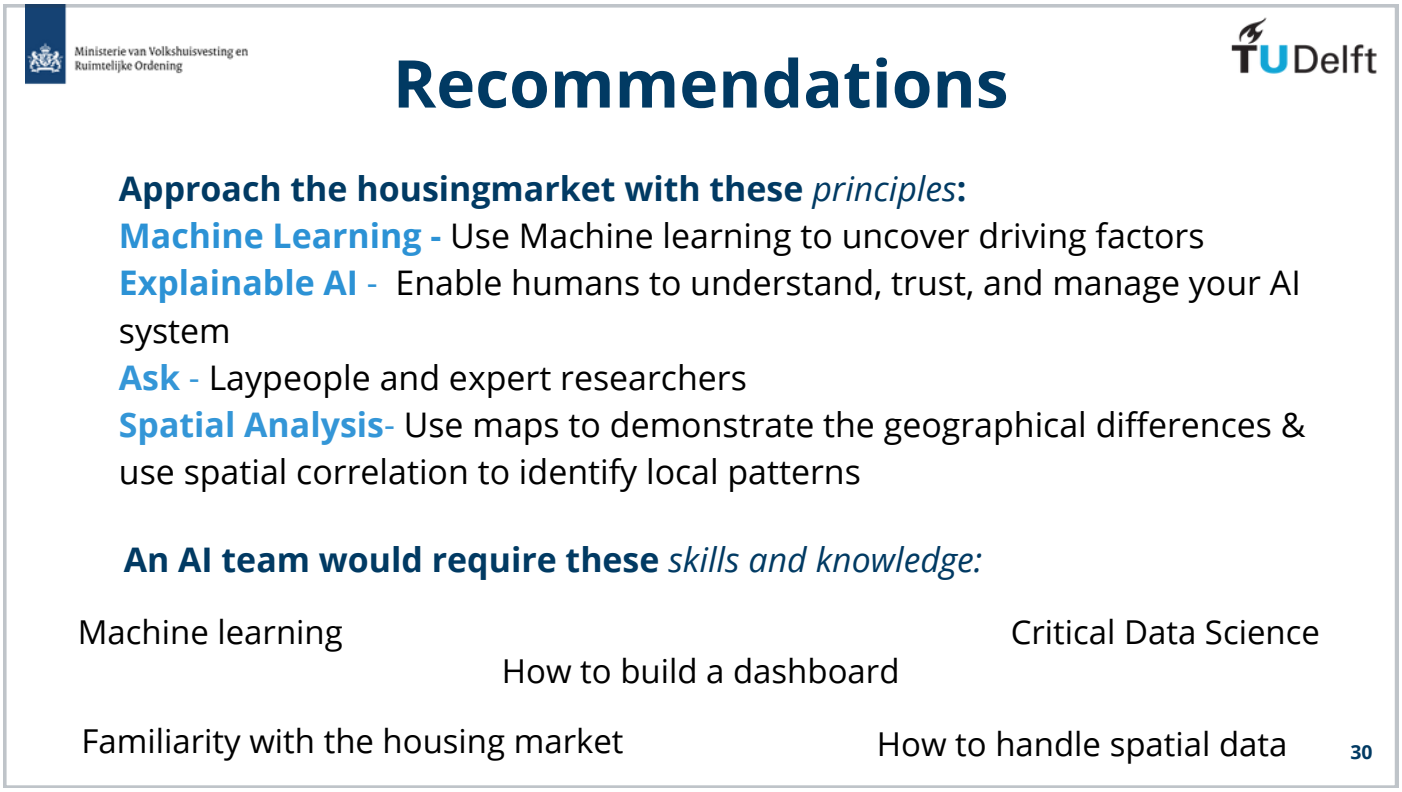
This leads to the recommendations.

Until now, local driving factors of housing demand are overlooked. A recommendation is to include this in further analysis.

This was also indicated as an innovation by both laypeople and experts in the housing market to adapt policy to local nuances. (Appendix A-D)

Indicated local phenomena by interviewees to take into account in future analysis were :
- Ripple effect
- Urbanisation
- Cultural differences
- Facilities



Another recommendation is to approach the housingmarket with these principles:

Explainable AI - Try to make your model more explainable while maintaining a high level of learning. Enable humans to understand, trust, and manage your AI system.

Ask - Laypeople and expert researchers since they have valuable insights into their own problems and (research)findings.

Spatial Analysis - Use maps to demonstrate the geographical differences and use spatial correlation to identify spatial patterns. Examples of spatial correlation methods are:
- Moran's I
- Cluster analysis
- LISA

An AI team would require these skills and knowledge:
Machine learning, Critical Data Science, Familiarity with the housing market, how to build a dashboard, how to handle spatial data.

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Research Recommendations

The approach of the product is *novel* for housing policy. **Applying machine learning** can uncover hidden patterns and provide important insights for designing more effective and localized housing policies.

Future research should explore how **machine learning** improves housing market predictability compared to **traditional methods** and **align** product design with policy-making processes.

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From our interview (Appendix C) and literature review, it was found that machine learning is not yet widely used in housing market research. Traditional methods such as regression analysis dominate. The novel approach of applying machine learning, as proposed in this product, has the potential to uncover key drivers and correlations in the housing market that remain hidden using traditional methods.

Future research is recommended to explore the positive effects of machine learning on housing market studies, particularly in terms of improving predictability and providing actionable insights for designing localized policies. Additionally, aligning the design choices of such products with the policy-making process is critical for their effective adoption.

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References

Belle, V., & Papantonis, I. (2021). Principles and Practice of Explainable Machine Learning https://www.frontiersin.org/articles/10.3389/fdata.2021.688969

Centraal Bureau voor de Statistiek. (2024, June 11). *Dashboard economie: Woningmarkt.* Retrieved January 20, 2025, from https://www.cbs.nl/nl-nl/visualisaties/dashboard-economie/woningmarkt

Gopal, K., Bod, E., Groenemeijer, L., van Leeuwen, G., Omtzigt, D., & Stuart-Fox, M. (2024). *Primos-prognose 2024: Prognose van bevolking, huishoudens en woningbehoefte.* ABF Research.

Hol, E. (2024). *De woon tweedeling in Nederland* [Image]. LinkedIn. https://www.linkedin.com/posts/eric-hol-32658611_tweedeling-huishoudens-woningwet-activity-7100374954797322240-S4Ng/

Kellij, S., & Hilhorst, E. (2023, November 2). *Negen op tien Nederlanders: sprake van 'wooncrisis'.* Retrieved January 19, 2025, from https://www.ipsos-publiek.nl/actueel/negen-op-tien-nederlanders-sprake-van-wooncrisis/

Ministerie van Volksverhuizing en Ruimtelijke Ordening. (n.d.). *Het statistisch woningtekort uitgelegd.* Volkshuisvesting Nederland. Retrieved January 19, 2025, from https://www.volkshuisvestingnederland.nl/onderwerpen/berekening-woningbouwopgave

Rijksoverheid. (n.d. a). *Wonen en volkshuisvesting (Regeerprogramma)*. Rijksoverheid. Retrieved January 26, 2025, from https://www.rijksoverheid.nl/regering/regeerprogramma/3a-wonen-en-volkshuisvesting

Rijksoverheid. (n.d. b). Wat is hypotheekrenteaftrek? Rijksoverheid. Retrieved January 26, 2025, from https://www.rijksoverheid.nl/onderwerpen/huis-kopen/vraag-en-antwoord/hypotheekrenteaftrek

Rijksoverheid. (2024, October 18). *Sneller naar 100.000 woningen per jaar. Rijksoverheid.* https://www.rijksoverheid.nl/actueel/nieuws/2024/10/18/sneller-naar-100.000-woningen-per-jaar

Rijksvastgoedbedrijf. (n.d.). *Rijksvastgoedbedrijf*. Retrieved January 26, 2025, from https://www.rijksvastgoedbedrijf.nl/

Staatscommissie Demografische Ontwikkelingen 2050. (2024). *Gematigde groei - Rapport van de Staatscommissie Demografische Ontwikkelingen 2050.* Den Haag.

Van Mil, J. (2024, February). *De wooncrisis: Een crisis over ongelijkheid.* Studium Generale, Utrecht University. Retrieved January 19, 2025, from https://www.sg.uu.nl/artikelen/2024/02/de-wooncrisis-een-crisis-over-ongelijkheid

Woonbond. (n.d.). *Woonbond successen.* Retrieved January 26, 2025, from https://www.woonbond.nl/woonbondsuccessen/

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Appendices

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Appendix A - interview with homeowner

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Description interviewee

Recently became homeowner with their partner in a large city centre, after their university studies. With the support of a family loan in addition to a mortgage they were able to afford a house and had no problem finding one in budget.

Key comments

- If it were not for their family loan, their study debt would be their biggest hurdle to being able to afford a house because of the lower morgage, even though they have sufficient monthly capacity.
- Options depended on location, getting into the
- Their timing was important as there was a window of opportunity in buying a house that was previously privately rented middle rent
- Recommendation: let study debt weigh less for morgage.

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This interview was conducted digitally via a textual medium on 18-01-2025. They agreed with the ethical review. They agreed anonymised comments would be shared.

The interviewee experienced no obstacles in getting the house that they now have. Though they note their search was made possible by a family loan.

Their dual-earner household in their opinion has enough capacity to carry the burden of a higher mortgage than is currently allowed because of their student loans. Currently, this motivates loaners to lie about their study debt. Should the study debt be of less importance for the height of the mortgage, they believe this will create a healthier climate that allows people to loan to their capacity and be less likely to lie.

They indicate the location is very relevant to how hard it is to move from renter to homeowner.

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Appendix B - interview with renter

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Description interviewee

Is looking to become a homeowner with their partner in travelling time of their job with the right public transport facilities. Has the capability of living with their parents until they have saved enough to buy.

Key comments

- They do not believe they would have enough capacity to save up to buy a house anytime soon if they would keep renting instead.
- Limited buying capability due to regulations on employment contract
- Read research into system dynamics that already predicted housing shortage, but those also show that the situation may improve.
- Recommendation: starters also want to move to more fitting housing so new projects must happen across the full spectrum of housing, with additional flexible addition for short term action.

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This interview was conducted in person on 14-01-2025. They agreed with the ethical review. They agreed anonymised comments would be shared.

This interviewee was asked about their personal obstacles to becoming a homeowner and what they believed are the most important things for the ministry to know.

The answers from this interview show the interviewee is well-read on the topic and are insightful about the obstacles that are most important for them. This shows that should the ministry want more insight into personal journey from renter to homeowner, instead of aggregated spatial phenomena, they can ask people themselves.

They indicate the location is very relevant to how hard it is to move from renter to homeowner.

The interviewee mentioned that for them the most important initiatives the government can take are influence more houses of diverse sizes, uses and prices (building robustly) but also for short term can create flexible temporary housing that can be placed where the starter-house shortage is an acute problem.

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Appendix C - interview expert researcher living preferences and the housing market

Description interviewee

Specialist in the field after 30 years of research. Good relations with bringing research into practice as they regularly advise and publish prognoses for public use.

Key comments

- Research indicates need for both structural reform and short-term action. Housing is a right and if the market fails, the government should step in to protect that right. They are on the right path.
- Homeowners obtain surplus value, obtaining advantage over renters.
- Building plans halted, but now can't restart due to unforeseen events.
- Where supply can't be increased, smartly use current housing.
- Recommendation: The types of households are changing, the market should change too - facilitate renting and buying together without being partners.

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This interview was conducted online on 20-01-2025. They agreed with the ethical review. They agreed anonymised comments would be shared.

Questions were asked about the researcher's expertise and what they think is most important for the ministry to know. The key comments are related to their expertise. Other than the comments noted on the slide, the researcher was asked about their opinion on applying machine learning in their research.

The interviewee noted concern and asked whether Machine Learning can take the variation through time well-enough into account. They warned about the limits of machine learning as a black box tool. The results should be substantiated with existing theory to be of use.

On the general topic of the factors that influence the ability to buy a house when renting they replied: the supply, the prices, the untransparent process of buying a house (lots of over-bidding).

Lastly, they mentioned an spatial phenomenon that supports more research into local factors: the ripple effect. The housing supply in the Randstad or other hubs become more expensive and limited, pushing people to the neighbouring areas and thus rippling the effect to other areas.

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Appendix D - World Café

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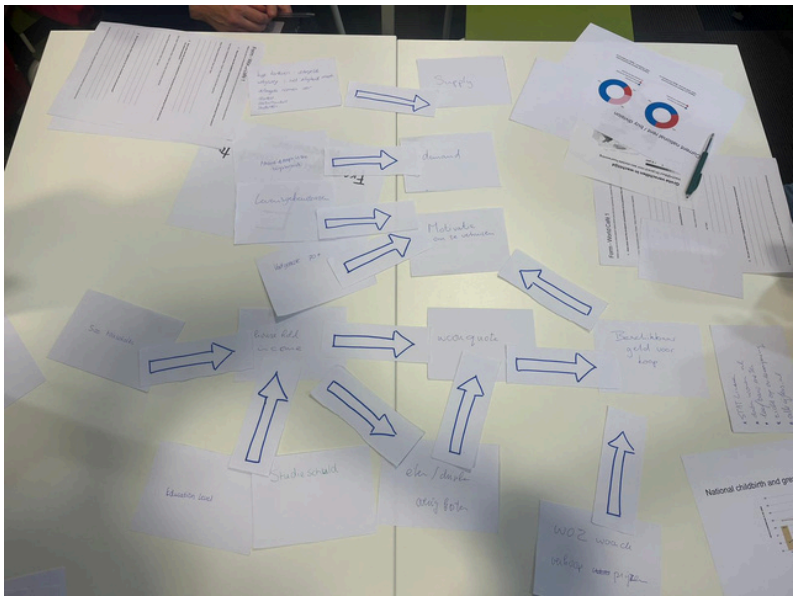

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The world café's were collaborative presentation moments where we got to present and discuss our ideas with the client and other students, teachers and guests.

The world cafés were not only used as feedback, but also as input moments. The slide shows an activity from the first world café. The cards on the table show the factors and the connections between those facors that were deemed most important by the participants for the topic of renter to homeowner.

We learned from this exercise that the participants had many factors that they deemed important to explore. The exercise paints the picture that someone may want to (not) move for several reasons, but regulations may limit supply and finances may limit capability.

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Appendix E - Video link

https://youtu.be/iGu4VGjovbM

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Appendix F - Link to GitHub

https://github.com/maaikekuipers/EPA221A_group5b

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